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FEASIBILITY STUDY FOR OPERABLE UNIT 2 VOLUME 4 OF 6 APPENDICES B, C AND D DRAFT APRIL 1994 REF: 5500, 5501, 5502, 5503, 5505, 5506, 5507

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FEASIBILITY STUDY REPORT FOR OPERABLE UNIT 2

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

VOLUME 4 OF 6
APPENDICES B, C, AND D

APRIL 1994

U.S. DEPARTMENT OF ENERGY
FERNALD FIELD OFFICE

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APPENDIX B

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs) AND TO BE CONSIDERED CRITERIA (TBCs)

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TABLE B-1
CHEMICAL-SPECIFIC REQUIREMENTS

Citation	Chemical	Requirement	Determination	Remarks
DRINKING WATER MAXIMUM CONTAMINANT LEVEL GOALS (MCLGs) AND MAXIMUM CONTAMINANT LEVELS (MCLs)				
EPA National Primary Drinking Water Regulations 40 CFR §141.15 and §141.16	MCLs for Radiological Contaminants	The following are maximum contaminant levels for radiological contaminants: Combined radium-226 and -228 . . . . . 5 pCi/L Gross alpha particle activity . . . . . 15 pCi/L (including radium-226 but excluding radon and uranium) Beta and photon radioactivity . . . . . 4 mrem/year from man-made radionuclides	Relevant and Appropriate	OEPA MCLs from OAC 3745-81-15 and -16 are the same as the Federal MCLs.
56 Federal Register 33050 (July 18, 1991)	Proposed MCLs for Radiological Contaminants	The following are the proposed maximum contaminant levels for radiological contaminants: Radium-226 . . . . . 20 pCi/L Radium-228 . . . . . 20 pCi/L Radon-222 . . . . . 300 pCi/L Uranium . . . . . 20 μg/L (30 pCi/L) Beta and photon emitters . . . . . 4 mrem ede/year (excluding radium-228) Adjusted gross alpha emitters . . . . . 15 pCi/L (excluding radium-226, uranium, and radon-222)	TBC	
EPA National Primary Drinking Water Regulations 40 CFR §141.61	MCLs for Organic Contaminants	The following are the maximum contaminant levels for organic contaminants: Benzo(a)pyrene . . . . . 0.0002 mg/L Polychlorinated biphenyls (PCBs) . . . . . 0.0005 mg/L	Relevant and Appropriate	Final MCLs are not presented for contaminants for which the non-zero MCLG is less than or equal to the MCL.
EPA National Primary Drinking Water Regulations 40 CFR §141.51	MCLGs for Inorganic Contaminants	The following are the non-zero maximum contaminant level goals for inorganic contaminants: Beryllium . . . . . 0.004 mg/L	Relevant and Appropriate	

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TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
DRINKING WATER MAXIMUM CONTAMINANT LEVEL GOALS (MCLGs) AND MAXIMUM CONTAMINANT LEVELS (MCLs) (continued)				
50 Federal Register 46936 (November 13, 1985)	Proposed MCLGs for Inorganic Contaminants	The following are proposed, non-zero, maximum contaminant level goals for inorganic contaminants: Arsenic . . . . . 0.05 mg/L	TBC	
Ohio Drinking Water Regulations OAC 3745-81-11	MCLs for Inorganic Contaminants	The following are the maximum contaminant levels for inorganic contaminants: Arsenic . . . . . 0.05 mg/L Chromium . . . . . 0.05 mg/L	Relevant and Appropriate	Final MCLs are not presented for contaminants for which the non-zero MCLG is less than or equal to the MCL. These MCLs are stricter state standards.
OHIO WATER QUALITY STANDARDS				
Ohio Water Quality Standards OAC 3745-1-21	Use Designation	Paddys Run and the Great Miami River are designated as: • warmwater aquatic life habitat • agricultural and industrial water supply • primary contact recreational use	Applicable	In addition to these overall designations: • Ross Rd. (River Mile (RM) 95.7) to Taylorsville Dam (RM 92.6) is a state resource water • RM 130 and RM 118 are public water supplies The FEMP effluent discharge pipe is located at RM 24.73, downstream of the state resource waters and public water supplies.
Ohio Water Quality Standards OAC 3745-1-07	Warmwater Habitat Water Quality Criteria	Parameter (μg/L) — outside mixing zone Max. / Avg. — inside mixing zone Max. Arsenic: 360 / 190 / 720 Beryllium (total): 520 / 23 / 1,000	Applicable	Beryllium is based on a water hardness of 100 mg/L calcium carbonate ($CaCO_3$).

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
OHIO WATER QUALITY STANDARDS (continued)				
Ohio Water Quality Standards OAC 3745-1-07 (continued)	Warmwater Habitat Water Quality Criteria		Applicable	
		Parameter (µg/L) — outside mixing zone Max. / Avg. — inside mixing zone Max. Chromium (total) 1,800 / 210 / 3,600 Chromium, Hexa-valent (diss) 15 / 11 / 31 Dieldrin - / 0.005 / - Fluoranthene 200 / 8.9 / 400 Polychlorinated Biphenyls (PCBs) - / 0.001 / -		Total chromium is based on a water hardness of 100 mg/L $CaCO_3$.
Ohio Water Quality Standards OAC 3745-1-07	Human Health and Agricultural Water Supply Criteria		Applicable	
		Parameter (µg/L) — Human Health (outside mixing zone) — Agri-cultural Arsenic - / 100 Beryllium (total) 1.17 / 100 Chromium (total) 3,433,000 / 100 Dieldrin 0.00076 / - Fluoranthene 54 / - Polychlorinated Biphenyls (PCBs) 0.00079 / - Polynuclear Aromatic Hyrdrocarbons (PAHs) 0.31 / -		

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
		RADIATION DOSE LIMITS		
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(a)(2)	Protection of the General Population from Releases of Radioactivity	Concentrations of radioactive material which may be released to the general environment in surface water, ground water, soil, plants or animals must not result in an effective dose equivalent that exceeds 25 mrems per year to any member of the public. Reasonable effort should be made to maintain releases of radioactivity in effluents to the general environment as low as is reasonably achievable.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (1)(a)	Public Dose Limits	The exposure of members of the public to radiation sources as a consequence of all routine DOE activities shall not cause, in a year, an effective dose equivalent greater than 100 mrem. Dose evaluations should reflect realistic exposure conditions. Specific authorization may be received for a temporary increase of the dose limit up to 500 mrem in a year.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (1)	Public Dose Limits	The public dose limits include consideration of all exposure modes from all DOE activities (including remedial activities). Effective dose equivalent is the sum of the effective dose equivalent (weighted summation of doses to various organs of the body) from exposures to radiation sources external to the body during the year plus the committed effective dose equivalent from radionuclides taken into the body during the year. Medical sources, consumer products, residual fallout from past nuclear accidents and weapons tests and naturally occurring radiation sources are not included in this summation.	TBC	

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
RADIATION DOSE LIMITS (continued)				
National Emission Standards for Hazardous Air Pollutants 40 CFR §61.92, 61.93 Subpart H [Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (1)(b)]	National Emissions Standards for Emissions of Radionuclides Other than Radon from DOE Facilities	Emissions of radionuclides (except radon-220 and radon-222) to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr. To determine compliance with the standard, radionuclide emissions shall be determined and effective dose equivalent values to members of the public calculated using EPA approved sampling procedures, computer models CAP-88 or AIRDOS-PC, or other procedures for which EPA has granted prior approval.	Applicable	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (3)(a)(5)	Interim Dose Limit for Native Aquatic Animal Organisms	The absorbed dose to native aquatic animal organisms shall not exceed 1 rad per day from exposure to the radioactive material in liquid wastes discharged to natural waterways.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (4)(c)	External Gamma Radiation	External gamma radiation levels on open lands shall comply with the basic public dose limit of 100 mrem effective dose equivalent in a year and the ALARA process, considering appropriate-use scenarios for the area.	TBC	
EFFLUENT AND AIR EMISSION STANDARDS				
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (1)(d)	Drinking Water System Standards	It is DOE policy to provide a level of protection for persons consuming water from a public drinking water supply operated by the DOE, either directly or through a DOE contractor, that is equivalent to that provided to the public by the public community drinking water standards of 40 CFR Part 141 (listed above). These systems shall not cause persons consuming the water to receive an effective dose equivalent greater than 4 mrem in a year. Combined Ra-226 and Ra-228 shall not exceed 5×10^{-9} μCi/mL and gross alpha activity (excluding radon and uranium) shall not exceed 1.5×10^{-8} μCi/mL.	TBC	

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
		EFFLUENT AND AIR EMISSION STANDARDS (continued)		
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (1)(d) (continued)	Drinking Water System Standards	The liquid effluents from DOE activities shall not cause private or public drinking water systems downstream of the facility discharge to exceed the drinking water radiological limits in 40 CFR Part 141 (listed above).	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter III	Derived Concentration Guides for Air and Water	The derived concentration guides (DCGs) are provided as reference values for conducting radiological environmental protection programs at operational DOE facilities and sites. DCG values are presented in Figures III-1 and III-3 of DOE Order 5400.5 for the following exposure modes: • ingestion of water • inhalation of air • immersion in a gaseous cloud	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter III (continued)	Derived Concentration Guides for Air and Water	The DCG values for internal exposure are based on a committed effective dose equivalent of 100 mrem for the radionuclide taken into the body by ingestion or inhalation during one year. The DCG values account for only three exposure pathways (ingested water <u>or</u> inhaled air <u>or</u> air immersion) and do not include other potentially significant pathways. When more complex environmental pathways are involved, a more complete pathway analysis is required for calculating public radiation doses resulting from the operation of DOE facilities.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (3)(a)	Discharges of Liquid Waste to Surface Waters	The best available technology is the prescribed level of treatment for liquid radioactive discharges to surface waters that would otherwise contain radioactive concentrations greater than the DCG values. Implementation of the best available technology process is not required for waste streams that contain radionuclide concentrations of not more than the DCG values at the point of discharge to a surface waterway.	TBC	

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
		EFFLUENT AND AIR EMISSION STANDARDS (continued)		
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (3)(a) (continued)	Discharges of Liquid Waste to Surface Waters	The DCG for waste streams containing more than one type of radionuclide shall be the sum of the fractional DCG values.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (3)(a)(4)	Prevention of Radionuclide Buildup in Sediments	Liquid process waste streams containing radioactive material in the solid present in the waste stream must not exceed 5 pCi/g above background level of settleable solids for alpha-emitting radionuclides or 50 pCi/g above background of settleable solids for beta-gamma-emitting radionuclides.	TBC	
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.02 (b) Subpart A 40 CFR §192.32 (b)(1)(ii) Subpart D Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (6)(d)	Control of Radon Emissions	The following standards apply to the: • control of residual radioactive materials from inactive uranium processing sites. • management of uranium byproduct materials after closure of a disposal area. • long-term management of uranium, thorium, and their decay products. Controls shall be designed to provide reasonable assurance that releases of radon-222 from the above materials to the atmosphere will not: • exceed an average annual release rate of 20 pCi/m^{2}s • increase the annual average concentration of radon-222 in air or above any location outside the disposal site by more than 0.5 pCi/L.	Relevant and Appropriate	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (6)(b)	Interim Storage of Residual Radioactive Material	Control and stabilization features of an interim storage facility for residual radioactive material shall be designed such that radon-222 concentrations in the atmosphere above the facility, in addition to background levels, will not exceed: • 100 pCi/L at any given point	TBC	

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
		EFFLUENT AND AIR EMISSION STANDARDS (continued)		
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (6)(b) (continued)	Interim Storage of Residual Radioactive Material	• an annual average concentration of 30 pCi/L over the facility area • an annual average concentration of 3 pCi/L at or above any location outside the facility area • flux rates from the storage of radon producing wastes shall not exceed 20 pCi/m^{2}s	TBC	
National Primary and Secondary Ambient Air Quality Standards 40 CFR §50	National Ambient Air Quality Standards	The following are the primary National Ambient Air Quality Standards (NAAQS): Criteria Pollutant / Primary Standard / Averaging Time Carbon Monoxide: 9 ppm, 8-hour; 35 ppm, 1-hour Lead: 1.5 μg/m^3, Quarterly average Nitrogen Dioxide: 0.053 ppm, Annual Particulate Matter: 50 μg/m^3, Annual; 150 μg/m^3, 24-hour Ozone: 0.12 ppm, 1-hour Sulfur oxides: 0.03 ppm, Annual; 0.14 ppm, 24-hour	Relevant and Appropriate	
Review of New Sources of Air Toxic Emissions OEPA Proposed Policy January 1994	De Minimis Emission Levels for Carcinogens	The following are the Ohio de minimis emission levels for classes A, B1, and B2 carcinogens: Carcinogen / EPA Class / Emission Level Chromium VI: A, 0.1 ton/year All Others: A, B1, B2, 1.0 ton/year	TBC	
Ohio Particulate Matter Standards OAC 3745-17-11	Restrictions on Particulate Emissions	The following are restrictions for particulates from any operation, process, or activity which releases or may release particulate emissions into the ambient air. These limits are based on the weight of material being processed.	Applicable	

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
EFFLUENT AND AIR EMISSION STANDARDS (continued)				
Ohio Particulate Matter Standards OAC 3745-17-11 (continued)	Restrictions on Particulate Emissions	Process Weight at Maximum Capacity lb/hr. / Allowable Rate of Particulate Emission lb/hr. 100 / 0.551 200 / 0.877 400 / 1.40 600 / 1.83 800 / 2.22 1000 / 2.58	Applicable	
RADIONUCLIDE CONCENTRATIONS IN SOILS				
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.12(a) Subpart B 40 CFR §192.20 Subpart C	Cleanup of Soils Contaminated with Residual Radioactive Materials	Remedial actions shall be conducted so as to provide reasonable assurance that, as a result of residual radioactive materials, the concentration of radium-226 in land averaged over any area of 100 m^2 shall not exceed the background level by more than: • 5 pCi/g, averaged over the first 15 cm of soil below the surface • 15 pCi/g, averaged over 15 cm thick layers of soil more than 15 cm below the surface Compliance with this requirement should be shown through measurements performed within the accuracy of currently available types of field and laboratory instruments in conjunction with reasonable survey and sampling procedures.	Relevant and Appropriate	
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.21 (f) and §192.22 (b) Subpart C	Supplemental Standards	Where radionuclides other than radium-226 and its decay product are present in sufficient quantity and concentration to constitute a significant radiation hazard from residual radioactive materials, remedial actions shall, in addition to satisfying the standards of 40 CFR §§ 192.02, Subpart A and 192.12, Subpart B (both listed above), reduce other residual radioactivity to levels that are as low as is reasonably achievable.	Relevant and Appropriate	

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
		RADIONUCLIDE CONCENTRATIONS IN SOILS (continued)		
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.32 (b)(2) Subpart D	Management of Uranium Byproduct Material	The requirements for the management of uranium byproduct materials after closure of a disposal area (40 CFR §192.32 (b)(1)) shall not apply to any portion of a disposal site which contains a concentration of radium-226 in land, averaged over areas of $100m^2$, which, as a result of uranium byproduct material, does not exceed the background level by more than the limits specified in 40 CFR §192.12 (a).	Relevant and Appropriate	
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §§ 192.40-192.42 Subpart E	Management of Thorium Byproduct Material	The following are requirements for the management of thorium byproduct materials: • the provisions for the management of uranium byproduct material (40 CFR §192.32) shall apply to thorium byproduct material and: - provisions applicable to the element uranium shall also apply to the element thorium - provisions applicable to radon-222 shall also apply to radon-220 - provisions applicable to radium-226 shall also apply to radium-228 With the concurrence of EPA, alternative provisions may be substituted for any of the above requirements provided the alternative provisions will provide at least an equivalent level of protection for human health and environment.	Relevant and Appropriate	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (4)(a)	Guidelines for Residual Radioactive Material	Guidelines for residual concentrations of radionuclides other than thorium and radium shall be derived from the basic dose limits by means of an environmental pathway analysis using specific property data where available. Procedures for these derivations are given in DOE/CH-8901. Residual concentrations of radioactive material in soil are defined as those in excess of background concentrations averaged over an area of $100\ m^2$.	TBC	

TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
		RADIONUCLIDE CONCENTRATIONS IN SOILS (continued)		
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (4)(a)(2),(3)	Generic Guidelines for Residual Concentrations	The generic guidelines for residual concentrations of radium-226, radium-228, thorium-230, and thorium-232 are: • 5 pCi/g, averaged over the first 15 cm of soil below the surface; and • 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface. These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If both thorium-230 and radium-226, or both thorium-232 and radium-228, are present and not in secular equilibrium, the appropriate guideline is applied as a limit for the radionuclide with the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that either the dose for the mixture will not exceed the basic dose limit or the sum of the ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1. Explicit formulas for calculating residual concentrations guidelines for mixtures are given in DOE/CH-8901.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (4)(a)(1)	Hot Spots	If the average concentration in any surface or below surface area less than or equal to 25 m^2, exceeds the limit or guideline by a factor of$(100/A)^{0.5}$ [where A is the area (in square meters) of the region in which the concentrations are elevated], limits for "hot spots" shall also be developed and applied. Procedures for calculating these hot spots limits, which depend on the extent of the elevated local concentrations, are given in DOE/CH-8901. In addition, reasonable efforts shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit in the soil, irrespective of the average concentration in the soil.	TBC	

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TABLE B-1
(Continued)

Citation	Chemical	Requirement	Determination	Remarks
RADIONUCLIDE CONCENTRATIONS IN SOILS (continued)				
EPA Guidance Methods for Evaluating the Attainment of Cleanup Standards, Vol. 1	Attainment of Soil Cleanup Standards	This document describes methods for testing whether soil chemical concentrations at a site are statistically below a cleanup standard or ARAR. If it can be reasonably concluded that the remaining soil or treated soil at a site has concentrations that are statistically less than relevant cleanup standards then the site can be judged protective of human health and the environment.	TBC	
LEAD SOIL CLEANUP STANDARDS				
Resource Conservation and Recovery Act 40 CFR §268.41	Requirements for Lead Cleanup	The maximum concentration of lead in the extract of any sample of treated soil is 5 mg/L.	Relevant and Appropriate	
PCB SOIL CLEANUP STANDARDS				
PCB Manufacturing, Processing, Distribution, and Use Prohibitions 40 CFR §761.125 (c)(4)(v)	Requirements for PCB Cleanup	Soil contaminated by a PCB spill in non-restricted access areas will be decontaminated to 10 ppm PCBs by weight, provided that the soil is excavated to a minimum depth of 10 inches. The excavated soil will be replaced with clean soil, i.e. containing less than 1 ppm PCBs, and the spill site will be restored (e.g. replacement of turf).	Relevant and Appropriate	The source of PCBs in Operable Unit 2 is unknown.

TABLE B-2
SOLID WASTE ACTION-SPECIFIC REQUIREMENTS

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS		
Resource, Conservation, and Recovery Act 42 U.S.C. §6903 (27)	Definition	Solid waste means any garbage, refuse, sludge from a waste treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semisolid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations and from community activities, but does not include source, special nuclear, or byproduct material as defined by the Atomic Energy Act of 1954.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-01 (UU)	Definition	Solid wastes means such unwanted residual solid or semisolid material as results from industrial, commercial, agricultural, and community operations, excluding earth or material from construction, mining, or demolition operations, or other waste materials of the type that would normally be included in demolition debris, nontoxic flyash, spent nontoxic foundry sand, and slag and other substances that are not harmful or inimical to public health, and includes, but is not limited to, garbage, tires, combustible and noncombustible material, street dirt, and debris. Solid waste does not include any material that is an infectious waste or a hazardous waste. For the purpose of this definition, "semisolid material" does not contain liquids which can be readily released under normal climatic conditions, as determined by method 9095 (paint filter liquids test) in SW-846: "Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods".	Applicable	
Resource, Conservation, and Recovery Act 40 CFR §261.3(a)	Definition	A solid waste is a hazardous waste, if: • it is not excluded from regulation as a hazardous waste under 40 CFR §261.4(b). • it exhibits any of the characteristics of hazardous waste. • it is listed in 40 CFR §§ 261.30 - 261.35. • it is a mixture of solid and hazardous wastes.	Applicable	

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TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-03 (H)(2)	Definition	Chapters 3745-27 (Ohio Solid Waste Disposal Regulations) and 3745-37 (Ohio Hazardous Waste Management Regulations) do not apply to lime sludge disposal or storage. Lime sludge is defined as a material resulting from the treatment of a water supply for drinking or industrial purposes.	Applicable	
Ohio Infectious Waste Regulations OAC 3745-27-01 (V) OAC 3745-27-30 (A),(E),(H) ORC 3734.021 (A)(1)(c),(d)	Definition	Infectious waste is defined by 9 categories of waste including human blood specimens and blood products, sharp wastes used in the treatment or inoculation of human beings, and any other waste materials generated in the diagnosis, treatment, or immunization of human beings. A generator who places all sharp infectious wastes and all unused hypodermic needles, syringes, and scalpel blades into a "SHARPS" container before they are transported and who generates less than 50 lbs. of infectious wastes each month and does not hold a certificate of registration as a generator of infectious wastes may transport and dispose of infectious wastes in the same manner as solid wastes. Treated infectious wastes can be transported and disposed in the same manner as noninfectious waste. Infectious waste that is also radioactive shall be managed in accordance with applicable Ohio Department of Health and U.S. Nuclear Regulatory Commission regulations.	Applicable	
Resource, Conservation, and Recovery Act 40 CFR §261.4(b)(4)	Definition	Flyash waste, bottom ash waste, slag waste, and fly gas emission control waste, generated primarily from the combustion of coal or other fossil fuels, are excluded from the definition of hazardous waste.	Applicable	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS (continued)		
Design Criteria: Disposal of Non-Toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes OEPA Policy 4.07	Definition	Nontoxic flyash, bottom ash, and foundry sand are exempted by Chapter 3734 of the ORC from the definition of solid waste, however, disposal of these wastes is subject to Ohio water, land, and air pollution control laws and regulations. Flyash will be considered nontoxic if its leachate does not exceed 30 times the levels specified in the Ohio Drinking Water Standards (3745-81-11(B)) for any parameter in the following table: Arsenic: OH Water Standard 0.05 mg/L; 30X Standard 1.5 mg/L; Fed/OH Haz. Waste Criteria 5.0 mg/L Barium: 1.0; 30.0; 100.0 Cadmium: 0.01; 0.3; 1.0 Chromium: 0.05; 1.5; 5.0 Lead: 0.05; 1.5; 5.0 Mercury: 0.002; 0.06; 0.02 Selenium: 0.01; 0.3; 1.0 All ash that exceeds the criteria for the definition of nontoxic, based on the results from the EP Toxicity test, shall be disposed according to solid waste or hazardous waste criteria as appropriate.	TBC	
55 Federal Register 30797, Section by Section Analysis, B.3. (July 27, 1990)	Definition	EPA has decided that firing range areas should not be considered solid waste management units. Unexploded ordinance fired during target practice is not discarded material which falls within the regulatory definition of "solid waste". Ordnance that does not explode, as well as fragments of exploded ordnance, would be expected to land on the ground. Hence, the "ordinary use" of ordinance includes placement on land.	TBC	According to this rule, the lead bullets in the soil embankment of the South Field Firing Range are not considered solid waste. EPA stated this position earlier in a September 6, 1988 memo from S. K. Lowrance which explained that discarded bullets are not considered solid waste and, therefore, also cannot be considered hazardous waste.

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS (continued)		
Ohio Petroleum Contaminated Soil Policy OEPA Policy PP 01 03 200	Definition	The basis of the "contained in" policy is that environmental media, such as soil or groundwater, are not considered to be waste material. Because they are not a solid waste, the mixture rule, as set forth in OAC 3745-51-03, does not apply when they become contaminated with a listed hazardous waste but only contains the waste. The result of this policy is that if the waste constituents can be removed, the soil is no longer considered to contain a hazardous waste. Therefore, since soil is not a waste material it does not have to be de-listed in order for it to be used for its intended purpose. However, as long as the soil contains the waste material, it must be managed as a hazardous waste. If we apply this concept to petroleum-contaminated soil, the soils containing a petroleum hydrocarbon would not need to be managed as a solid waste if the contaminants were removed.	TBC	
Proposed Ohio Construction Debris Regulations OAC 3745-29-01 OAC 3745-29-08 (B)(1), (2),(4)	Definition	Construction and demolition debris means those materials resulting from the alteration, construction, destruction, rehabilitation, or repair of any manmade physical structure, including, without limitation, houses, buildings, industrial or commercial facilities, or roadways. Construction or demolition debris does not include reinforced or non reinforced concrete, asphalt, building or paving brick, or building or paving stone that is stored for a period of less than two years for recycling into a usable construction material. Construction debris disposal facilities that existed prior to the issuance of this rule are not required to install a recompacted soil liner or a leachate management system. Disposal facilities that have reached final elevations and no additional disposal will occur after the issuance date of this rule are not required to construct a cap system.	TBC	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS (continued)		
CERCLA Compliance with Other Laws Manual Section 2.7	Definition	Placement/disposal of waste does not occur under the following circumstances: • waste is consolidated within a unit (including an area of contamination that can be viewed as a single unit); • waste is capped in place, including grading prior to capping; • waste is treated in situ; and • waste is processed within the unit in order to improve its structural stability for closure or for movement of equipment over the area.	TBC	
Resource, Conservation, and Recovery Act 40 CFR §260.10	Definition	Remediation waste means all solid and hazardous waste, and all media (including groundwater, surface water, soils, and sediments) and debris, which contain listed hazardous wastes or which themselves exhibit a hazardous waste characteristic, that are managed for the purpose of implementing corrective action requirements under 40 CFR §264.101 and RCRA section 3008(h). For a given facility, remediation wastes may originate only from within the facility boundary, but may include waste managed in implementing RCRA sections 3004(v) or 3008 (h) for releases beyond the facility boundary.	Relevant and Appropriate	
Resource, Conservation, and Recovery Act 40 CFR §264.552 (a),(c)	Definition	For the purpose of implementing corrective action for solid waste management units, the Regional Administrator may designate an area at the facility as a corrective action management unit (CAMU). One or more CAMU's may be designated at a facility. • Placement of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes. • Consolidation or placement of remediation wastes into or within a CAMU does not constitute creation of a unit subject to minimum technology requirements.	Relevant and Appropriate	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS (continued)		
Resource, Conservation, and Recovery Act 40 CFR §264.552 (a),(c) (continued)	Definition	• The CAMU shall facilitate the implementation of reliable, effective, protective, and cost-effective remedies. • Waste management activities associated with the CAMU shall not create unacceptable risks to humans or to the environment resulting from exposure to wastes. • The CAMU shall include uncontaminated areas of the facility only if including such areas for the purpose of managing remediation waste is more protective than management of such wastes at contaminated areas of the facility. • Areas within the CAMU, where wastes remain in place after closure of the CAMU, shall be managed and contained so as to minimize future releases, to the extent practicable. • The CAMU shall expedite the timing of remedial activity implementation, when appropriate and applicable. • The CAMU shall enable the use, when appropriate, of treatment technologies (including innovative technologies) to enhance the long-term effectiveness of remedial actions by reducing the toxicity, mobility, or volume of wastes that will remain in place after closure of the CAMU. • The CAMU shall, to the extent practicable, minimize the land area of the facility upon which wastes will remain in place after closure of the CAMU.	Relevant and Appropriate	
Resource, Conservation, and Recovery Act 40 CFR §264.553 (a),(b)	Definition	For temporary tanks and container storage areas used for treatment or storage of remediation wastes during remedial activities, the Regional Administrator may determine that a design, operating, or closure standard applicable to such units may be replaced by alternative requirements which are protective of human health and the environment. Any temporary unit to which alternative requirements are applied shall be:	Relevant and Appropriate	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS (continued)		
Resource, Conservation, and Recovery Act 40 CFR §264.553 (a),(b) (continued)	Definition	• located within the facility boundary; and • used solely for treatment or storage of remediation wastes.	Relevant and Appropriate	
		SOLID WASTE DISPOSAL		
Ohio Solid Waste Disposal Regulations OAC 3745-27-05 (A)	Solid Waste Disposal Methods	Solid waste shall be disposed of only by the following methods: • sanitary landfill • incineration • composting Methods not mentioned above and not prohibited by this chapter, OAC 3745-27, may be used provided that such methods are demonstrated to the satisfaction of the Director to be capable of disposing of solid waste without creating a nuisance or a health hazard, without causing water pollution, and without violating these regulations and any regulation adopted by the Director pursuant to Ohio Revised Code Chapter 3704 (Air Pollution Control).	Applicable	
US EPA Solid Waste Disposal Regulations 40 CFR §257.3-7	Open Burning Prohibited	The solid waste disposal facility or practice shall not engage in open burning of residential, commercial, institutional, or industrial solid waste. This requirement does not apply to land-clearing debris, diseased trees, debris from emergency clean-up operations, and ordnance.	Applicable	
US EPA Solid Waste Disposal Regulations 40 CFR §257.3-3	Surface Water	A solid waste disposal facility shall not cause a discharge of pollutants into waters of the United States that is in violation of the requirements of the NPDES under section 402 of the Clean Water Act, as amended.	Applicable	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
US EPA Solid Waste Disposal Regulations 40 CFR §257.3-3 (continued)	Surface Water	A solid waste disposal facility shall not cause a discharge of dredged material or fill material to waters of the United States that is in violation of the requirements under section 404 of the Clean Water Act, as amended. A solid waste disposal facility or practice shall not cause non-point source pollution of waters of the United States that violates applicable legal requirements implementing an area-wide or Statewide water quality management plan that has been approved by the Administrator under section 208 of the Clean Water Act, as amended.	Applicable	
US EPA Solid Waste Disposal Regulations 40 CFR §257.3-4	Groundwater Protection	A solid waste disposal facility or practice shall not contaminate an underground drinking water source beyond the solid waste boundary.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (C)(1),(2),(3),(4),(5),(6),(7),(9)	Landfill Construction	The following layers must be installed in the construction of a sanitary landfill (from bottom to top): Recompacted Soil Liner The recompacted soil liner shall be: • constructed using loose lifts 8 inches thick with a maximum permeability of 1×10^{-7} cm/s. • constructed of a soil with a maximum clod size of 3 inches or half the lift thickness, whichever is less. • constructed of soil with: - 100% of the particles having a maximum dimension not greater than 2 inches. - not more than 10% of the particles, by volume, having a dimension greater than 0.75 inches. - not less than 50% of the particles, by weight, passing through the 200-mesh sieve.	Applicable	This applies to new disposal of solid waste.

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (C)(1),(2),(3),(4),(5),(6),(7),(9) (continued)	Landfill Construction	- not less than 25% of the particles, by weight, having a maximum dimension not greater than 0.002 millimeters. • compacted to at least 95% of the maximum "Standard Proctor Density" using ASTM D-698 or at least 90% of the maximum "Modified Proctor Density" using ASTM D-1557. • compacted at a moisture content at or wet of optimum. Alternatives for the above requirements may be used if it is demonstrated to the satisfaction of the Director that the materials and techniques will result in each lift having a maximum permeability of 1×10^{-7} cm/s. Additionally, the recompacted soil liner shall: • not comprised of solid waste. • be constructed using the same number of passes and lift thickness, and the same or similar type and weight of compaction equipment established by testing (as defined in this table). • be placed on the bottom and exterior excavated sides of the landfill and have a minimum bottom slope of 2% and a maximum slope based on: - compaction equipment limitations; - slope stability; - maximum friction angle between any soil-geosynthetic interface and between any geosynthetic-geosynthetic interface; and - resistance of geosynthetics and geosynthetic seams to tensile forces. • constructed on a prepared surface that shall:	Applicable	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (C)(1),(2),(3),(4),(5),(6),(7),(9) (continued)	Landfill Construction	- be free of debris, foreign material, and deleterious material; - be able to bear the weight of the landfill and its construction operations without causing or allowing a failure of the liner to occur through settling; and - not have any abrupt changes in grade that may result in damage to geosynthetics. • be 5 feet thick, although the Director may approve an alternate thickness, to be no less than 3 feet, based upon the result of calculations or on a design that is no less protective of human health and the environment. • have a factor of safety for hydrostatic uplift not less than 1.4. • be adequately protected from damage due to desiccation, freeze/thaw cycles, wet/dry cycles, and the intrusion of objects during construction and operation.	Applicable	
		Geomembrane		
		The geomembrane shall be: • placed on the recompacted soil liner. • negligibly permeable to fluid migration. • physically and chemically resistant to chemical attack by the solid waste, leachate, or other materials which may come in contact with the geomembrane. • seamed to allow no more than negligible amounts of leakage with seaming material that is physically and chemically resistant to chemical attack by the solid waste, leachate, or other materials which may come in contact with the seams.		

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (C)(1),(2),(3),(4),(5),(6),(7),(9) (continued)	Landfill Construction	• have properties for its installation and use which are acceptable to the Director. • protected from the drainage layer by a cushion layer, as required by the Director.	Applicable	
		Leachate Management System		
		The leachate management system shall: • be designed to prevent clogging and crushing of the system and to limit the level of leachate in areas other than lift stations to a maximum of 1 foot. • include a drainage layer placed on top of the geomembrane composed of granular material that must: - have a minimum permeability of 1×10^{-3} cm/s; - have a minimum thickness of 1 foot; - have a negligible amount of fines; and - not contain carbonate material. An alternate material and/or thickness may be used if it is demonstrated to the satisfaction of the Director that the material meets the requirements. • include leachate collection pipes to remove leachate from the bottom of the landfill. The pipes must: - be imbedded in the drainage layer; - have a minimum slope of 0.5%; - have lengths and configuration which shall not exceed the capabilities of clean-out devices; - be provided with access for clean-out devices which shall be protected from differential settling;		

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TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (C)(1),(2),(3),(4),(5),(6),(7),(9) (continued)	Landfill Construction	- have joints sealed to prevent separation; and - be physically and chemically resistant to attack by the solid waste, leachate, or other materials that they may come in contact with. Sealing material and means of access for clean-out devices shall also be physically and chemically resistant to attack by the solid waste, leachate, or other materials that they may come in contact with. An alternate means for leachate removal may be used if it is demonstrated to the satisfaction of the Director that the means for leachate removal meets the requirements. • include a filter layer to prevent clogging of the leachate collection system, as required by the Director. • include a protective layer to protect the recompacted soil liner, geomembrane, and leachate collection system from the intrusion of objects during construction and operation. • include lift stations which are to be protected from adverse effects from leachate and differential settling. If manholes are used as lift stations, they must be equipped with automatic high level alarms located no greater than 6 feet above the invert of the leachate inlet pipe. Lift station pipes should be of adequate capacity and shall automatically commence pumping before the leachate elevation activates the high level alarm.	Applicable	
		Leachate Collection and Storage		
		Collected leachate shall be managed in one of the following ways: • treated and disposed on site at the sanitary landfill facility;		

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (C)(1),(2),(3),(4),(5),(6),(7),(9) (continued)	Landfill Construction	• treated on site and disposed off site of the sanitary landfill facility; or • treated and disposed off site of the sanitary landfill facility. Any leachate conveyance and storage structures located outside the limits of solid waste placement shall be no less protective of the environment than the landfill, as determined by the Director, and: • The structures must be monitored, as required by the Director. • Storage tanks must be provided with spill containment • Leachate lines must be double-cased • Storage structures must have a minimum of 1 week of storage capacity using design assumptions simulating final closure. • If at any time leachate is evaluated to be hazardous in accordance with rule 3745-52-11 of the OAC, it shall be managed in accordance with Chapters 3745-50 to 3745-69 of the OAC, and the generator standards for storage shall apply in accordance with Chapter 3745-52 of the OAC.	Applicable	
		Surface Water Control		
		• Any permanent surface water control structures shall be designed to accommodate, by non-mechanical means, the peak flow from the 100-year/24-hour storm event. • Any temporary surface water control structures shall be designed to accommodate the peak flow from the 25-year/ 24-hour storm event. • Surface water control structures shall be designed to minimize silting and scouring.		

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (C)(1),(2),(3),(4),(5),(6),(7),(9) (continued)	Landfill Construction	• If sedimentation ponds are used, they shall be designed and constructed according to OAC 3745-27-08 (C)(6)(d).	Applicable	
		Benchmarks		
		• At least 3 permanent third order benchmarks on separate sides of the landfill shall be in easy access to the limits of solid waste placement. • The benchmarks shall have a stability class of A or B and be referenced horizontally and vertically to the National Geodetic Reference System.		
		Groundwater Control		
		• Any permanent groundwater control structures shall adequately control groundwater infiltration through the use of non-mechanical means such as impermeable barriers or permeable drainage structures. • No permanent groundwater control structures may be used to dewater an aquifer system.		
EPA Criteria for Municipal Solid Waste Landfills 40 CFR §258.40	Landfill Design Criteria	The liner and leachate system shall be designed and constructed to maintain less than a 30-cm depth of leachate over the liner. The geomembrane must be at least 30-mil thick.	Relevant and Appropriate	
EPA Criteria for Municipal Solid Waste Landfills 40 CFR §258.26	Run-On/Run-Off Control Systems	The landfill shall have: • a run-on control system to prevent flow onto the active portion of the landfill during the peak discharge from a 25-year storm.	Relevant and Appropriate	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
EPA Criteria for Municipal Solid Waste Landfills 40 CFR §258.26 (continued)	Run-On/Run-Off Control Systems	• a run-off control system from the active portion of the landfill to collect and control at least the water volume resulting from a 24-hour, 25-year storm.	Relevant and Appropriate	
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (D) and (E)	Landfill Construction	Prior to being used in the construction of the recompacted soil liner and drainage layer of the sanitary landfill or the landfill cap, the following characteristics of the earthen materials must be determined to show that the material is suitable for use in construction of the landfill.	Applicable	
		Soil Material Specifications		
		The following tests shall be performed on representative samples at least once for every 1,500 yd^3 of soil except the recompacted permeability test, which shall be performed at least once for every 10,000 yd^3 of soil. • recompacted permeability at construction specifications; • moisture content and density using an approved ASTM method; • grain size distribution using ASTM D-422 for sieve and hydrometer methods; and • Atterberg limits using ASTM D-423 and D-424 methods.		
		Granular Drainage Material Specifications		
		The following tests shall be performed at least once for every 3,000 yd^3 of material. • permeability;		

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TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (D) and (E) (continued)	Landfill Construction	• grain size distribution using ASTM D-422 for the sieve method; and • chemical compatibility testing may be required by the Director.	Applicable	
		Geosynthetic Material Specifications		
		Geosynthetics, other synthetic materials, and joint sealing compounds used in the construction of a sanitary landfill facility or a sanitary landfill cap system shall be shown to: • be physically and chemically resistant to attack by the solid waste, leachate, or other materials that they may come in contact with using USEPA Method 9090 or other documented data. • have properties acceptable for installation and use.		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (F)(1), (3),(4)	Landfill Construction	The following activities must be performed to ensure that the components of the sanitary landfill facility meet the specifications of this rule.	Applicable	
		Test Pads		
		The recompacted soil liner and the recompacted soil barrier layer in the cap system shall be modeled by the construction of test pads. The test pads shall: • be designed such that the proposed tests are appropriate and their results are valid. • be constructed to establish the construction details which are necessary to obtain sufficient compaction to satisfy the permeability requirement. The construction details include:		

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (F)(1), (3),(4) (continued)	Landfill Construction	- lift thickness; - water content necessary to achieve the desired compaction; and - type, weight, and number of passes of construction equipment. • be constructed prior to the construction of the sanitary landfill component which the test pad will model. • be constructed whenever there is a significant change in soil material properties. • have a minimum width three times the width of the compaction equipment, and a minimum length two times the length of compaction equipment, including power equipment and any attachments. • be comprised of at least four lifts. • be tested for field permeability, following the completion of test pad construction. For each lift a minimum of 3 tests for moisture content and density shall be performed. • be reconstructed as many times as necessary to meet the permeability requirement. Any amended construction details shall be noted. An alternative to test pads may be used if it is demonstrated to the satisfaction of the Director that the alternative meets the requirements.	Applicable	

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TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (F)(1),(3),(4) (continued)	Landfill Construction	Moisture Content and Density Testing Moisture content and density testing of the recompacted soil liner and recompacted soil barrier in the cap system shall be performed at a frequency of no less than 5 tests per acre per lift. Any penetrations shall be repaired using methods acceptable to the Director. Geomembrane Testing • For the purpose of testing every seaming apparatus in use each day, peel and shear tests shall be performed on scrap pieces of geomembrane at the beginning of the seaming period and every four hours thereafter. • Nondestructive testing shall be performed on 100% of the geomembrane seams. • Destructive testing for peel and shear shall be performed at least once for every 500 feet of seam length. An alternate means may be used if it is demonstrated to the satisfaction of the Director that the alternate means meets the requirements.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (G)	Landfill Construction	All tests failing to meet the specifications outlined above must be investigated and the areas reconstructed to meet specifications.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (H)	Landfill Construction	A Quality Assurance/Quality Control Plan for construction shall include: • sampling and testing procedures to be used in the field and in the laboratory; • testing frequency; • parameters and sample locations; • procedures to be followed if a test fails;	Applicable	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-08 (H) (continued)	Landfill Construction	• the management structure and the experience and training of the testing personnel; and • contingency plan for anticipated construction difficulties. The Quality Assurance/Quality Control Plan shall certify the design and construction of any of the following items which are incorporated into the landfill design: • in-situ foundation preparation; • liner system; • geomembrane; • leachate management system; • cap system; • permanent ground water control structures; and • explosive gas control/extraction systems.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-09 (H)	Sanitary Landfill Operation	To demonstrate that the solid wastes to be received at the landfill facility will not compromise the integrity of any material used to construct the landfill facility, the Director may require chemical compatibility testing to be performed.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-09 (N)(1), (2)	Sanitary Landfill Operations	Surface water shall be diverted from areas where solid waste is being, or has been, deposited. The facility shall be properly graded and provided with additional drainage facilities as necessary to ensure minimal infiltration of water through the cover material and cap system, and minimal erosion of the cover material and cap system. If ponding or erosion occurs, action will be taken to correct the conditions causing the ponding or erosion.	Applicable	

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TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-09 (O)	Sanitary Landfill Operations	If leachate is detected on the surface of the landfill facility, then the outbreak(s) shall be repaired and: • leachate shall be contained and properly managed at the sanitary landfill facility. • if necessary, leachate shall be collected and disposed in accordance with paragraph (C)(4) of rule 3745-27-08 of the OAC. • actions shall be taken to minimize, control, or eliminate the conditions which contribute to the production of leachate.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-09 (P)	Sanitary Landfill Operations	If the facility utilizes pumps for leachate removal, at least one lift station back-up pump shall be kept at the sanitary waste landfill facility at all times.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-09 (Q)	Sanitary Landfill Operations	The collection pipe network of the leachate management system shall be inspected after placement of the initial lift of waste to ensure that crushing has not occurred and shall be inspected annually thereafter to determine that clogging has not occurred.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-09 (R)	Sanitary Landfill Operations	If deemed acceptable by the Director, leachate may be temporarily stored within the limits of solid waste placement until the leachate can be treated and disposed.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-10	Groundwater Monitoring Program	All new sanitary landfill facilities and all sanitary landfill facilities undergoing closure shall implement a program capable of determining the impact of the landfill facility on the quality of groundwater occurring within the uppermost aquifer system and all significant zones of saturation above the uppermost aquifer system underlying the landfill facility. The groundwater monitoring system shall collect samples that represent the quality of groundwater that has not been affected by past or present operations and the groundwater passing directly downgradient of the limits of solid waste placement.	Applicable	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-10 (continued)	Groundwater Monitoring Program	If contamination from the landfill is discovered, corrective action shall be taken.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-11 (B)	Final Closure of Landfill Facilities	Closure of the sanitary landfill facility must be completed in a manner that minimizes the need for further maintenance and minimizes post-closure formation and release of leachate and explosive gases to air, soil, groundwater, or surface water to the extent necessary to protect human health and the environment.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-11 (G)(1), (2)	Construction of a Landfill Cap System	A cap system which shall minimize infiltration, must be constructed in all areas of solid waste placement: • The cap system shall have a minimum slope of 5% and a maximum slope of 25% or some alternate slope based on stability analyses. • The cap system shall have a maximum projected erosion rate of 5 tons/acre/year. • Any penetrations into the cap system shall be sealed so that the integrity of the soil barrier layer is maintained. The cap system shall, at a minimum, consist of the following (from bottom to top):	Applicable	
		Recompacted Soil Barrier Layer		
		The recompacted soil barrier layer of the cap shall be: • a minimum of 2 feet thick. • constructed in accordance with the specifications outlined above for construction of the recompacted soil liner for a landfill facility ((C)(1)(a) to (C)(1)(e) of OAC 3745-27-08) and modeled by the construction of a test pad.		

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
SOLID WASTE DISPOSAL (continued)				
Ohio Solid Waste Disposal Regulations OAC 3745-27-11 (G)(1), (2) (continued)	Construction of a Landfill Cap System	**Granular Drainage Layer** The granular drainage layer shall be: • a minimum of 1 foot thick. • constructed on top of the recompacted soil barrier layer in accordance with the specifications outlined above for the drainage layer included in the leachate management system of a sanitary landfill facility ((C)(3)(a) of 3745-27-08 of the OAC).	Applicable	
		Soil Vegetative Layer The soil vegetative layer shall: • consist of soil and vegetation placed on top of the granular drainage layer. • have soil of sufficient thickness and fertility to support its vegetation and to protect the underlying layer from damage due to root penetration and frost. • healthy grasses or other vegetation shall form a complete and dense vegetative cover.		
		Surface Water Control • Land surfaces shall be graded to prevent ponding of water where solid waste has been placed. • Drainage facilities shall be provided to direct surface water from the sanitary waste landfill facility.		

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		SOLID WASTE DISPOSAL (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-11 (G)(5)(b)	Final Closure of Landfill Facilities	A notation must be recorded on the deed to the sanitary landfill facility property, or on some other instrument which is normally examined during title search, that will in perpetuity notify any potential purchaser of the property that the land has been used as a sanitary landfill facility. The notation shall include information describing acreage, exact location, depth, volume, and nature of the solid waste deposited in the sanitary landfill facility.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-14 (A)(1), (2)	Sanitary Landfill Post-Closure Care	Following completion of final closure activities in accordance with rule 3745-27-11 of the OAC, post-closure care activities shall be conducted at the sanitary landfill facility for a minimum of 30 years. Post-closure care activities for all sanitary landfill facilities shall include, but are not limited to: • continuing operation and maintenance of the leachate management system, the surface water management system, any explosive gas extraction and/or control system, any explosive gas monitoring system, and the groundwater monitoring system • maintaining the integrity and effectiveness of the cap system, including making repairs to the cap system as necessary to correct the effects of settling, dead vegetation, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the cap system	Applicable	
EPA Criteria for Municipal Solid Waste Landfills 40 CFR §258.61	Post-Closure Care	The Director of Ohio EPA may allow the owner or operator to stop managing leachate if the owner or operator demonstrates that leachate no longer poses a threat to human health and the environment.	Relevant and Appropriate	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
INFECTIOUS WASTE MANAGEMENT				
Ohio Solid and Hazardous Waste Regulations ORC 3734.03	Open Burning or Dumping	No person shall dispose of treated or untreated infectious wastes by open burning or open dumping.	Applicable	
Ohio Infectious Waste Regulations OAC 3745-27-34 (B) and (C)	Packaging of Infectious Wastes	Sharps shall be packaged in a "SHARPS" container that is rigid, puncture resistant, leak resistant, and closed tightly. The container shall be labeled "SHARPS" and, if the waste has not been treated, with the international biohazard symbol. Containers holding infectious wastes shall not be dropped, managed, or transferred in such a manner as to cause damage to the bag or container. Infectious wastes shall not be transferred through the use of chutes.	Applicable	
Ohio Infectious Waste Regulations OAC 3745-27-31 OAC 3745-27-33 Ohio Solid and Hazardous Waste Regulations ORC 3734.021 (A)(2), (B),(D) ORC 3734.022	Transportation of Infectious Waste	Any person who transports infectious wastes off the premises where they were generated must follow the requirements outlined in these rules.	Applicable	
EXEMPTED WASTE DISPOSAL				
Design Criteria: Disposal of Non-Toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes OEPA Policy 4.07	Non-Toxic Flyash Landfill Design	The recompacted soil liner of a non-toxic flyash disposal facility shall be at least 1½ feet thick and shall be thick enough to allow a fluid migration time of travel from the top of the soil liner to the uppermost aquifer of no less than 15 years. The time of travel shall be calculated using the equation in Attachment 1. An underdrain system should be provided for the entire disposal area, with the contaminated drainage directed to a wastewater treatment facility.	TBC	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		EXEMPTED WASTE DISPOSAL (continued)		
Design Criteria: Disposal of Non-Toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes OEPA Policy 4.07 (continued)	Non-Toxic Flyash Landfill Design	A diversion ditch system shall be placed around the perimeter of the disposal area to minimize the contact of clean, off-site runoff with the ash fill. The diversion system should be designed to convey the peak runoff volume generated in a 10-year storm event. Erosion controls should also be provided. Ash should be placed in lifts, 16 inches maximum, and compacted to a minimum of 90% standard proctor for flyash and 75% standard relative density for bottom ash or an engineering study should be completed to determine suitable lift specifications such that undue subsidence will be minimized.	TBC	
Design Criteria: Disposal of Non-Toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes OEPA Policy 4.07	Cap System	A low permeability cover that will minimize water penetration should be installed for the finished disposal area. The cap should consist of a thickness of at least 2 ft. with permeability of less than 1×10^{-7} cm/sec and 6-12 inches of material suitable for establishing and maintaining a vegetative cover. Final grades of 2% to 25% are recommended. A suitable vegetative cover should be provided as soon as feasible after sections of the fill have achieved final grade and capping.	TBC	
		POLYCHLORINATED BIPHENYL (PCB) DISPOSAL		
PCB Manufacturing, Processing, Distribution, and Use Prohibitions 40 CFR §761.3	Excluded PCB Materials	PCB materials which appear at concentrations less than 50 ppm are excluded from the following PCB disposal requirements.	Relevant and Appropriate	
PCB Manufacturing, Processing, Distribution, and Use Prohibitions 40 CFR §761.60 (a)(3)	Liquid PCB Disposal Requirements	Liquids, other than mineral oil dielectric fluid, containing a PCB concentration of 50 ppm or greater, but less than 500 ppm, shall be disposed of: • in an incinerator which complies with 40 CFR §761.70	Relevant and Appropriate	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
POLYCHLORINATED BIPHENYL (PCB) DISPOSAL (continued)				
PCB Manufacturing, Processing, Distribution, and Use Prohibitions 40 CFR §761.60 (a)(3) (continued)	Liquid PCB Disposal Requirements	• in a chemical waste landfill which complies with 40 CFR §761.75 if information is provided to the owner or operator of the landfill that shows that the waste does not exceed 500 ppm PCB and is not an ignitable waste • in a high efficiency boiler provided that the requirements of this section are met • in a facility that is approved in accordance with 40 CFR §761.60(e)	Relevant and Appropriate	
PCB Manufacturing, Processing, Distribution, and Use Prohibitions 40 CFR §761.60 (a)(4)	Non-Liquid PCB Disposal Requirements	Any non-liquid PCBs at concentrations of 50 ppm or greater in the form of contaminated soil, rags, or other debris shall be disposed of: • in an incinerator which complies with §761.70, or • in a chemical waste landfill which complies with §761.75.	Relevant and Appropriate	
ASBESTOS MANAGEMENT AND DISPOSAL				
Ohio Asbestos Handling Regulations OAC 3745-20-05 (C)	Asbestos Packaging	Each owner or operator of any demolition or renovation operation to whom this rule applies shall seal all friable asbestos-containing waste material into durable leak-tight disposal containers or use an approved alternative disposal system in accordance with the following: • Asbestos containing waste materials shall be sealed in plastic bags having a thickness of at least 0.006 inches (6 mils). A second clean, leak-tight plastic bag having a thickness of at least 6 mils shall fully contain the first bag	Applicable	

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		ASBESTOS MANAGEMENT AND DISPOSAL (continued)		
Ohio Asbestos Handling Regulations OAC 3745-20-05 (C) (continued)	Asbestos Packaging	• Whenever necessary to prevent any asbestos-containing waste material from penetrating a container, the materials shall be sealed into a combination of a 6 mil plastic bag and a leak-tight steel, plastic, or fiber drum, or reinforced disposal box, leak-tight polypropylene woven fabric bag, or similar suitable and durable container. Drums shall be fitted with a matching lid and lock-rims and boxes shall be banded and sealed with reinforced tape or in accordance with manufacturers' recommendations. • Facility components coated with, covered or containing friable asbestos materials and removed in units or sections shall be sealed with at least 0.012 inched (12 mils) of leak-tight plastic or at least 0.010 inches (10 mils) of leak-tight polypropylene woven fabric. • Asbestos containing waste materials, facility components, and contaminated debris may be disposed of using an alternate disposal system which has received the prior written approval of the Director.	Applicable	
National Emission Standard for Asbestos 40 CFR §61.151 (a) Ohio Asbestos Handling Regulations OAC 3745-20-07 (A),(C)	Inactive Asbestos Waste Disposal Sites	Each owner or operator of an inactive asbestos waste disposal site shall do one of the following: • discharge no visible emissions from an inactive waste disposal site; • cover the asbestos-containing waste material with at least 6 inches of compacted nonasbestos-containing material and grow and maintain a cover of vegetation on the area adequate to prevent exposure of the asbestos-containing waste material; or • cover the asbestos-containing waste material with at least 2 feet of compacted nonasbestos-containing material, and maintain the cover to prevent exposure of the asbestos-containing waste material.	Federal Relevant and Appropriate, Ohio Applicable	The Federal requirement is relevant and appropriate because it specifically applies to a type of facility that is not found in Operable Unit 2. The Ohio requirement is generally applicable to any inactive asbestos waste disposal site.

TABLE B-2
(Continued)

Citation	Action	Requirement	Determination	Remarks
		ASBESTOS MANAGEMENT AND DISPOSAL (continued)		
National Emission Standard for Asbestos 40 CFR §61.151 (a) Ohio Asbestos Handling Regulations OAC 3745-20-07 (A),(C) (continued)	Inactive Asbestos Waste Disposal Sites	The owner or operator may use an alternative control method that has received prior approval of the Administrator.	Federal Relevant and Appropriate, Ohio Applicable	

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ATTACHMENT 1
FLUID MIGRATION TIME OF TRAVEL (TOT) FOR AN EXEMPTED WASTE LANDFILL FACILITY

$$TOT = \frac{d}{a\,k}$$

TOT = time of travel

d = distance

k = hydraulic conductivity*

a = constant determined by geologic or liner materials where:
- a = 2 for clay
- a = 2.5 for silt
- a = 3.5 for sand or gravel
- a = porosity for bedrock material
- a = 5 for fractured bedrock

* For recompacted liners, the soil must exhibit a conductivity of less than or equal to 1×10^{7} cm/sec under field placement conditions, and the time of travel equation shall use 0.1 feet per year in the calculation. Other geologic materials may use their actual measured hydraulic conductivity.

TABLE B-3
RADIOLOGICAL ACTION-SPECIFIC REQUIREMENTS

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS		
Atomic Energy Act 42 U.S.C. §2014 (e)(2), (ee) Nuclear Waste Policy Act 42 U.S.C. §10101 (12), (16),(23)	Definition	The term low-level waste means radioactive material that is not: • high-level radioactive waste, the highly radioactive material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations. • spent nuclear fuel, fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing. • transuranic waste, material contaminated with elements that have an atomic number greater than 92, including neptunium, plutonium, americium, and curium, and that are in concentrations greater than 10 nanocuries per gram. • byproduct material, the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.	Applicable	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV	Definition	Residual radioactive material is defined as: • residual concentrations of radionuclides in soil (soil is defined as unconsolidated earth material, including rubble and debris that might be present in the earth material); • concentrations of airborne radon decay products; • external gamma radiation; • surface contamination; and • radionuclide concentrations in air or water resulting from, or associated with, any of the above.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DEFINITIONS (continued)		
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(i)(6) Attachment 2 (1)	Definition	Radioactive material that is below regulatory concern is a definable amount of low-level waste that can be deregulated with minimal risk to the public. Waste containing amounts of radionuclides below regulatory concern, as defined by Federal regulations, may be disposed without regard to radioactivity content.	TBC	
		DOE ALARA POLICY		
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter I (4) and Chapter II (2)	As Low As Reasonably Achievable (ALARA) Process	The order adopts the ALARA process in planning and carrying out all DOE activities. ALARA requires judgement with respect to what is reasonably achievable. Factors that relate to societal, technological, economic, and other public policy considerations shall be evaluated to the extent practicable. Factors to be considered, at a minimum, shall include: • maximum dose to members of the public; • collective dose to the population; • alternative processes, such as alternative treatment of discharge streams, operating methods, or controls; • doses for each process alternative; • cost for each of the technological alternatives; • examination of the changes in cost among alternatives; and • changes in societal impact associated with process alternatives (e.g., differential doses from various pathways).	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
		DOE ALARA POLICY (continued)		
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter I (4) and Chapter II (2) (continued)	As Low As Reasonably Achievable (ALARA) Process	Except for meeting requirements of NEPA, qualitative analyses are acceptable, in most instances, for ALARA judgements, especially when the potential doses are well below the dose limit. The bases for these judgements should be documented. More detailed analyses should be considered if the decision might result in doses that approach the limit.	TBC	
		GENERAL RADIOACTIVE MATERIALS DISPOSAL REQUIREMENTS		
Radiation Protection of the Public and the Environment DOE Order 5400. 5 Chapter II (3)(b)	Discharges of Liquid Waste to Aquifers and Phaseout of Soil Columns	New or increased discharges of radionuclides in liquid waste to active soil columns and virgin soil columns is prohibited.	TBC	
		MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTE		
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(a)	Performance Objectives of Low-Level Radioactive Waste Management	DOE low-level radioactive waste shall be managed to accomplish the following performance objectives: • protection of public health and safety; • protection of the public and the environment from releases of radioactivity (see chemical-specific requirements for radioactive dose limitations); and • protection of groundwater resources, consistent with Federal, State, and local requirements.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(c)	Low-Level Radioactive Waste Generation	Technical and administrative controls shall be directed to reducing the gross volume of waste generated and/or the amount of radioactivity requiring disposal. Waste reduction efforts shall include consideration of process modification, process optimization, materials substitution, and decontamination.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTE (continued)				
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(c) (continued)	Low-Level Radioactive Waste Generation	All DOE low-level waste generators shall establish auditable programs to assure that the amount of low-level waste generated and/or shipped for disposal is minimized. Each DOE low-level waste generator shall separate uncontaminated waste from low-level waste to facilitate cost effective treatment and disposal. Each DOE low-level waste generator preparing a design for a new process or process change shall incorporate principles into the design that will minimize the generation of low-level waste.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(d)	Waste Characterization	Low-level waste shall be characterized with sufficient accuracy to permit proper segregation, treatment, storage, and disposal. This characterization shall ensure that, upon generation after processing, the actual physical and chemical characteristics and major radionuclide content are recorded and known during all stages of the waste management process. Waste characterization data shall be recorded on a waste manifest and shall include: • the physical and chemical characteristics of the waste; • volume of the waste (total of waste and any solidification or absorbent media); • weight of the waste (total of waste and any solidification or absorbent media); • major radionuclides and their concentrations; and • packaging date, package weight, and external volume.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTE (continued)				
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(f)	Waste Treatment	Waste shall be treated by appropriate methods so that the disposal site can meet the performance objectives stated above. Waste treatment techniques such as incineration, shredding, and compaction to reduce volume and provide more stable waste forms shall be implemented as necessary to meet performance requirements. Use of waste treatment techniques to increase the life of the disposal facility and improve long-term facility performance, by improved site stability and reduction of infiltrating water, is required to the extent it is cost effective. The development of large scale waste treatment facilities shall be supported by the appropriate National Environmental Policy Act documentation. Operation of waste treatment facilities shall be supported by adequate documentation.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(g)	Waste Shipment	The volume of waste and number of shipments of low-level wastes shall be minimized and the shipments will be conducted based on plans developed by field organizations. Generators shall provide an annual forecast in the third quarter of the fiscal year to the field organizations managing the off-site disposal facility to which the waste is to be shipped. Generators must receive advance approval from the receiving facility and shall certify prior to shipment that waste meets the receiving facility waste acceptance criteria. The certification program shall be auditable and able to withstand independent review.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(i)(1)-(6)	Waste Disposal	Low-level waste shall be disposed of by methods appropriate to achieve the performance objectives stated in paragraph 3a (listed above), consistent with the radiation dose limits in paragraph 3b (see chemical-specific requirements).	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTE (continued)				
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(i)(1)-(6) (continued)	Waste Disposal	Engineered modifications (stabilization, packaging, burial depth, barriers) for specific waste types and for specific waste compositions for each disposal site shall be developed to achieve the performance objectives. Site specific waste classification limits may be developed if operationally useful in determining how specific wastes should be stabilized and packaged for disposal. Disposition of waste designated as greater than class C, as defined in 10 CFR §61.55, must be handled as a special case. Disposal systems for such waste must be justified by a specific performance assessment through the NEPA process and with the concurrence of DOE headquarters. The following are additional disposal requirements intended either to improve stability of the disposal site or to facilitate handling and provide protection of the health and safety of personnel at the disposal site: • Waste must not be packaged for disposal in cardboard or fiberboard boxes, unless such boxes meet DOT requirements and contain stabilized waste with a minimum of void space. For all types of containers, void spaces within the waste and between the waste and its packaging shall be reduced as much as practical. • Liquid wastes, or wastes containing free liquid, must be converted into a form that contains as little freestanding and noncorrosive liquid as is reasonable achievable, but, in no case, shall the liquid exceed 1 percent of the volume of the waste when the waste is in a disposal container, or 0.5 percent of the volume of the waste processed to a stable form. • Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTE (continued)				
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(i)(1)-(6) (continued)	Waste Disposal	• Waste must not contain, or be capable of generating quantities of toxic gases, vapors, or fumes harmful to persons transporting, handling, or disposing of the waste. This does not apply to radioactive gaseous waste packaged as identified in the next requirement. • Waste in a gaseous form must be packaged at a pressure that does not exceed 1.5 atmospheres at 20°C. • Waste must not be pyrophoric. Pyrophoric materials contained in waste shall be treated, prepared, and packaged to be nonflammable.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(i)(8)	Disposal Facility and Disposal Site Design	Design criteria shall be established prior to selection of new disposal facilities, new disposal sites, or both. These design criteria shall be based on analyses of physiographic, environmental, and hydrogeological data to assure that the policy and requirements of this Order can be met. The criteria shall be also based on assessments of projected waste volumes, waste characteristics, and facility and disposal site performance. Disposal units will be designed consistent with disposal site hydrology, geology, and waste characteristics and in accordance with NEPA.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(i)(9)	Disposal Facility Operations	Operating procedures for low-level waste disposal facilities shall be developed so that they: • protect the environment, health and safety of the public, and facility personnel; • ensure the security of the facility; • minimize the need for long-term control; and • meet the requirements of the closure/post-closure plan. Permanent identification markers for disposal excavations and monitoring wells shall be emplaced.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTE (continued)				
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(i)(9) (continued)	Disposal Facility Operations	Operating procedures shall include training for disposal facility operating personnel, emergency response plans, and a system of reporting unusual occurrences to DOE. Waste placement into disposal units should minimize voids between containers. Operations are to be conducted so that active waste disposal operations will not have an adverse effect on filled disposal units.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(j)	Disposal Site Closure/Post Closure	Site-specific comprehensive closure plans shall be developed for new and existing operating low-level waste disposal sites. The plan shall address closure of disposal sites within a 5-year period after each is filled and shall conform to the requirements of the NEPA process. Performance objectives for existing disposal sites shall be developed on a case-by-case basis as part of the NEPA process. During closure and post closure, residual radioactivity levels for surface soils shall comply with existing DOE decommissioning guidelines. Corrective measures shall be applied to new disposal sites or individual disposal units if conditions occur or are forecasted that could jeopardize attainment of the performance objectives of this Order. Inactive disposal facilities, disposal sites, and disposal units shall be managed in conformance with RCRA, CERCLA, and the Superfund Amendments and Reauthorization Act (SARA). Closure plans for new and existing operating low-level waste disposal facilities shall be reviewed and approved by the appropriate field organization.	TBC	

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TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
MANAGEMENT OF LOW-LEVEL RADIOACTIVE WASTE (continued)				
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(j) (continued)	Disposal Site Closure/Post Closure	Termination of monitoring and maintenance activity at closed facilities or sites shall be based on an analysis of site performance at the end of the institutional control period.	TBC	
Radioactive Waste Management DOE Order 5820.2A Chapter III (3)(k)	Environmental Monitoring	Each low-level waste treatment, storage, and disposal facility shall be monitored by an environmental monitoring program that, at a minimum, meets the following requirements: • The program shall be designed to measure: - operational effluent releases; - migration of radionuclides; - disposal unit subsidence; and - change in disposal facility and disposal site parameters which may affect long-term site performance. • Based on the characteristics of the facility being monitored, the program may include, but not necessarily be limited to, monitoring surface soil, air, surface water, and, in the subsurface, soil and water, both in the saturated and the unsaturated zones. • The monitoring program shall be capable of detecting changing trends in performance sufficiently in advance to allow application of any necessary corrective action prior to exceeding performance objectives. The monitoring program shall be able to ascertain whether or not effluents from each treatment, storage, or disposal facility or disposal site meet the requirements of applicable EH Orders.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
		LOW-LEVEL RADIOACTIVE WASTE CONFINEMENT		
General Design Criteria DOE Order 6430.1A 1323-5.3	Low-Level Radioactive Liquid Waste Confinement	The following shall be applicable to the low-level radioactive liquid waste confinement system: • A dike or berm around the process shall provide secondary confinement. • A tertiary confinement system is not required. • Process and waste storage vessel shall be vented through appropriate treatment systems that control the release of radioactive material in gaseous effluents. • Retention basins shall comply with DOE 5400.1 and shall be lined, fenced, and posted with appropriate radiation warning signs. A system for monitoring radionuclide migration from the basin shall be available. • An impervious berm or dike shall be capable of retaining the maximum radioactive liquid waste inventory that may be releases by a leak or failure of a primary confinement vessel. A capability shall exist to transfer waste that has leaked into the secondary confinement.	TBC	
General Design Criteria DOE Order 6430.1A 1324-5.3	Low-Level Solid Waste Confinement	Low-level solid waste that is disposed to the ground shall be confined by a site-specific system of barriers that may include, but not necessarily be limited to, waste form, waste packaging, and the geologic setting. When site permeability characteristics do not provide the required confinement capabilities, the confinement system shall be augmented by the following: • constructing low permeability walls around the low-level waste; • lining the walls and bottom of the excavated area with low permeability material; and • other suitable methods for reducing permeability.	TBC	

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TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
LOW-LEVEL RADIOACTIVE WASTE CONFINEMENT (continued)				
General Design Criteria DOE Order 6430.1A 1324-5.3 (continued)	Low-Level Solid Waste Confinement	Means shall be provided to minimize contact of emplaced low-level waste with water. Active water control measures shall not be required following permanent closure. Typical requirements for water control are as follows: • placing a layer of highly permeable material beneath the low-level waste to channel any percolating water to a sump; • mounding the soil surface to facilitate surface water runoff; • use of a suitable low-permeability cover material (e.g., clay) over the disposal area to prevent contact of the waste by infiltrating rainwater. This cover material shall be protected by a layer of overburden (e.g., sand, gravel, top soil). • a site diversion system for surface water runoff during operation of the facility; • temporary protective covers (e.g., tarpaulin) before the completion of the natural in-place soil barrier over the low-level waste; • revegetation of the overburden layer; and • other suitable and reliable means for minimizing water contact with low-level waste.	TBC	
General Design Criteria DOE Order 6430.1A 1324-6	Radioactive Solid Waste Confinement Systems	The following requirements outline the confinement system for radioactive solid waste: • Primary confinement consists of process systems equipment and its associated ventilation and off-gas system, storage containers, or other waste and site-specific engineered barriers.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
		LOW-LEVEL RADIOACTIVE WASTE CONFINEMENT (continued)		
General Design Criteria DOE Order 6430.1A 1324-6 (continued)	Radioactive Solid Waste Confinement Systems	• Secondary confinement consists of process cell barriers and the ventilation systems associated with the cells or building, or a large storage building or structure. In some cases, a drum, cask, or other waste and site-specific engineered barrier shall provide secondary confinement. • The natural geologic setting composes the tertiary confinement system. In addition, the tertiary confinement system shall meet the following performance objectives: • Following permanent closure, on-going site maintenance shall not be needed. • In the absence of unplanned natural processes or human contact with a low-level waste disposal facility, calculated contaminant levels in groundwater at the site boundary shall not exceed the maximum contaminant levels (MCLs) established pursuant to the Safe Drinking Water Act (see chemical-specific requirements). • In the event of human-induced activities following permanent closure, or reasonably foreseeable but unplanned natural processes, the guidelines of DOE Order 6430.1A, Section 1300-1.4.2, Accidental Releases, shall not be violated. Institutional controls may be relied on for a limited time following closure. For the purposes of calculation, these controls shall not be relied on for more than 100 years following permanent closure.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
CONTROL OF URANIUM AND THORIUM BYPRODUCT MATERIAL				
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.02 (a) Subpart A	Control of Residual Radioactive Materials	Controls of residual radioactive materials from inactive uranium processing sites shall be designed to be effective for up to 1,000 years, to the extent reasonably achievable, and in any case, for at least 200 years.	Relevant and Appropriate	
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.20 Subpart C	Implementation	Reasonable assurance to show compliance with 40 CFR §192.02 (Subpart A) standards should be done through the use of analytical models and site-specific analyses.	Relevant and Appropriate	
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §192.32 (b)(1)(i) Subpart D	Management of Uranium Byproduct Material	Disposal areas for the management of uranium byproduct materials after closure shall each comply with the closure performance standard in 40 CFR §264.111 with respect to nonradiological hazards and shall be designed to provide reasonable assurance of control of radiological hazards to be effective for 1,000 years, to the extent reasonable, and, in any case, for at least 200 years	Relevant and Appropriate	
Health and Environmental Protection Standards for Uranium and Thorium Mill Tailings 40 CFR §§ 192.40-192.42 Subpart E	Management of Thorium Byproduct Material	The provisions for the management of uranium byproduct material (40 CFR §192.32) shall apply to thorium byproduct material and provisions applicable to the element uranium shall also apply to the element thorium	Relevant and Appropriate	
MANAGEMENT OF RESIDUAL RADIOACTIVE MATERIAL				
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter II (5)	Release of Property	Real property (land and structures), personal property, materials, and equipment shall be released if the concentration of radioactivity is within the limits of residual radioactive contamination.	TBC	

TABLE B-3
(Continued)

Citation	Action	Requirement	Determination	Remarks
MANAGEMENT OF RESIDUAL RADIOACTIVE MATERIAL (continued)				
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (6)	Control of Residual Radioactive Material Above the Guidelines	Residual radioactive material with concentrations above the generic guidelines (see chemical-specific requirements) shall be managed in accordance with Chapter II, Requirements for Radiation Protection of the Public and the Environment, and operational and control requirements.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (6)(b)	Interim Storage of Residual Radioactive Material	Control and stabilization features of an interim storage facility for residual radioactive material shall be designed to provide to the extent reasonably achievable, an effective life of 50 years with a minimum life of at least 25 years. Access to a property and use of on-site material contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls. These control features should be designed to provide, to the extent reasonable, an effective life of at least 25 years.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (6)(c)	Interim Management of Residual Radioactive Material	A property may be maintained under an interim management arrangement when residual radioactive material exceeds guideline values if the residual radioactive material is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (6)(d)	Long-Term Management of Residual Radioactive Material	To properly manage uranium, thorium, and their decay products, access to a property and use of on-site materials contaminated by residual radioactive material should be controlled through appropriate administrative and physical controls such as those described in 40 CFR 192. These controls should be designed to be effective to the extent reasonable for at least 200 years.	TBC	
Radiation Protection of the Public and the Environment DOE Order 5400.5 Chapter IV (7)	Supplemental Limits and Exceptions for Residual Radioactive Material	If special specific property circumstances indicate that the concentration guidelines or authorized limits are not appropriate, supplemental limits or an exception may be requested to those guidelines or limits.	TBC	

TABLE B-4
OTHER ACTION-SPECIFIC REQUIREMENTS

Citation	Action	Requirement	Determination	Remarks
		AIR POLLUTION CONTROL		
Ohio General Provisions on Air Pollution Control OAC 3745-15-07 ORC 3704.01-.05	Prevention of Air Pollution Nuisance	Measures shall be taken to adopt and maintain a program for the prevention, control, and abatement of air pollution in order to protect and enhance the quality of the state's air resource so as to promote the public health, welfare, and economic vitality of the people of the state. The emission or escape into open air from any source whatsoever of smoke, ashes, dust, dirt, grime, acids, fumes, gases, vapors, odors, and combinations of the above in such a manner or in such amounts as to endanger the health, safety, or welfare of the public or to cause unreasonable injury or damage to property shall be declared to be a public nuisance. It is unlawful for any person to cause, permit, or maintain any such public nuisance.	Applicable	
Ohio Particulate Matter Standards OAC 3745-17-07	Control of Visible Particulate Emissions from Stationary Sources	Visible particulate emissions from any stack shall not exceed 20 percent opacity, as a six-minute average. Transient exceedance limits are included in this regulation.	Applicable	
Ohio Emissions of Particulate Matter OAC 3745-17-07(B)(5), (6)	Control of Visible Particulate Emissions	There shall be no visible particulate emissions from any unpaved roadway, parking area, or material storage piles except for a period of time not to exceed thirteen minutes during any sixty-minute observation period.	Applicable	
Ohio Emissions of Particulate Matter OAC 3745-17-08	Restriction of Emission of Fugitive Dust	No person shall cause or permit any fugitive dust source to be operated; or any materials to be handled, transported or stored; or a building or its appurtenances or a road to be used constructed, altered, repaired or demolished without taking or installing reasonably available control measures to prevent fugitive dust from becoming airborne. Such reasonably available control measure shall include, but not be limited to, one or more of the following which are appropriate to minimize or eliminate visible particulate emissions of fugitive dust:	Relevant and Appropriate	This requirement is applicable only to certain cities in Butler and Hamilton Counties.

TABLE B-4
(Continued)

Citation	Action	Requirement	Determination	Remarks
AIR POLLUTION CONTROL (continued)				
Ohio Emissions of Particulate Matter OAC 3745-17-08 (continued)	Restriction of Emission of Fugitive Dust	• the use of water or other suitable dust suppression chemicals for the control of fugitive dust from the demolition of existing buildings or structures, construction operations, the grading or roads or the clearing of land; or • the periodic application of asphalt, oil, water, or other suitable dust suppression chemicals on dirt or gravel roads and parking lots, and any other surfaces which cause emissions of fugitive dust.	Relevant and Appropriate	
WATER POLLUTION CONTROL				
National Pollutant Discharge Elimination System 40 CFR §122.26 (a)(1)(ii) 40 CFR §122.26 (b)(14)(v),(x)	Storm Water Discharge Associated with Industrial Activity	A discharge composed entirely of storm water associated with industrial activity is required to obtain a NPDES permit. These categories of facilities are considered to be engaging in "industrial activity": • landfills, land application sites, and open dumps that receive or have received any industrial wastes (waste that is received from any of the facilities described under this subsection) including those that are subject to regulation under subtitle D of RCRA; and • construction activity including clearing, grading, and excavation activities that disturbs 5 acres or more of total land area.	Applicable	Engineering controls will be implemented to monitor and control stormwater runoff during removal, treatment, and disposal of Operable Unit 2 material.
Clean Water Act §404 (33 U.S.C. §1344) Guidelines for Specifications of Disposal Sites for Dredged or Fill Material 40 CFR §230.10	Discharge of Dredged or Fill Material	No discharge of dredged or fill material shall be permitted: • if there is a practicable alternative to the proposed discharge which would have less adverse impact on the aquatic ecosystem, so long as, the alternative does not have other significant adverse environmental consequences.	Applicable	

TABLE B-4
(Continued)

Citation	Action	Requirement	Determination	Remarks
		WATER POLLUTION CONTROL (continued)		
Clean Water Act §404 (33 U.S.C. §1344) Guidelines for Specifications of Disposal Sites for Dredged or Fill Material 40 CFR §230.10 (continued)	Discharge of Dredged or Fill Material	• unless appropriate and practicable steps have been taken which will minimize potential adverse impacts of the discharge on the aquatic ecosystem. No discharge of dredged or fill material shall be permitted if it: • causes or contributes, after consideration of disposal site dilution and dispersion, to violations of any applicable state water quality standard. • violates any applicable toxic effluent standard or prohibition under section 307 of the Clean Water Act. • jeopardizes the continued existence of species listed as endangered or threatened under the Endangered Species Act of 1973, as amended, or results in likelihood of the destruction or adverse modification or a habitat which is determined to be a critical habitat under the Endangered Species Act of 1973, as amended.	Applicable	
Clean Water Act Nationwide Permit Program 33 U.S.C. §1341(a)(1),(d) 33 CFR §330.1 (c)	Nationwide Permits - Terms and Conditions	An activity is authorized under an NWP only if that activity and the permittee satisfy all of the following NWPs terms and conditions. Potentially applicable NWPs include: • Nationwide Permit #26 - Headwaters and Isolated Waters Discharges - The discharge does not cause the loss of more than 10 acres of waters of the United States. - The permittee notifies the district engineer if the discharge would cause the loss of waters of the United States greater than one acre. - For discharges in special aquatic sites, including wetlands, the notification must also include a delineation of affected special aquatic sites, including wetlands.	Applicable	In a January 17, 1992 letter to the U.S. Army Corps of Engineers, OEPA conditionally certified that projects authorized by these Nationwide Permits will comply with the applicable provisions of the Federal Water Pollution Control Act.

TABLE B-4
(Continued)

Citation	Action	Requirement	Determination	Remarks
		WATER POLLUTION CONTROL (continued)		
Clean Water Act Nationwide Permit Program 33 U.S.C. §1341(a)(1),(d) 33 CFR §330.1 (c) (continued)	Nationwide Permits - Terms and Conditions	- The discharge, including all attendant features, both temporary and permanent, is part of a single and complete project. • Nationwide Permit #38 - Cleanup of Hazardous and Toxic Waste - This permit authorizes specific activities required to effect the containments, stabilization or removal of hazardous or toxic waste materials that are performed ordered, or sponsored by a government agency with established legal or regulatory authority provided the permittee notifies the district engineer. - For discharges in special aquatic sites, including wetlands, the notification must also include a delineation of affected special aquatic sites, including wetlands. - This nationwide permit does not authorize the establishment of new disposal sites or the expansion of existing sites used for the disposal of hazardous or toxic waste.	Applicable	
Clean Water Act Nationwide Permit Program 33 CFR §330.4 (c)(1) Ohio Section 401 Water Quality Certifications OAC 3745-32	Nationwide Permits - Terms and Conditions	State 401 water quality certification pursuant to section 401 of the Clean Water Act, or waiver thereof, is required prior to the issuance or reissuance of individual or nationwide permits authorizing activities which may result in a discharge into waters of the United States	Applicable	
Clean Water Act General Regulatory Policies 33 CFR §323.3	Permits for Discharges of Dredged or Fill Material	Permits will be required for the discharge of dredged or fill material into waters of the United States including wetlands. Certain discharges specified in 33 CFR Part 330 are permitted by that regulation (nationwide permits).	Applicable	

TABLE B-4
(Continued)

Citation	Action	Requirement	Determination	Remarks
		WATER POLLUTION CONTROL (continued)		
Clean Water Act General Regulatory Policies 33 CFR §323.3 (continued)	Permits for Discharges of Dredged or Fill Material	If a discharge of dredged or fill material is not permitted by 33 CFR Part 330 (Nationwide Permits), an individual section 404 permit will be required for the discharge of dredged or fill material into waters of the United States. Discharges of dredged or fill material into waters of the United States done by or on behalf of any Federal agency, other than the Corps of Engineers, are subject to the authorization procedures of these regulations.	Applicable	
Ohio Water Pollution Control Regulations ORC 6111.04	Acts of Pollution Prohibited	No person shall cause pollution or place or cause to be placed any sewage, industrial waste, or other wastes in a location where they cause pollution of any waters of the state. No person to whom a permit has been issued shall place or discharge, or cause to be placed or discharged, in any waters of the state any sewage, industrial waste, or other wastes in excess of the permissive discharges specified under such existing permit without first receiving a permit from the Director to do so.	Applicable	

TABLE B-5
LOCATION-SPECIFIC REQUIREMENTS

Citation	Location	Requirement	Determination	Remarks
THREATENED AND ENDANGERED SPECIES PROTECTION				
Procedures for Implementing the National Environmental Policy Act 40 CFR §6.302(h) Endangered and Threatened Wildlife and Plants 50 CFR §17.21,§17.94 Interagency Cooperation-Endangered Species Act 50 CFR §402.01	Endangered Species and Critical Habitat	All Federal agencies must insure that any action authorized, funded, or carried out by them is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of the constituent elements essential to the conservation of a listed species within a defined critical habitat.	Applicable	A baseline ecological survey, conducted by Miami University, found no federally listed endangered species at the Fernald site. However, the study did locate individuals of two state-listed endangered plants (slender fingergrass [*Digitaria filiformis*] and mountain bindweed [*Polygonum cilinode*]) and one state-listed threatened invertebrate (Sloan's crayfish [*Orconectes sloanii*]). The Miami University study and subsequent studies identified suitable habitat for two federally-listed endangered species (Indiana bat [*Myotis sodalis*] and running buffalo clover [*Trifolium stoloniferum*]), one state-listed endangered species (cave salamander [*Eurycea lucifuga*]) and one state-listed threatened species (spring coralroot [*Corallorhiza wisteriana*]).
Interagency Cooperation-Endangered Species Act 50 CFR §402.12 (a),(b)	Biological Assessment	A biological assessment shall evaluate the potential effects of the action on listed and proposed critical habitat and determine whether any such species or habitat are likely to be adversely affected by the action and is used in determining whether formal consultation or a conference is necessary. These procedures are required for Federal actions that are "major construction activities".	Applicable	
Ohio Endangered Species Regulations ORC 1531.25	Endangered Animal Species	No person shall take or possess any native species of wild animal, or any eggs or offspring thereof, that is threatened with state-wide extinction.	Applicable	See first remark.

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
THREATENED AND ENDANGERED SPECIES PROTECTION (continued)				
Ohio Endangered Species Regulations ORC 1518.02 OAC 1501:18-1	Endangered Plant Species	No person shall root up, injure, destroy, remove, or carry away on or from public highways, public property, or waters of the state, or on or from the property of another, without the written permission of the owner, lessee, or other person entitled to possession, any endangered or threatened plant listed in OAC 1501:18-1.	Applicable	See first remark.
Classification of Solid Waste Disposal Facilities and Practices 40 CFR §257.3-2	Any	Solid waste disposal facilities or practices shall not cause or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife. Solid waste disposal facilities or practices shall not result in the destruction or adverse modification of the critical habitat of endangered or threatened species as identified in 50 CFR Part 17.	Applicable	See first remark.
HISTORIC AND CULTURAL RESOURCE PROTECTION				
Antiquities Act of 1906 16 U.S.C. §431	Antiquity Preservation	No person may appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity situated or controlled by the Government of the United States.	Applicable	A survey of the Operable Unit 2 areas was performed in March 1993 and it was determined that the areas had already been sufficiently disturbed so that there would be no requirement to consult the State Historic Preservation Officer (SHPO). Any other proposed areas of disturbance for Operable Unit 2 remedial actions will be surveyed and the SHPO consulted as necessary.

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
HISTORIC AND CULTURAL RESOURCE PROTECTION (continued)				
Archeological Recovery Act 16 U.S.C. §408(a) Procedures for Implementing the National Environmental Policy Act 40 CFR §6.301 (c) Protection of Archaeological Resources 43 CFR §7.4(a)	Archaeological Resource Recovery and Preservation	Whenever any Federal agency finds, or is notified, in writing, by an appropriate historical or archaeological authority, that its activities in connection with any Federal construction project or federally licensed project, activity, or program may cause irreparable loss or destruction of significant scientific prehistorical, historical, or archaeological data, such agency shall notify the Secretary of the Interior, in writing, and shall provide the Secretary with appropriate information concerning the project, program, or activity. No person may excavate, remove, damage, or otherwise alter or deface or attempt to excavate, remove, damage, or otherwise alter or deface any archaeological resource located on public lands unless such activity is pursuant to a permit. If an EPA activity may cause irreparable loss or destruction of significant scientific, prehistoric, historic, or archaeological data, the responsible official or the secretary of the Interior is authorized to undertake data recovery and preservation activities.	Applicable	See above remark.
National Historic Preservation Act 16 U.S.C. §470f 16 U.S.C. §470h-2 (a)(1) National Historic Landmarks Program 36 CFR 65.2(c)(2) Procedures for Implementing the National Environmental Policy Act 40 CFR §6.301 (a),(b)	Historic Preservation	A Federal agency must take into account the effect of any undertaking on any district, site, building, structure, or object that is included in, or eligible for, inclusion in the National Register of Historic Places. The heads of all Federal agencies shall assume responsibility for the preservation of historic properties which are owned or controlled by such agency. Prior to any Federal undertaking which may directly and adversely affect any National Historic Landmark, the head of the responsible agency shall, to the extent possible, minimize the harm to such landmark.	Applicable	See above remark.

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		FLOODPLAINS/WETLANDS PROTECTION		
Procedure for Implementing the National Environmental Policy Act 40 CFR §6.302(a) [Executive Order 11990]	Protection of Wetlands	Federal agencies conducting certain activities must avoid, to the extent possible, the adverse impacts associated with the destruction or loss of wetlands and to avoid support of new construction in wetlands when a practicable alternative exists.	Applicable	An updated site-wide delineation of Fernald wetlands, performed in accordance with the U.S. Army Corps of Engineers Wetland Delineation Manual, was completed in March 1993. While no wetlands were located in Operable Unit 2, some nearby wetlands may be effected during the Operable Unit 2 remedial action.
Procedures for Implementing the National Environmental Policy Act 40 CFR §6.302(b) [Executive Order 11988]	Floodplain Management	Federal agencies must evaluate the potential effects of actions they may take in a floodplain to avoid, to the extent possible, adverse effects associated with direct and indirect development of a floodplain.	Applicable	An updated floodplain determination was performed for Paddys Run in October 1993 using the Army Corps of Engineers' standard HEC2 water surface profile analysis program. The 100-year flood elevations reach the western slope of the Inactive Flyash Pile and the toe of the South Field slope.
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.3(a), (b)(1),(2),(3),(5),(6),(c), (d);(e)	Floodplain/Wetlands	DOE shall exercise leadership and take action to: • avoid to the extent possible the long- and short-term adverse impacts associated with the destruction of wetlands and the occupancy and modification of floodplains and wetlands, and avoid direct and indirect support of floodplain and wetlands development wherever there is a practicable alternative. • incorporate floodplain management goals and wetlands protection considerations into its planning, regulatory, and decision-making processes and shall to the extent practicable: - reduce the hazard and risk of flood loss. - minimize the impact of floods on human safety, health, and welfare.	Applicable	

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		FLOODPLAINS/WETLANDS PROTECTION (continued)		
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.3(a),(b)(1),(2),(3),(5),(6),(c),(d),(e) (continued)	Floodplain/Wetlands	- restore and preserve natural and beneficial values served by the floodplains. - minimize the destruction, loss, or degradation of wetlands. - preserve and enhance the natural and beneficial values of wetlands • undertake a careful evaluation of the potential effects of any DOE action taken in a floodplain and any new construction undertaken by DOE in wetlands not located in a floodplain • identify, evaluate, and as appropriate, implement alternative actions which may avoid or mitigate adverse floodplain/wetlands impacts • provide opportunity for early public review of any plans or proposals for actions in floodplains and new construction in wetlands	Applicable	
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.5(b),(h)	Floodplain/Wetlands	This part shall apply to all proposed floodplain/wetlands actions, including those sponsored jointly with other agencies, where practicable alternatives to the proposed actions are still available. The policies and procedures of this part which are applicable to floodplain actions shall apply to all proposed actions which occur in a wetlands located in a floodplain.	Applicable	
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.11(a),(b),(c)	Floodplain/Wetlands	Concurrent with its review of a proposed action to determine appropriate NEPA requirements, DOE shall determine applicability of the floodplain management and wetlands protection requirements of this part.	Applicable	

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		FLOODPLAINS/WETLANDS (continued)		
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.11(a),(b),(c) (continued)	Floodplain/Wetlands	In making a floodplain determination, DOE shall utilize the Flood Insurance Rate Maps (FIRMs) or the Flood Hazard Boundary Maps (FHBMs) prepared by the Federal Insurance Administration of the Department of Housing and Urban Development to determine if a proposed action is located in the base or critical action floodplain, as appropriate. For a proposed action in an area of predominantly Federal or State land holdings where FIRM or FHBM maps are not available, information shall be sought from the land administering agency (e.g., Bureau of Land Management, Soil Conservation Service, etc.) or from agencies with floodplain analysis expertise.	Applicable	
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.12(a)	Floodplain/Wetlands	If DOE determines, pursuant to 10 CFR §§ 1022.5 and 1022.11, that this part is applicable to the proposed action, DOE shall prepare a floodplain/wetlands assessment, according to the requirements in this section (10 CFR §1022.12).	Applicable	
DOE Compliance with Floodplain/Wetlands Environmental Review Requirements 10 CFR §1022.15(a)	Floodplain/Wetlands	If DOE finds that no practicable alternative to locating in the floodplain/wetlands is available, consistent with the policy set forth in Executive Order 11988, DOE shall, prior to taking action, design, or modify its action in order to minimize potential harm to or within the floodplain/wetlands.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (A)(3)	Floodway	A solid waste disposal facility may not be located in a floodway.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(10)	Floodplain	The limits of solid waste placement and the leachate management system cannot be located in a regulatory floodplain, unless deemed acceptable by the Director.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(14)	Stream, Lake, or Wetland	The limits of waste placement cannot be located within 200 feet of a stream, lake, or natural wetland, unless deemed acceptable by the Director.	Applicable	

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		GROUNDWATER PROTECTION		
Safe Drinking Water Act 42 U.S.C. §1424(e)	Sole Source Aquifer	All Federal financially assisted projects constructed in the area of a sole source aquifer and its principal recharge zone will be subject to EPA's review to insure that these projects are designed and constructed so that they do not create a significant hazard to public health.	Applicable	A notice in 53 FR 15876 (May 4, 1988) designated the Buried Valley Aquifer System of the Great Miami/ Little Miami River Basins of southwestern Ohio as a sole or principal source of drinking water. The Fernald site is located above this aquifer.
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(4)	Any	A sanitary landfill facility may not be located within the surface and subsurface areas surrounding a public water supply well through which contaminants may move toward and may reach the public water supply well within a period of 5 years.	Applicable	
OEPA Guidance on Solid Waste Siting Criteria: Minimum Distance From a Public Water Supply Well GD202.105	Any	To avoid the application of the siting criteria in OAC 3745-27-07 (B)(4): • It should be shown, using site-specific and publicly available information, that the nearest public water supply well hydrogeologically downgradient from the solid waste landfill facility is more than 5 years time of travel from the boundaries of the solid waste landfill facility. • The five year time of travel shall be calculated beginning at the facility boundary of the solid waste landfill facility closest to the public water supply well and proceeding in a hydraulically downgradient direction ending at the well screen of all public water supply wells intersected with the five year time of travel. • Many methods can be used to demonstrate compliance with this rule, from simple groundwater velocity equations to complex three-dimensional models. The demonstration should use the method best suited to the site-specific situation.	TBC	

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TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		GROUNDWATER PROTECTION (continued)		
OEPA Guidance on Solid Waste Siting Criteria: Minimum Distance From a Public Water Supply Well GD202.105 (continued)	Any	• To be considered for an exemption from this rule, the following will need to be demonstrated: - that there is at least 50 feet of separation between the bottom of the solid waste landfill facility liner and the aquifer system in which the public water supply well is screened. - that any release of leachate shall be detected prior to reaching the aquifer system in which the public water supply well is screened. - that once leachate is released below the liner, the leachate shall not reach the aquifer system in which the public water supply well is screened within a time span of 100 years plus the anticipated life of the solid waste landfill facility which shall include the 30 year post-closure care period.	TBC	
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(5)	Any	A sanitary landfill facility cannot be located above an aquifer declared by the federal government under the Safe Drinking Water Act to be a sole source aquifer.	Applicable	
OEPA Guidance on Solid Waste Siting Criteria: Sole Source Aquifer GD202.101	Exemption	The Director may grant an exemption to the prohibition of siting a sanitary landfill facility over a sole source aquifer (OAC 3745-27-07 (B)(5)) under ORC 3734.02 (G). In order to grant an exemption, the Director needs to determine that no adverse impact to human health or safety or the environment will occur due to granting the exemption. The decision to grant an exemption from this rule is made on a site by site basis. Among the items that should be considered when determining if a waiver will be granted are whether a significant thickness of low permeable material exists between the sanitary landfill facility liner and the sole source aquifer and whether there is an inter-connection between the sole source aquifer and any significant saturated zones which exist above the sole source aquifer.	TBC	

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		GROUNDWATER PROTECTION (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(9)	Any	A sanitary landfill facility cannot be located above an unconsolidated aquifer capable of sustaining a yield of 100 gallons per minute for a 24-hour period to a water supply well located within 1,000 feet of the limits of solid waste placement, unless deemed acceptable by the Director.	Applicable	
OEPA Guidance on Solid Waste Siting Criteria: 100 Gallon Per Minute Aquifer GD202.102	Exemption	An exemption to the prohibition of siting a sanitary landfill facility over an unconsolidated aquifer capable of sustaining a yield of 100 gallons per minute for a 24-hour period (OAC 3745-27-07 (B)(9)) may be obtained by demonstrating that the thickness and lack of permeability of the sediment that exists between the bottom of the proposed sanitary landfill facility liner and the top of the unconsolidated high yield aquifer provide adequate protection to the unconsolidated high yield aquifer from the effects of a release of leachate from the sanitary landfill facility. The sediment should prevent leachate from migrating from the bottom of the sanitary landfill facility liner to the high yield aquifer in a time period equal to the active life of the facility including the post-closure care period.	TBC	
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(11)	Water Supply Well or Developed Spring	The limits of sold waste placement cannot be located within 1,000 feet of a water supply well or developed spring unless it is deemed acceptable by the Director or it is: • controlled by the applicant, is needed as a source of nonpotable water, no other reasonable alternate water source is available, and the well is constructed to prevent contamination of the groundwater, OR • located at least 500 feet hydrogeologically upgradient from the limits of solid waste placement, OR • separated from the limits of solid waste placement by a hydrogeologic barrier, OR	Applicable	

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		GROUNDWATER PROTECTION (continued)		
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(11) (continued)	Water Supply Well or Developed Spring	• constructed and used solely for monitoring groundwater quality	Applicable	
OEPA Guidance on Solid Waste Siting Criteria: Minimum Isolation Distances to Wells and Developed Springs GD202.103	Any	This guidance clarifies when exceptions to the required 1,000 foot isolation distance from water supply wells and developed springs (OAC 3745-27-07 (B)(11)) apply and when a situation contrary to the rule can be deemed acceptable to the Director.	TBC	
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(15)	Any	The isolation distance between the uppermost aquifer system and the bottom of the recompacted soil liner of a sanitary landfill system cannot be less than 15 feet of in situ or added geologic material deemed acceptable by the Director.	Applicable	
OEPA Guidance on Solid Waste Siting Criteria: Material Acceptable to the Director GD202.104	Any	For geologic material to be deemed acceptable to the Director as added fill under OAC Rule 3745-27-07 (B)(15), it must be able to meet the following criteria: • the geologic material must be impermeable enough so it will not store, transmit or yield a significant amount of water to a well or spring • the geologic material must be able to impede both physically and chemically, the flow of leachate constituents through it In order to meet both criteria listed above, the added geologic material should: • be classified as CL, SC, GC, CL-ML, or CH under the Unified Soil Classification System (USCS) • be composed of particles of which at least 25% by dry weight will pass through a No. 200 (75 μm) sieve • be composed of no more than 25% by dry weight particles which will not pass through a No. 4 sieve	TBC	

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		GROUNDWATER PROTECTION (continued)		
OEPA Guidance on Solid Waste Siting Criteria: Material Acceptable to the Director GD202.104 (continued)	Any	• no particle should be greater than 8 inches in diameter • have a final permeability of no more than $1x10^{-8}$ cm/sec • be recompacted in a manner that when the landfill is constructed on it, no damage to the landfill liner will occur due to settling of the added material	TBC	
Design Criteria: Disposal of Non-toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes OEPA Policy 4.07	Any	A facility for non-toxic fly ash disposal shall not normally be sited within the surface and subsurface areas surrounding the wellhead of a public well field through which contaminants are likely to move toward and may reach the wellhead within a period of five years. A facility for non-toxic fly ash disposal shall not normally be located above a federally declared sole source aquifer. A facility for non-toxic fly ash disposal shall not normally be located over an unconsolidated aquifer capable of yielding greater than 100 gallons per minute to a well within 1,000 feet of the limits of waste placement The isolation distance between the uppermost aquifer and the bottom of the liner of an ash disposal facility shall be no less than 5 feet of in situ or added geological material acceptable to the Director and shall not exceed a maximum permeability of 1×10^{-5} cm/sec.	TBC	
Design Criteria: Disposal of Non-toxic Flyash, Bottom Ash, Foundry Sand, and Other Exempted Solid Wastes OEPA Policy 4.07	Exemption	The identified pollution control measures for siting criteria and liner design (also see action-specific requirements) should be considered and evaluated for the disposal site. Supporting documentation and evidence must be submitted if the identified measures are not proposed to be utilized for pollution control.	TBC	

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TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
OTHER SOLID WASTE SITING CRITERIA				
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(12)	Any	The limits of waste placement cannot be located within 300 feet of the sanitary landfill facility's property line, unless deemed acceptable by the Director.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-07 (B)(13)	Any	The limits of solid waste placement cannot be located within 1,000 feet of a domicile whose owner has not consented in writing to the location of the sanitary landfill facility.	Applicable	
Ohio Solid Waste Disposal Regulations OAC 3745-27-09(Y)	Exemption from Siting Criteria	Section 3745-27-09 (Y) states the permittee shall submit to the Director, upon every tenth anniversary of the effective date of a permit to install that approved the initial construction of the facility, an analysis demonstrating that the design, construction and final closure plan of the sanitary landfill facility continue to constitute best available technology. If the Director determines that the design is no longer consistent with best available technology as being applied to the sanitary landfill industry in the state of Ohio, the permittee may be required to submit a permit to install application for necessary modifications to the landfill facilities. If a permit to install is required, the Director shall not apply the siting criteria outlined in paragraph (B) of OAC 3745-27-07, when considering the permit to install application.	Applicable	
RADIOLOGICAL SITING CRITERIA				
Radioactive Waste Management DOE Order 5820.2A Chapter III (7)	Disposal Site Selection	Disposal site selection criteria (based on planned waste confinement technology) shall be developed for establishing new low-level waste disposal sites. Disposal site selection shall be based on an evaluation of the prospective site in conjunction with planned waste confinement technology, and in accordance with the National Environmental Policy Act process.	TBC	

TABLE B-5
(Continued)

Citation	Location	Requirement	Determination	Remarks
		RADIOLOGICAL SITING CRITERIA		
Radioactive Waste Management DOE Order 5820.2A Chapter III (7) (continued)	Disposal Site Selection	Site selection shall also be based on the following criteria: • The disposal site shall have hydrogeologic characteristics which, in conjunction with the planned waste confinement technology, will protect the groundwater resource. • The potential for natural hazards such as floods, erosion, tornadoes, earthquakes, and volcanoes shall be considered in site selection. • Site selection criteria shall address the impact on current and projected populations, land use resources development plans and nearby public facilities, accessibility to transportation routes and utilities, and the location of waste generation.	TBC	
Joint NRC-EPA Guidance on Siting of Mixed Low-Level Radioactive and Hazardous Waste Units (March 13, 1987)	Any	Areas with highly vulnerable hydrogeology deserve special attention in the siting of a mixed low-level waste disposal facility. Hydrogeology is considered vulnerable when groundwater travel time along any 100-foot flow path from the edge of the engineered containment structure in less than approximately 100 years. Disposal sites located in areas of vulnerable hydrogeology may require extensive, site-specific investigations which could lead to and provide bases for restrictions or modifications to design or operating practices. However, a finding that a site is located in an area of vulnerable hydrogeology alone, based on the EPA criteria, is not considered sufficient to prohibit siting under RCRA.	TBC	

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TABLE B-6
NON-ARAR REQUIREMENTS

Citation	Action	Requirement
OSHA Worker Protection Requirements 29 CFR §§ 1904 and 1910	Worker Safety	These regulations establish requirements to protect workers who could be exposed to radiation, noise, hazardous wastes, or other contaminants or hazards at the remediation site.
DOT Requirements for Transportation of Hazardous Materials 49 CFR §§ 171-173 and 177-179	Transportation of Wastes Off Site	No one may transport hazardous materials on public highways except in accordance with these regulations: • Part 171 - General requirements for transporting hazardous materials. • Part 172 - This part establishes shipping papers, marking, labeling, placarding, and emergency response information requirements. • Part 173 - This part establishes packaging and other shipping requirements for hazardous materials, including radioactive materials. • Part 177 - This part establishes requirements for the transporter. • Part 178 - This part establishes specifications for shipping containers. • Part 179 - This part establishes specifications for tanks cars.
Highway Improvement Act of 1982 23 U.S.C. §127	Transportation of Wastes Off Site	Establishes vehicle weight limits for interstate highways.
Resource, Conservation, and Recovery Act 40 CFR §262.20	Transportation of Hazardous Waste	A generator who transports, or offers for transportation, hazardous waste for off-site treatment, storage, or disposal must prepare a Manifest OMB control number 2050-0039 on EPA form 8700-22, and, if necessary, EPA form 8700-22A, according to the instructions included in the Appendix to Part 262.
Resource, Conservation, and Recovery Act 40 CFR §§ 262.30 - 262.33	Transportation of Hazardous Waste	Before transporting hazardous waste or offering hazardous waste for transportation off site, a generator must package, label, mark, and placard the waste in accordance with §§ 172, 173, 178, and 179 of the Department of Transportation regulations listed above (49 CFR).
Resource, Conservation, and Recovery Act 40 CFR § 262.34	Hazardous Waste Accumulation Time	A generator may accumulate hazardous waste on-site for 90 days or less without a permit or without having interim status, provided that it is stored according to the requirements of this section. A generator who accumulates hazardous waste for more than 90 days is an operator of a storage facility and is subject to the requirements of 40 CFR Parts 264 and 265 and the permit requirements of 40 CFR Part 270 unless he has been granted an extension to the 90-day period. Such extension may be granted by EPA is hazardous wastes must remain on-site for longer than 90 days due to unforeseen, temporary, and uncontrollable circumstances.
Resource, Conservation, and Recovery Act 40 CFR §263	Transportation of Hazardous Waste	Persons transporting hazardous waste within the United States must comply with the regulations of this part, including manifest requirements and management of accidental hazardous waste discharges.

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(Continued)

Citation	Action	Requirement
Nevada Test Site (NTS) Waste Acceptance Criteria, Certification, and Transfer Requirements	Disposal of Waste at NTS	Establishes the wastes that the facility will accept for disposal.
Native American Graves Protection and Repatriation Act 25 U.S.C. §3001	Protection of American Indian Grave Sites	Provides for return of human remains and cultural objects from Native American graves to affiliated tribes.
Fish and Wildlife Coordination Act 16 U.S.C. §66, *et sec.*	Protection of Fish and Wildlife	Requires consultation with state agencies for the purpose of conserving fish and wildlife resources when conducting activities that might affect any body of water.
Farmland Protection Policy Act 7 U.S.C. §4201, *et sec.*	Protection of Prime Agricultural Soils	Requires protection and maintenance of farmland for its beneficial use as national resource.
DOE Order 1540.1	Contractual obligation for activities at DOE facilities	Materials Transportation and Traffic Management
DOE Order 5440.1E	Contractual obligation for activities at DOE facilities	NEPA Compliance Program
DOE Order 5480.1B	Contractual obligation for activities at DOE facilities	Environmental, Safety, and Health Program for DOE Operations
DOE Order 5480.4	Contractual obligation for activities at DOE facilities	Environmental Protection, Safety, and Health Protection Standards
10 CFR §835 DOE Order 5480.11	Contractual obligation for activities at DOE facilities	Radiation Protection for Occupational Workers
DOE Order 5483.1A	Contractual obligation for activities at DOE facilities	Occupational Safety and Health Programs for DOE Employees at Government-Owned, Contractor-Operated Facilities
DOE Order 5700.6C	Contractual obligation for activities at DOE facilities	Quality Assurance

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Appendix C

Risk Evaluation for Remedial Alternatives Under Consideration for Operable Unit 2 at the Fernald Environmental Management Project in Fernald, Ohio

Prepared by
Jacobs Engineering Group
April 29, 1994

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ACRONYM LIST

a	Adult (in exposure parameter tables)
ABS	Adsorption factor
ACGIH	American Conference of Government Industrial Hygienists
AF	Skin adherence factor
AFP	Active Flyash Pile
ARAR	Applicable or Relevant and Appropriate
ASV	Alternative-Specific Values
AT	Averaging time
ATDSR	Agency for Toxic Substances and Disease Registry
BEIR	Biological Effects of Ionizing Radiation
BW	Body weight
°C	degrees Celsius
CEDE	Committed Effective Dose Equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CF	Conversion Factor
CFR	Code of Federal Regulations
CH	Chlorinated Hydrocarbons
Ci	Curie
CIS	Characterization Investigation Study
cm	Centimeter
CNS	Central Nervous System
CLP	Contract Laboratory Program
COC	Contaminant of Concern
cpm	counts per minute
CRARE	Comprehensive Response Action Risk Evaluation
CRU2	CERCLA/RCRA Unit 2
CSM	Conceptual Site Model
CSV	Chemical-Specific Values
CT	Central Tendency
Cu	Copper
DOE	United States Department of Energy
DOE-FN	United States Department of Energy - Fernald Field Office
dpm	disintegrations per minute
DQO	data quality objective
DVS	Data Validation Support
ECAO	Environmental Criteria and Assessment Office
ED	Exposure duration
EF	Exposure frequency
EPA	United States Environmental Protection Agency
Fe	Iron
FEMP	Fernald Environmental Management Project
FERMCO	Fernald Environmental Restoration Management Company
FI	Fraction ingested
FS	Feasibility Study
ft.	foot, feet
µg/L	microgram/liter
g	gram
gal	gallon
GI	Gastrointestinal
HCl	Hydrochloric Acid
HEAST	Health Effects Assessment Summary Tables

HI	Hazard Indices
HQ	Hazard Quotient
I	Intake
IARC	International Agency for Research on Cancer
ICRP	International Commission on Radiological Protection
IFP	Inactive Flyash Pile
ILCR	Incremental Lifetime Cancer Risk
in.	inch(es)
IR	Ingestion rate
IRIS	Integrated Risk Information System
ISCLT2	Industrial Source Complex Long-Term dispersion model
Kg	Kilogram
L	liter
lb	pound
LSP	Lime Sludge Ponds
LLW	Low-Level Waste
LOAEL	lowest observed adverse effect level
LSP	Lime Sludge Ponds
m	meter
mg	milligram
mi	mile
mL	milliliter
Mn	Manganese
MSL	Mean sea level
mtu	metric tons uranium
MUSLE	Modified Universal Soil Loss Equation
NaOH	Sodium Hydroxide
NCP	National Contingency Plan
NOAEL	No observed adverse effect level
NOEL	No observed effect level
NRC	Nuclear Regulatory Commission
OAC	Ohio Administrative Code
oc	Older child (in Exposure Parameter Table)
OEPA	Ohio Environmental Protection Agency
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
OU 1	Operable Unit 1
OU 2	Operable Unit 2
OVA	Organic Vapor Analyzer
PCB	Polychlorinated Biphenyl
pCi/g	picocuries per gram
ppb	parts per billion
PPE	Personal Protective Equipment
PAH	Polynuclear Aromatic Hydrocarbons
PRG	Preliminary Remediation Goals
PRLs	Proposed Remediation
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RAWPA	Risk Assessment Work Plan Addendum
RCRA	Resource Conservation and Recovery Act
RfC	Reference Concentration
RfD	Reference Dose
RI	Remedial Investigation

RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
RME	Reasonable Maximum Exposure
Rn	Radon
SAS	Statistical Analysis Software
SF	South Field
SF(e)	External Radiation Slope Factor
SF(i)	Inhalation Slope Factor
SF(o)	Oral Slope Factor
SVOC	Semi-Volatile Organic Compound
SWL	Solid Waste Landfill
TCLP	Toxicity Characteristics Leaching Procedure
TEF	Toxicity Equivalency Factor
TF	Toxicity Factor
TLD	Thermoluminescent Dosimeter
TLV	Threshold Limit Value
TOC	Total Organic Carbon
TOX	Total Organic Halogen
TPH	Total Petroleum Hydrocarbon
TSS	Total Suspended Solids
TWA	Time weighted average
U	Uranium
UBK	Uptake/Biokinetic
UCL	Upper Confidence Limit
USDA	United States Department of Agriculture
UF	Uncertainty factor
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
WRS	Wilcoxon Rank Sum
yc	young child (used in Exposure Parameter tables)
yr	year
Zn	Zinc

C.1.0 INTRODUCTION

C.1.1 OBJECTIVE AND SCOPE

The five subunits comprising Operable Unit 2 (the Active Flyash Pile, the South Field, the Inactive Flyash Pile, the Solid Waste Landfill, and the Lime Sludge Ponds) were determined to be associated with potentially unacceptable levels of risk to human health during the Baseline Risk Assessment completed as part of the Remedial Investigation (RI) (DOE 1993a). Consequently the development and evaluation of remedial alternatives is required. This appendix summarizes the baseline risk at each subunit on the site and includes lists of radionuclides and other contaminants of concern (COCs) contributing to risk. The information in the Baseline Risk Assessment establishes the "baseline" risk associated with each subunit against which residual risk remaining after implementation of remedial alternatives are evaluated.

The objective of the risk evaluation presented in this appendix is to support the feasibility study in screening and evaluating remedial alternatives by determining each alternatives' ability to reduce or mitigate risk to human health resulting from COCs identified in the RI by determining each alternatives ability to maintain long-term protectiveness; and, by determining the risk associated with implementation of the remedial alternatives themselves, due to exposure to COCs, construction, and transportation. This risk evaluation is intended to obtain and present this information so that decisionmakers can select the most appropriate remedial alternatives from a list of potential alternatives on the basis of long-term and short-term effectiveness in mitigating risk.

The scope of this risk evaluation includes all five OU2 subunits. Since independent sets of alternatives were identified for each subunit, this risk evaluation independently evaluates alternatives for each subunit.

C.1.2 THE ALTERNATIVE EVALUATION PROCESS

The selection of the most appropriate remedial alternative for a contaminated site involves evaluating alternatives against nine evaluation criteria. These nine evaluation criteria are listed in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) at 40 CFR 300.430, Remedial Investigations/Feasibility Study (FS) and Selection of Remedy. Of the nine evaluation criteria, two are considered threshold criteria. Overall protection of human health and the environment, and compliance with Applicable or Relevant and Appropriate Requirements (ARAR) are threshold criteria that each remedial alternative must meet in order to be eligible for selection. The five primary balancing criteria include long-term effectiveness and permanence; reduction of toxicity, mobility, or volume through treatment; short-term effectiveness; implementability; and cost. The last two criteria, state acceptance and community acceptance, are modifying criteria that must be considered in the remedy selection process.

The evaluation of the threshold criteria for overall protection of human health and the environment relies on an evaluation of risk, as does the evaluation of the primary balancing criteria of long-term effectiveness and permanence and short-term effectiveness. The evaluation of long-term effectiveness ordinarily takes into consideration the magnitude of residual risk remaining from untreated waste or treatment residuals remaining at the conclusion of remedial activities. Long-term effectiveness evaluation also includes an evaluation of the alternatives' ability to maintain protection over time and risks posed should the remedial alternative need to be replaced. An evaluation of short-term effectiveness ordinarily involves an evaluation of new risks that might be posed to the community (nearby populations) during implementation of an alternative and the potential impacts on workers during remedial action and the effectiveness and reliability of the protective measures. Thus, the detailed analyses of the alternatives under consideration in this FS include risk evaluations intended to 1) demonstrate the degree to which alternatives meet their intended function of mitigating long-term risk to human health (and the environment); and, 2) the degree to which implementation of alternatives is associated with short-term risk.

Remedial alternatives for subunits within Operable Unit 2 are described in detail in Section 2.0 of the FS report.

C.1.3 ORGANIZATION OF THIS APPENDIX

Operable Unit 2 consists of five subunits. The RI and Baseline Risk Assessment characterized and assessed risks independently for each subunit in order to facilitate subunit-specific remedial decisions. This previous process is the basis for the organization of the FS. An independent set of remedial alternatives is developed in the FS for each subunit. The risk evaluation of the remedial alternatives presented in this appendix provides a subunit-by-subunit evaluation of the specific alternatives developed for each subunit.

The general methodology used in the risk evaluation of the remedial alternatives for all subunits is presented first, in Section C.2.0. Section C.2.1 contains a discussion of the remedial action objectives and the general types of alternatives under consideration. Section 2.2 describes the methodology used to determine short-term risks that may exist when alternatives are implemented. This includes a discussion of how workers are protected during remedial alternative implementation; a discussion of the methodology used to assess risks due to construction and transportation activities; and a description of the methodology used to assess short-term risks due to the presence of COCs in remediated media. Section 2.3 describes the methodology used to determine residual risks and overall protectiveness associated with alternatives.

Section 2.0 is followed by the specific results of the application of the risk evaluation methodology to the alternatives for each of the subunits in Sections C.3.0 through C.7.0. The risk evaluation for each subunit contains the following sections:

- A summary of results of the Baseline Risk Assessment for that subunit;
- A description of the remedial alternatives under consideration for that subunit;
- A discussion of the short-term risks associated with the alternatives under consideration; and,

- An evaluation of long-term effectiveness of the alternatives under consideration.

Finally, the ability of the on-site disposal cell to mitigate risk to identified receptors based on uranium isotope leachate activity is evaluated in Section 8.0.

C.2.0 METHODOLOGY

The overall objective of the risk evaluation of remedial alternatives is to determine the short-term and long-term human health risks associated with a remedial alternative. Evaluation of short-term human health risks involves evaluating any new risks that might occur while implementing the remedy. This includes risks to both neighboring populations and to on-site workers. Evaluation of the long-term human health risks involves evaluating residual risk (risk that remains at the completion of the remedial action), as well as long-term protectiveness (the alternatives' ability to maintain protection over time). This section describes the general methodology used to estimate short-term and residual risks associated with the remedial alternatives developed for each subunit, as well as the preferred alternatives' ability to maintain protectiveness over time.

Although the list of remedial alternatives and their characteristics is specific to each subunit, the general types of alternatives are similar across subunits. They all address the requirement to remediate soil/source material to which receptors may be directly exposed or which contain contaminants that can migrate to groundwater resulting in its unacceptable degradation. Important remedial action objectives are therefore 1) preventing direct contact with contaminated soil and 2) preventing the migration of contaminants to groundwater. These and other remedial action objectives and the potential remedial alternatives designed to achieve them are described in detail in Section 2.0 of the FS.

The remedial alternatives under consideration are very generally described in Section C.2.1. The description in Section C.2.1 focuses primarily on 1) a description of the activities associated with alternative implementation which contribute to short-term risk; and, 2) a description of the alternatives general overall protectiveness. Detailed descriptions of the specific alternatives associated with each subunit are described in greater detail in Sections C.3.0 through C.7.0.

Short-term and residual risks associated with the alternatives at each of the subunits are evaluated using similar general methodology. There are some differences, however, between assessment of short-term and long-term risk which are described separately in Section C.2.2.2 and C.2.2.3.

Risk evaluation methodologies are then applied to the evaluation of alternatives for each subunit in Sections C.3.0 through C.7.0. For each subunit, the following is presented:

1) A brief summary of the results of the subunit-specific baseline risk assessment;

2) A description of subunit-specific remedial alternatives;

3) An assessment of short-term risks associated with implementation of alternatives determined as described in Section C.2.2;

4) An assessment of residual risks remaining after implementation of alternatives determined as described in Sections C.2.2 and C.2.3; and,

5) An assessment of long-term effectiveness of remedial alternatives, where warranted, as described in Section C.2.4.

C.2.1 DESCRIPTION OF GENERAL REMEDIAL ALTERNATIVES

C.2.1.1 Remedial Action Objectives

Remedial Action Objectives (RAOs) are site-specific, qualitative goals that define the objective of taking remedial actions. Because RAOs for protecting environmental receptors typically seek to preserve or restore a resource (e.g., groundwater and surface soil), they are expressed in terms of the medium of interest and target cleanup levels

whenever possible. RAOs specify: the contaminants of concern; exposure route(s) and receptor(s); and acceptable contaminant levels or range of levels for each exposure route (i.e., a preliminary remedial goal, or PRG).

Potential risks associated with exposures due to Operable Unit 2 contamination were assessed in considerable detail in the Baseline Risk Assessment in the RI report for Operable Unit 2 (DOE 1993a) in order to identify media contributing to unacceptable levels of risk that should be addressed to achieve RAOs. From this assessment, contaminated media and COCs for Operable Unit 2 were identified. A summary of the conclusions of the Baseline Risk Assessment is presented in Section 1.7.3 of the FS report. In all cases, soil and waste material are the media requiring remediation. This is because in general, direct contact with surface soil and future migration of soil contaminants to groundwater were found to present risks exceeding the 1.0E-06 level. Risks due to current contamination of groundwater are beyond the scope of the Operable Unit 2 RI and are not addressed in either the Baseline Risk Assessment or this FS risk evaluation. Therefore, remedial action objectives for groundwater are not developed. Only remedial alternatives addressing solid and waste material are developed. The remedial alternatives considered for all subunits are similar in process and technologies in that they involve removal and/or treatment of soil/waste material and placement in either an on-site or off-site disposal cell.

In Section 2.0 of the FS the detailed development of RAOs is presented. Contaminants of concern are identified for all media for each subunit. Allowable exposures in terms of the environmental media of interest are identified and preliminary remediation goals (PRGs) for COCs are derived. PRGs are derived COC concentrations in environmental media that are associated with an acceptable level of risk. They can be viewed as preliminary cleanup criteria. Achieving PRGs is one RAO. Meeting this and other RAOs is the basis for the detailed development and evaluation of remedial alternatives especially in terms of the alternatives' ability to mitigate risk.

C.2.1.2 Development of Preliminary Remedial Goals (PRGs)

Preliminary remedial goals (PRGs) are specific, risk-based RAOs. PRGs are contaminant concentrations in environmental media associated with an acceptable level of risk to identified receptors. PRGs are chemical-specific,

medium-specific concentrations that address all contaminants and all pathways found to be of concern in the baseline risk assessment. In the early stages of the RI/FS, as stated in the SWCR (DOE 1993c), PRGs are used as action levels to determine if constituents in the environment need to be addressed in the FS. PRGs are not intended to be final action levels for remedial actions. Final action levels are developed from preliminary remedial levels (PRLs) which account for other, non-risk-based factors.

PRGs must comply with ARARs as well as be protective of human health. However, ARARs do not exist for all COCs. Moreover, some ARAR-based PRGs are less stringent than PRGs based on a 1.0E-06 to 1.OE-04 risk range and, therefore, do not necessarily meet the "protectiveness of human health" objective. Therefore, both ARAR-based and risk-based PRGs are considered during this stage of evaluation.

The development of PRGs is described in Section 2.0 of the FS report and briefly summarized below. A detailed description of the derivation process is discussed in Attachment III to this appendix. PRG Subunit specific PRGs are presented in Sections C.3.1, C.4.1, C.5.1, C.6.1 and C.7.1 for the Active Flyash Pile, South Field Inactive Flyash Pile, Solid Waste Landfill and Lime Sludge Ponds, respectively.

To develop risk-based PRGs, target risk levels are established for carcinogens, and target hazard quotients and target HIs (the sum of the target hazard quotients) are established for noncarcinogens. Once established, these target risk levels are used in calculating the PRGs. For carcinogens, EPA has identified, in the NCP, a target range for incremental risks of 1.0E-06 to 1.0E-04 to limit the possibility that an individual will develop cancer due to exposures to residual contaminants at an NPL site [40 Code of Federal Regulations (CFR) 300]. As part of cleanup at NPL sites, EPA strives to manage possible incremental cancer risks within the target range with 1.0E-06 generally serving as the point of departure. For sites where the total estimated ILCR for each receptor is less than 1.0E-04, action may not be warranted. However, the total incremental risk should be less than 1.0E-04 after remediation. Hence, at the FEMP site PRGs are calculated assuming 1.0E-06 is the acceptable carcinogenic risk level. Noncarcinogenic PRGs are based on an acceptable hazard index of 0.2.

The Baseline Risk Assessment in the RI Report presented risk information for a range of receptors under current and future land use scenarios. PRGs are calculated for three of the future receptors: the future on-property farmer; the future off-property farmer; and, the future expanded trespasser.

The most severely impacted potential receptor identified in the Baseline Risk Assessment for Operable Unit 2 was the future on-property farmer who was assumed to possibly reside on either the South Field or Solid Waste Landfill if the facility became privately held. For PRG development, the on-property resident farmer was assumed to be exposed to COCs in the soil via the inhalation of dusts, consumption of farm products contaminated by dust deposition, oral ingestion of soil, dermal contact, and external radiation pathways associated with the soils. Additionally, the on-property resident farmer was assumed to be exposed to COCs in groundwater through ingestion. These are the same pathways of exposure used in the baseline risk assessment for this receptor.

In addition to the future on-property farm land use scenario, the federal government would retain ownership to preclude further development (including the establishment of residential or farming units). This future land use scenario, termed Future Land Use With Continued Federal Ownership, where the land use is a government reserve, does not assume any form of perpetual maintenance or active access restrictions to the site following the completion of remedial actions and attainment of site-wide remedial goals. It is assumed that the site will be fenced, and "No Trespassing" and "No Hunting" signs will be posted.

An on-property receptor was employed assuming a trespassing type exposure which includes both adult and child/youth age groups for the future land use with continued federal ownership scenario. The frequency of exposure was expanded to account for the lack of access controls. The expanded trespassing type scenario was employed because it represents an upper bound estimate of the exposures a receptor could reasonably be expected to receive under the assumption that the federal government continues to exercise its rights of ownership to preclude site development for residential use, farming use, industrial/commercial use, and recreational use (i.e., ball fields, jogging trails, biking trails, etc.). The expanded trespasser receptor is an individual who visits the property during childhood then visits during adulthood, perhaps for roaming, hiking, bird watching, or similar activities. Due to the size of the

site, fencing, and signs indicating "No Trespassing" and "No Hunting", it is assumed that hunting is not a likely activity. The expanded trespasser is assumed to be exposed to soil contaminants via oral ingestion, dermal contact, inhalation of dusts, and external radiation pathways. Groundwater PRGs were not developed for the expanded trespasser since there were no viable pathways of exposure.

Finally, PRGs for an off-property farmer were developed. This receptor was selected as a receptor under either the Future Land Use With and Without Continued Federal Ownership scenarios. The off-property farmer is assumed to be exposed to soils within the Operable Unit 2 area through the inhalation of re-suspended dust containing COCs and the consumption of farm products (i.e., milk, meat, and vegetables) contaminated by dust deposition.

C.2.1.3 General Alternatives

In order to evaluate the short term risks associated with alternatives, the activities involved in their implementation need to be described.

C.2.1.2.1 Subunit Alternatives

U-238 is the most important COC requiring remediation at subunits within Operable Unit 2 since it is the COC most often associated with unacceptable risks due to its presence in soil and its potential migration to groundwater. All of the alternatives evaluated involve some degree of removal and/or treatment of contaminated material to ensure the remaining material does not exceed the soil PRGs for U-238. Soil PRGs are derived in order to be protective of the on-property RME farmer, the expanded trespasser and the off-property farmer.

The technical approach for analysis of subunit alternatives involves breaking implementation of each alternative into a sequence of general tasks. The general alternatives for each subunit are described in Section 4.0 of the FS Report. This highlights tasks anticipated to significantly contribute to COC short-term risks, and to transportation and construction risk. This information is organized in one table per alternative which is included in Attachment I of

this appendix. For each task, the potential for exposure to contaminants was noted. This information was used to define which tasks would result solely in a transportation or construction risk or in both COC risks and transportation/construction risk for remedial workers.

Following division of each alternative into tasks, the following parameters were estimated for use in later risk calculations: the duration of each task in days, total crew, total crew labor hours, average labor hours per person, and the maximum anticipated exposures in terms of hours/day/person. Next, volumes of material to be excavated and transported by truck or by rail and the associated haul distances were estimated for each task to provide inputs for quantifying transportation risk. The volume of material to be transported was calculated by multiplying the average bulking factor (determined through laboratory tests) for the material being excavated by the in place volume estimated to be above the soil PRG. For off-site disposal of noncontaminated flyash alternatives, the distance from the site to the off-site disposal area was assumed to be 25 miles. For those alternatives involving stockpiling, an in-situ cap, or soil treatment, the distance from the excavation area to the on-site stockpile, in situ cap area, and treatment area was measured on a site-specific basis. If material required transportation/relocation, a minimum traveled distance of one mile was used in calculations. For alternatives involving off-site low level radioactive waste soil disposal of contaminated material at the Nevada Test Site (NTS), a combination of trucking and rail transport was assumed. It was assumed that the rail distance would be 2212 miles and that the truck distance would be 111 miles for each one-way trip. The trucking distance was assumed to allow for transport from the rail off-loading center to the NTS. For alternatives requiring off-site disposal at the NTS of less than one railcar, the material is assumed to be transported by truck.

For each task involving excavation and transportation of contaminated material, the number of trucks required for transporting the material was then calculated. This step consisted of first multiplying the volume of material to be transported (in cubic feet) by the average density (pounds per cubic feet- based on laboratory data) and dividing this value (pounds) by the capacity of an average truck, assumed to be 20 cubic yards per truck. The number of trucks was then multiplied by the one-way transport distance to estimate the cumulative one-way transport distance corresponding to all truckloads of the excavated material. This is the standard unit used in evaluating transportation

physical hazards. The same methodology was used for estimating rail-related transportation risk. In this case, 10 rail cars (gondolas), each with a capacity of 70 tons, were assumed to comprise one standard (nonexclusive) rail volume unit.

C.2.1.2.2 On-site Disposal Cell for all Subunits.

The preferred alternative for all subunits involves placement of contaminated material in a common on-site disposal cell. This on-site disposal facility would be constructed in the southeast corner of the FEMP site, east of the site access road. The contaminated material exceeding the PRGs from Operable Unit 2 would be consolidated and disposed in this facility. This facility would include a liner system, leachate collection and treatment system, and a capping system. This facility would be constructed in accordance with applicable federal, state and local ARARs and DOE guidelines. The design life and expected effective life would be 200 and 1,000 years, respectively. Additional information on this facility is provided in Section 5.2.3.

Aquifer modeling was performed for the purpose of assessing the long-term protectiveness of this alternative. concentrations of U-234, U-235/236 and U-238 in saturated groundwater immediately below the disposal cell and at the downgradient FEMP fenceline were estimated.

The model selected to evaluate groundwater flow is ODAST (Javendel et al. 1984), a one-dimensional analytical solution, used for determining fate and transport and transport of the selected radionuclides. The computer code calculates the normalized concentrations of a given constituent in a uniform flow field from a source having a varying or constant concentration. ODAST evaluates the basic one-dimensional analytical solute transport equation as a function of seepage velocity, dispersion coefficient, source decay, retardation factor, depletion time and source rate. For this modeling run, contaminant loading was estimated based on the assumption that the clay liner and cap remains intact, but that the leachate collection system fails at time zero.

Groundwater concentrations were estimated using the HELP model (U.S. EPA, 1984). The HELP model is a quasi-two-dimensional hydrologic model of water movement across, into, through and out of a waste unit. The model accepts climatologic, soil and design data and simulates a number of hydraulic processes.

For the on-site disposal cells, the HELP model was used to simulate infiltration through the disposal facility cap, based on the soil characteristics, local precipitation and weather data. The model was run to "steady state", that is until successive simulations showed no appreciable change in soil moisture.

In order to evaluate long-term risks the ability of the alternatives to meet specified PRGs was assumed.

C.2.2 Human Health Risk Evaluation

In evaluating the effectiveness of the remedial alternatives, two types of human health risk are examined; short-term and long-term. Short-term human health risks associated with a remedial alternative are those occurring during implementation of the alternative. Long-term human health risks are those risks that will remain after the remedy is complete (EPA 1991). Long-term risks include risks associated with treatment residuals and untreated wastes; and, an assessment of the remedial alternatives' ability to provide protectiveness over time. Residual risk assessments are usually done in conjunction with treatment-based remedies. Long-term protectiveness is usually associated with containment-based remedies. This OU2 FS risk evaluation examines both assessments quantitatively.

C.2.2.1 Risk Assessment Methodology

The analysis of both short-term and long-term human health risk follows the same basic methodology as the baseline risk assessment for OU2 which is described in detail in Section B.2.0 of the RI Report (DOE 1993a). It follows the general four-step process: 1) COPC identification, 2) exposure assessment, 3) toxicity assessment, and 4) risk characterization. Completion of these processes for the specific risk evaluations presented here are discussed in the sections that follow.

C.2.2.1.1 Contaminants of Concern (COCs).

Constituents of potential concern (CPCs) are identified in the baseline risk assessment. They are the subset of chemicals that remain after a two-step statistical and toxicological screening process which identifies the chemicals

and radionuclides that, based on their prevalence, concentration, and relative toxicity, are considered to be of potential concern to human health. These are the constituents that are quantitatively evaluated in the baseline risk assessment which is presented as Appendix B of the Operable Unit 2 RI report (DOE 1993a).

CPCs are identified for every contaminated medium independently for each subunit; and are carried through a quantitative risk assessment on a subunit-specific basis. All constituents associated with a carcinogenic risk of 1.0E-06 or greater, or a hazard index of 0.2 or greater in the baseline risk assessment are then identified as contaminants of concern (COCs). These are the contaminants that must be addressed by remedial alternatives.

COCs are identified independently for each subunit and are summarized below in Sections C.3.1, C.4.1, C.5.1, C.6.1, and C.7.1 for the Active Flyash Pile, South Field, Inactive Flyash Pile, Solid Waste Landfill, and Lime Sludge Ponds, respectively.

C.2.2.1.2 Exposure Assessment.

The exposure assessment of this risk evaluation identifies the pathways of COC exposure that may occur during remedial alternative implementation, as well as after remedial action has taken place; and, identifies possible receptors.

Since all of the alternatives identified for Operable Unit 2 involve soil handling activities, the pathways of COC exposure contributing to short term risk involve direct contact with soil via inhalation, dermal contact, external radiation, and ingestion. Potential short-term receptors who may be exposed to soil via these pathways are nonremedial workers in the vicinity who may not be protected, and members of the public. A potential trespasser is assumed to be a member of the public for the purpose of assessing short-term risk to an individual coming onto the areas being remediated. An off-site farmer is a member of the public who may experience contact with contaminated soil even while remaining off-site, via inhalation of dust. These three receptors and the pathways via which they can be exposed to COCs during remedial alternative implementation are summarized in Table C.2-1(a).

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TABLE C.2-1(a)

EXPOSURE SCENARIOS FOR ESTIMATION OF SHORT-TERM RISK

Short-Term Receptor	Direct Contact Medium	Route of Exposure
trespassing youth	air	inhalation
	soil	ingestion dermal contact external radiation
nonremedial workers*	air	inhalation
	soil	ingestion dermal contact external radiation
off-property farmer	air	inhalation

- remedial workers assumed to be protected

Long-term receptors who may be exposed to soil via the aforementioned pathways are the future expanded trespasser, future off-property farmer and the future on-property farmer. These are some of the receptors used to estimate baseline risks for Operable Unit 2 in the baseline risk assessment. In addition, with some of the alternatives, the on-property farmer may be exposed to contaminants in groundwater via ingestion, dermal contact and inhalation while bathing, as well as via consumption of beef, milk and homegrown produce contaminated by biouptake of contaminated groundwater. The on-property farmer may be further exposed to groundwater contaminants migrating from treatment or containment based options into the Great Miami Aquifer. These three receptors and the pathways via which they might be exposed to COCs after remedial alternative implementation are summarized in Table C.2-1(b).

The intake equations utilized to estimate COC exposures to these short-term and long-term receptors are equivalent to the equations utilized in the baseline risk assessment for Operable Unit 2 and are not repeated here. The reader is referred to the detailed discussion of intake equations presented in the Baseline Risk Assessment in the RI Report.

The exposure parameter values identified in the intake equations used to estimate exposure differ depending on whether exposures are assumed to be short-term or long-term. Parameter values used to estimate short term and long term risk are listed in Tables C.2-2(a) and C.2-2(b), respectively.

To quantify potential short-term risks it was assumed that COC exposure point concentrations would be the most highly contaminated material being addressed. Air concentrations resulting from this material becoming airborne were estimated as described in Table C.2-3.

To quantify potential long-term residual risks, exposure point concentrations used to estimate intake via inhalation of resuspended particulate matter at the Active Flyash Pile, Inactive Flyash Pile and South Field, modeled air concentrations, assuming the most highly contaminated material within the subunit for the alternative being evaluated, would become exposed over time. Based on the OU4 FS/CRARE (DOE, 1993) it was determined that no significant

TABLE C.2-1(b)

EXPOSURE SCENARIOS FOR ESTIMATION OF LONG-TERM RISK

Receptor	Direct Contact Medium	Route of Exposure
expanded trespasser	air	inhalation
	soil	ingestion dermal contact external radiation
on-property RME farmer	air	inhalation
	soil	ingestion dermal contact external radiation
	groundwater	ingestion inhalation dermal contact
	homegrown produce	ingestion
	homegrown beef/milk	ingestion
off-property farmer	air	inhalation
	homegrown produce	ingestion
	homegrown beef/milk	ingestion of milk and beef
	groundwater	ingestion inhalation dermal contact

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TABLE C.2-2(a)

PARAMETERS USED TO ESTIMATE POTENTIAL SHORT-TERM EXPOSURE[a]

Pathway Parameters	Trespassing Youth	Non-remediation Worker	Off-property Farmer
Inhalation of VOCs, Fugitive Dust, Radon			
Inhalation Rate (IR) (m^3/hr)	0.83[a]	0.83[a]	0.83
Exposure Time (ET) (hr/d)	4[d]	8[h]	5.7[b]
Exposure Frequency (EF) (d/yr) may be < alt duration	52[c] (or asv)	50[d] (or asv)	350 (or asv)
Exposure Duration (ED) (yr)	asv	asv	asv
Body Weight (BW) (kg)	43[b]	70[b]	70[b]
Averaging Time (AT) - Noncancer (d)	asv[e]	asv[e]	asv[e]
Averaging Time (AT) - Cancer (d)[f]	25550	25550	25550
Incidental Ingestion of Soil/Sediment			
Ingestion Rate (IR) (mg/d)	100	0.18	NA
Fraction Ingested from Contaminated Source (FI)	0.25	0.25	NA
Exposure Frequency (EF) (d/yr)	52[c] (or asv)	50[d] (or asv)	NA
Exposure Duration (ED) (yr)	asv	asv	NA
Body Weight (BW) (kg)	43[b]	70[b]	NA
Averaging Time (AT) - Noncancer (d)	asv[e]	asv[e]	NA
Averaging Time (AT) - Cancer (d)[f]	25550	25550	NA
CF - rads (g/mg)	1.0E-3[h]	1.0E-3	NA
CF - chem (kg/mg)	1.0E-6[h]	1.0E-6	NA
Dermal Contact with Soil/Sediment			
Skin Surface Area Available for Contact (SA) (cm^2)	4200[g]	5750[g]	NA
Skin Adherence Factor (AF) (mg/cm^2)	1.0[g]	1.0[g]	NA
Adsorption Factor (ABS) (unitless)	csv	csv	NA
Exposure Frequency (EF) (d/yr)	52[c] (or asv)	50[d] (asv)	NA
Exposure Duration (ED) (yr)	asv	asv	NA
Body Weight (BW) (kg)	43[b]	70[b]	NA
Averaging Time (AT) - Noncancer (d)	asv[e]	asv[e]	NA
Averaging Time (AT) - Cancer (d)[f]	25550	25550	NA
CF (mg/kg)	1.0E-6	1.0E-6	NA

TABLE C.2-2(a) (Continued)

Pathway Parameters	Trespassing Youth	Non-remediation Worker	Off-property Farmer
External Radiation from Soil/Sediment			
ET_{in} (hr/day)	0	0[h]	NA
ET_{out} (hr/day)	4[c]	8[h]	NA
EF (day/yr)	52[c] (or asv)	50[d] (or asv)	NA
ED (yrs)	asv	asv	NA
Sh_{in} (unitless)	NA	NA	NA
Sh_{out} (unitless)	0	0	NA
CF (yr/hr)	1.1E-4[l]	1.1E-4[l]	NA

[a] Derived by dividing the adult human inhalation rate of 20 m^3/day by 24 hours/day, and rounding to two significant figures (EPA 1989).
[b] Parameter values obtained from the Risk Assessment Work Plan Addendum (DOE 1992) unless otherwise noted.
[c] Specific guidance from EPA Region 5. Standard trespass scenario assumes 4 hr/d, 52 d/yr; maybe modified if asv ED is less than 52 days.
[d] Number of days nonremedial worker may be expected to visit remedial area.
[e] Calculated as the product of ED (years) for the specific alternative x 365 days/year.
[f] Averaging time for carcinogenicity calculated as the product of 70 years x 365 days/year.
[g] From Dermal Exposure Assessment Principals and Applications, EPA/600/8-91/011B.
[h] Assumes non-remediation worker spends 8 hr work day outdoors.
asv = alternative-specific value
csv = Chemical-specific value
NA = Not applicable

TABLE C.2-2(b)

PARAMETERS USED TO ESTIMATE POTENTIAL RESIDUAL RISK[a]

Pathway Parameters	Off-property Farmer	On-property Farmer	Expanded Trespasser oc/a
Inhalation of VOCs, Fugitive Dust, Radon			
Inhalation Rate (IR) (m^3/hr)	0.83[b]	0.83[b]	0.83[b]/0.83[b]
Exposure Time (ET) (hr/d)	5.7	5.7	2[c]/1[c]
Exposure Frequency (EF) (d/yr)	350	350	110[h]/40[h]
Exposure Duration (ED) (yr)	70	70	12/32
Body Weight (BW) (kg)	70	70	43/70
Averaging Time (AT) - Noncancer (d)[g]	25550	25550	4380/11680
Averaging Time (AT) - Cancer (d)[g]	25550	25550	25550/25550
Incidental Ingestion of Soil			
Ingestion Rate (IR) (mg/d)	NA	180[d]	100[d]/100[d]
Fraction Ingested from Contaminated Source (FI)	NA	1e	0.125[h]/0.0625[h]
Exposure Frequency (EF) (d/yr)	NA	350	110[h]/40[h]
Exposure Duration (ED) (yr)	NA	70	12/32
Body Weight (BW) (kg)	NA	70	43/70
Averaging Time (AT) - Noncancer (d)[g]	NA	25550	4380/11680
Averaging Time (AT) - Cancer (d)[g]	NA	25550	25550/25550
CF - rads (g/mg)	NA	1.0E-3	1.0E-3/1.0E-3
CF - chem (kg/mg)	NA	1.0E-6	1.0E-6/1.0E-6
Dermal Contact with Soil			
Skin Surface Area Available for Contact (SA) (cm^2)	NA	5750[f]	4200[f]/5750[f]
Skin Adherence Factor (AF) (mg/cm^2)	NA	1.0[f]	1[f]/1[f]
Adsorption Factor (ABS) (unitless)	NA	csv	csv/csv
Exposure Frequency (EF) (d/yr)	NA	350	110[h]/40[h]
Exposure Duration (ED) (yr)	NA	70	12/32
Body Weight (BW) (kg)	NA	70	43/70
Averaging Time (AT) - Noncancer (d)[g]	NA	25550	4380/11680
Averaging Time (AT) - Cancer (d)[g]	NA	25550	25550[a]/25550[a]
CF (mg/kg)	NA	1.0E-6	1.0E-6/1.0E-6

TABLE C.2-3

EXPOSURE POINT CONCENTRATIONS FOR ESTIMATION OF SHORT-TERM RISKS

General Technology/ Process Option	Exposure Point Concentrations	
	Soil	Air
No Action	current surface soil/material COC concentrations	current air COC concentrations from RI, Section 5.0
Institutional Control	current surface soil/material COC concentrations	current air COC concentrations from RI, Section 5.0
In-situ containment	highest COC concentrations exposed during removal of soil/source material	estimated from the equation: $C_a = (D_1)(C_s)(CF)$ where: C_a = COC air concentration (mg/m^3) D_1 = dust loading factor (6.0×10^{-4} g/m^3) C_s = COC soil concentration ($\mu g/g$) CF = conversion factor (10^{-3} mg/kg) for radionuclides: $C_a = (D_1)(C_s)$ C_a = COC air concentration (pCi/m^3) D_1 = dust loading factor (6×10^{-4}) g/m^3 C_s = contaminant concentration in soil (pCi/g)
Removal	highest COC concentrations exposed during removal of soil/source material	
In-situ Treatment	highest COC concentrations exposed during treatment	
Ex-situ Treatment	highest COC concentrations exposed during treatment	
Disposal	highest COC concentrations exposed during removal	

emissions occur from the disposal facilities or capped areas. Therefore residual risk calculation for the Solid Waste Landfill and the Lime Sludge Ponds are unnecessary.

Air concentrations and deposition rates used to calculated long-term risk are summarized in Tables C.2-4(a), (b), and (c). Air modeling results used to estimate the inhalation intake and thus risk reflect characteristics inherent to each land use scenario. Future land use with continued federal ownership --i.e., the expanded trespasser and off-property farmer--assumes an 85% vegetative cover. Future land use without federal ownership assumes a 50% vegetative cover. These assumptions were made to determine realistic, yet conservative surface soil and air concentrations that identified receptors may encounter at Operable Unit 2 subunits.

Where appropriate, groundwater concentrations (of uranium isotopes by the remedial alternatives) that would exist following implementation of specified alternatives for the Inactive Flyash Pile, the South Field and the Active Flyash Pile were determined. These concentrations are summarized in Table C.2-5 and were used as a groundwater exposure concentration to estimate residual groundwater risk for the future on-property farmer receptor. Potential groundwater exposures to the off-property receptor were also quantified.

C.2.2.1.3 Toxicity Assessment.

A toxicity assessment examines information concerning the potential effects of exposure to COCs and summarizes EPA-approved toxicity values. The goal is to provide, for each CPC, a quantitative estimate of the relationship between the magnitude and type of exposure and severity or probability of human health effects. The toxicity assessment contains a compilation of toxicity values for COCs. This section presents tabulated summary toxicity information for COCs with noncarcinogenic and carcinogenic effects for which a risk evaluation is performed.

Noncarcinogens. For noncarcinogens, it is assumed that a dose exists below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. The potential

TABLE C.2-4(a)
AIR CONCENTRATIONS AND DEPOSITION RATES USED TO CALCULATE LONG-TERM RISK
ACTIVE FLYASH

		CONSOLIDATION/CONTAINMENT				*ON-SITE DISPOSAL*			
	Surface Soil	Conc'n in Air (mg/m3; pCi/m3)		Deposition Rate (mg/m2/hr; pCi/m2/hr)		Conc'n in Air (mg/m3; pCi/m3)		Deposition Rate (mg/m2/hr; pCi/m2/hr)	
Contaminant	Concentrations*	On-Subunit	Off-Site	On-Subunit	Off-Site	On-Subunit	Off-Site	On-Subunit	Off-Site
Arsenic	2.92E+01	7.45E-05	3.01E-06	2.76E-07	1.35E-08	9.99E-05	4.11E-06	4.09E-07	1.83E-08
Beryllium	5.44E+00	3.19E-06	1.29E-07	1.19E-08	5.75E-10	4.28E-06	1.76E-07	1.75E-08	7.83E-10
U-Total	8.42E+00	4.36E-05	2.01E-06	1.77E-07	9.13E-09	4.82E-05	2.34E-06	1.96E-07	1.06E-08
Neptunium-237	5.00E+00	1.01E-06	4.08E-08	3.76E-06	1.83E-07	1.36E-06	5.57E-08	5.55E-06	2.48E-07
Radium-226+D	1.14E+00	7.54E-06	3.22E-07	2.90E-05	1.45E-06	8.82E-06	4.11E-07	3.64E-05	1.85E-06
Radium-228+D	9.00E-01	6.12E-06	2.63E-07	2.36E-05	1.19E-06	7.08E-06	3.33E-07	2.91E-05	1.50E-06
Thorium-228+D	1.74E+00	1.22E-05	5.28E-07	4.74E-05	2.39E-06	1.41E-05	6.64E-07	5.70E-05	2.99E-06
Thorium-230	2.67E+00	1.77E-05	7.58E-07	6.83E-05	3.41E-06	2.07E-05	9.67E-07	8.53E-05	4.34E-06
Thorium-232	1.20E+00	8.78E-06	3.83E-07	3.42E-05	1.72E-06	1.01E-05	4.77E-07	4.01E-05	2.15E-06
Uranium-234	1.00E+00	7.61E-06	3.34E-07	2.98E-05	1.51E-06	8.67E-06	4.12E-07	3.44E-05	1.86E-06
Uranium-235/236	3.40E-02	8.95E-05	4.66E-06	3.98E-04	2.16E-05	8.95E-05	4.66E-06	3.98E-05	2.16E-05
Uranium-238+D	1.05E+00	7.46E-06	3.23E-07	2.90E-05	1.46E-06	8.58E-06	4.05E-06	3.46E-05	1.83E-06

*Exposed till and exposed GMA were used to model air concentrations and deposition rates. Surface soil concentrations selected reflect the most conservative exposed soil concentrations from either soil type.

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TABLE C.2-4(b)
AIR CONCENTRATIONS AND DEPOSITION RATES USED TO CALCULATE LONG-TERM RISK
INACTIVE FLYASH
All Alternatives

	Surface Soil Concentration (mg/kg; pCi/kg)	onc'n in Air (mg/m3; pCi/m3 On-Subunit	Off-Site	Deposition Rate (mg/m2/hr; pCi/m2/hr) On-Subunit	Off-Site
Arsenic	6.90E+00	3.02E-05	2.70E-06	1.27E-07	1.24E-08
Beryllium	1.40E+00	4.45E-06	3.83E-07	1.71E-08	1.76E-09
U-TOTAL	5.86E+00	2.88E-05	2.51E-06	1.11E-07	1.15E-08
Benzo(a)pyrene	7.00E+00	2.18E-05	1.15E-06	8.96E-08	5.41E-09
Aroclor-1254	4.00E-02	1.24E-07	6.59E-09	5.11E-10	3.09E-11
CS-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NP-237	1.80E-01	9.18E-07	8.14E-08	3.61E-09	3.74E-10
PU-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PU-239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RA-226	1.01E+00	4.74E-06	4.32E-07	1.99E-08	1.99E-09
RA-228	7.30E-01	3.18E-06	2.82E-07	1.34E-08	1.30E-09
SR-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH-228	8.33E-01	3.12E-06	2.63E-07	1.31E-08	1.21E-09
TH-230	2.03E+00	1.01E-05	8.87E-07	3.89E-08	4.08E-09
TH-232	7.32E-01	2.74E-06	2.31E-07	1.15E-08	1.07E-09
U-234	1.09E+00	5.28E-06	4.58E-07	2.03E-08	2.10E-09
U-235	8.00E-02	3.83E-07	3.30E-08	1.47E-09	1.52E-10
U-238	1.44E+00	6.79E-06	5.80E-07	2.60E-08	2.66E-09

*Exposed till and exposed GMA were used to model air concentrations and deposition rates. Surface soil concentrations selected reflect the most conservative exposed soil concentrations from either soil type.

TABLE C.2-4(c)
AIR CONCENTRATIONS AND DEPOSITION RATES USED TO CALCULATE LONG-TERM RISK
SOUTH FIELD
Consolidation/Containment

Contaminant	Surface Soil Concentration (mg/kg; pCi/k	Conc'n in Air (mg/m3; pCi/m3) On-Subunit	On-Site	Off-Site	Deposition Rate (mg/m2/hr; pCi/m2/hr) On-Subunit	On-Site	Off-Site
Arsenic	7.64E+00	5.44E-05	3.20E-04	3.77E-06	2.07E-07	1.37E-06	1.83E-08
Beryllium	8.80E-01	3.37E-06	1.93E-05	1.56E-07	1.22E-08	8.06E-08	7.72E-10
Chromium	1.99E+01	1.21E-04	7.00E-04	6.60E-06	4.47E-07	2.96E-06	3.24E-08
U-TOTAL	2.97E+02	1.13E-04	6.64E-04	7.32E-06	4.28E-07	2.83E-06	3.55E-08
Benzo(a)pyrene	7.00E+00	3.94E-05	2.25E-04	1.82E-06	1.43E-07	9.41E-07	9.01E-09
Aroclor 1254	3.50E-02	2.25E-07	1.29E-06	1.04E-08	8.16E-10	5.38E-09	5.15E-11
Aroclor 1260	3.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CS-137	1.90E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NP-237	5.00E+00	3.20E-05	1.83E-04	1.48E-06	1.16E-04	7.66E-04	7.33E-06
RA-226	9.21E+00	7.19E-06	4.21E-05	4.69E-07	2.72E-05	1.80E-04	2.27E-06
RA-228	1.94E+00	6.60E-06	3.84E-05	3.98E-07	2.47E-05	1.63E-04	1.94E-06
TH-228	1.70E+00	5.53E-06	3.21E-05	3.22E-07	2.05E-05	1.36E-04	1.58E-06
TH-230	1.38E+01	9.60E-06	5.17E-05	6.78E-07	3.70E-05	2.24E-04	3.26E-06
TH-232	1.29E+01	5.06E-06	2.94E-05	3.00E-07	1.88E-05	1.24E-04	1.46E-06
U-234	7.83E+01	2.08E-05	1.20E-04	1.08E-06	7.65E-05	5.05E-04	5.31E-06
U-235	4.05E+00	1.27E-06	7.28E-06	6.26E-08	4.63E-06	3.06E-05	3.08E-07
U-238	5.70E+01	2.68E-05	1.54E-04	1.37E-06	9.83E-05	6.48E-04	6.75E-06

*Exposed till, exposed fill and exposed GMA were used to model air concentrations and deposition rates. Surface soil concentrations selected reflect the most conservative exposed soil concentrations from either soil type.

TABLE C.2-4(c)
(continued)

On-Site Disposal

Contaminant	Surface Soil Concentration (mg/kg; pCi/k	Conc'n in Air (mg/m3; pCi/m3) On-Subunit	On-Site	Off-Site	Deposition Rate (mg/m2/hr; pCi/m2/hr) On-Subunit	On-Site	Off-Site
Arsenic	7.64E+00	8.14E-05	5.12E-04	5.26E-06	3.09E-07	2.21E-06	2.57E-08
Beryllium	8.80E-01	5.78E-06	3.94E-05	2.96E-07	2.21E-08	1.68E-07	1.39E-09
Chromium	1.99E+01	1.91E-04	1.25E-03	1.05E-05	7.12E-07	5.34E-06	5.15E-08
U-TOTAL	2.97E+02	2.23E-03	1.52E-02	8.40E-05	8.22E-06	6.42E-05	4.00E-07
Benzo(a)pyrene	7.00E+00	4.63E-05	1.99E-04	2.20E-06	1.69E-07	8.64E-07	1.09E-08
Aroclor 1254	3.50E-02	3.85E-07	2.63E-06	1.97E-08	1.47E-09	1.12E-08	9.38E-11
Aroclor 1260	3.50E-02	2.81E-07	1.90E-06	1.01E-08	0.00E+00	8.03E-09	4.81E-11
CS-137	6.92E-01	5.11E-06	3.47E-05	1.84E-07	1.87E-05	1.46E-04	8.74E-07
NP-237	5.00E+00	3.35E-05	1.07E-04	1.56E-06	1.22E-04	4.71E-04	7.72E-06
RA-226	9.21E+00	7.06E-05	4.83E-04	2.78E-06	2.60E-04	2.04E-03	1.32E-05
RA-228	1.94E+00	1.68E-05	1.16E-04	8.11E-07	6.38E-05	4.94E-04	3.98E-06
TH-228	1.70E+00	1.49E-05	1.03E-04	7.05E-07	5.66E-05	4.39E-04	3.41E-06
TH-230	1.38E+01	1.05E-04	7.18E-04	4.09E-06	3.87E-04	3.04E-03	1.94E-05
TH-232	1.29E+01	9.71E-05	6.61E-04	3.65E-06	3.57E-04	2.79E-03	1.74E-05
U-234	7.83E+01	5.86E-04	3.98E-03	2.17E-05	2.16E-03	1.68E-02	1.03E-04
U-235	4.05E+00	3.04E-05	2.07E-04	1.13E-06	1.12E-04	8.71E-04	5.37E-06
U-238	5.70E+01	4.45E-04	3.03E-03	1.68E-05	1.64E-03	1.28E-02	7.98E-05

*Exposed till, exposed fill and exposed GMA were used to model air concentrations and deposition rates. Surface soil concentrations selected reflect the most conservative exposed soil concentrations from either soil type.

TABLE C.2-5

ODAST MODELING RESULTS
MAXIMUM CONCENTRATIONS OF URANIUM
IN GREAT MIAMI AQUIFER IN 460 YEARS

SUBUNIT/DISPOSAL AREA	ALTERNATIVE	COC	GMA MAX. CONC. ON-SITE	AT 460 YRS (pCi/L) OFF-SITE
AFP	Alternative 5 Consolidation/ Containment	U-234 U-235/236 U-238	N/A N/A N/A	N/A N/A N/A
SF/IFP	On-site Disposal Alternatives	U-234 U-235/236 U-238	8.71E-01 4.6E-02 9.57E-01	1.39E-01 7.0E-03 1.53E-01
SF/IFP	SF 7 IFP 7 Consolidation Contamination	U-234 U-235/236 U-238	9.35E-01 4.9E-02 1.03E+01	1.65E-01 9.0E-03 1.81E-01
OU-2 Disposal Cell	a	U-234 U-235/236 U-238	N/A N/A N/A	N/A N/A N/A

a = Represents long-term protectiveness of disposal cell, or contaminant leachate loading into Great Miami Aquifer. Model assumes cap remains intact and leachate collection system fails at time zero.

N/A = Not Applicable. Detailed Great Miami Aquifer modeling was not performed due to low loading concentration.

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for noncarcinogenic health effects resulting from exposure to chemical contaminants is assessed by comparing an exposure estimate (intake) to a reference dose (RfD). It represents a daily intake of contaminants per kilogram of body weight that is not sufficient to cause the threshold effect of concern for the contaminants (mg/kg-day).

An RfD is specific to the chemical, the route of exposure, and exposure duration. It is derived from an EPA review of relevant human and animal studies to ascertain the no-observed adverse effect level (NOAEL) or if data is inadequate for such a determination, the lowest-observed adverse effect level (LOAEL). The NOAEL (or LOAEL) is then divided by uncertainty factors to ensure that the RfD will be protective of human health. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is 1. A brief discussion on the derivation of RfDs is presented in Section B.2.5 of the Baseline Risk Assessment for Operable Unit 2 (DOE 1993a).

To evaluate short-term noncarcinogenic hazard, subchronic, rather than chronic, RfDs are used. Subchronic RfDs for the noncarcinogenic COCs evaluated in this risk evaluation are summarized in Table C.2-6(a). Chronic RfDs are used to evaluate long-term noncarcinogenic hazards. Chronic RfDs for these COCs are summarized in Table C.2-6(b).

Chemical Carcinogens. Toxicity information considered in the assessment of potential carcinogenic risks includes (1) a weight-of-evidence classification and (2) a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of available data from human and animal studies.

For carcinogens, it is assumed that there is no dose at which adverse health effects will be observed. Cancer slope factors are toxicity values used to quantitatively express the probability that exposure to a contaminant will cause cancer. Slope factors represent the upper-bound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals and are typically calculated for compounds that are human carcinogens (weight-of-evidence classification

TABLE C.2-6(a)

REFERENCE DOSES FOR NONCARCINOGENIC CHEMICALS

SHORT-TERM HAZARD

COC	Subchronic Oral Reference Dose (mg/kg-day)	Subchronic Inhalation Reference Dose (mg/kg-day)	Effect of Concern		Uncertainty Factor		
			Oral	Inhalation	Oral	Inhalation	Source
Inorganics							
Arsenic	3×10^{-4}	ND	Keratosis; Hyperpigmentation	ND	3	ND	a
Beryllium (Soluble Salts)	5×10^{-3}	ND	None Observed	ND	100	ND	a
Uranium	3×10^{-3}	ND	Reduced body weight, renal damage	ND			b

a HEAST March 1993. Chronic oral RfDs are adopted as subchronic oral RfDs.
b Subchronic RfD not available. Value used is the chronic oral RfD.

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TABLE C.2-6(b)

REFERENCE DOSES FOR NONCARCINOGENIC CHEMICALS LONG-TERM HAZARD

Chemicals	Chronic Oral Reference Dose (mg/kg/day)	Chronic Inhalation Reference Dose[a] (mg/kg/day)	Reference Concentration (mg/m^3)	Effect of Concern		Uncertainty Factor		
				Oral	Inhalation	Oral	Inhalation	Source
				INORGANICS				
Arsenic	3×10^{-4}	ND	ND	Keratosis; Hyperpigmentation	ND	3	ND	b
Beryllium (Soluble Salts)				None Observed	ND	100	ND	b
Chromium (VI)	5×10^{-3}			None Reported	Nasal Mucosa Atrophy	500	300	b
Benzo(a)anthracene	ND	ND	ND	ND	ND	ND	ND	b
Benzo(a)pyrene								
Benzo(b)fluoranthene								
Benzo(g,h,i)perylene								
Benzo(k)fluoranthene								
bis(2-ethylhexyl)phthalate								
Dibenzo(a,h)anthracene								
Dieldrin								
Endrin ketone								
ideno(1,2,3-cd)pyrene								
Polychlorinated Biphenyls	ND	ND	ND	ND	ND	ND	ND	b

[a] Where only a reference concentration for inhalation is available, derived by assuming a 70 kg adult inhales $20m^3$ of air per day.
[b] EPA IRIS database 1993, July 1993.

ND = No data available

A) or probable human carcinogens (weight-of-evidence classification B1/B2). Slope factors are specific to a chemical and route of exposure and expressed in units of $(mg/kg\text{-}d)^{-1}$ for both oral and inhalation routes. Slope factors for COCs addressed in this risk evaluation are presented in Table C.2-7. The primary sources of these toxicity values are EPA's *Integrated Risk Information System (IRIS)* (EPA 1993a) and the quarterly updated HEAST (EPA 1993b). Other EPA sources of cancer slope factors were also consulted when available. Surrogate chemicals were not used for cancer slope factor derivation unless the chemical similarity was very close and the derivation was highly defensible. However, exceptions were made for the carcinogenicity of PCB isomers, dioxins and furans, and PAHs. These exceptions are discussed at length in the Toxicity Assessment (Section 2.5) of the Baseline Risk Assessment for Operable Unit 2 (DOE 1993a).

The following exceptions, where information from one chemical was used to model a compound class, are noted:

- The carcinogenicity of all polychlorinated biphenyl (PCB) isomers is assumed to be equal to the carcinogenicity of Aroclor-1260 because dose-response data for other isomers are inconclusive.

- The carcinogenicity of PAHs is determined initially using the benzo(a)pyrene cancer slope factors, and refined using a relative potency approach (Clement 1988, 1990).

Slope factors for chemical, carcinogenic COCs evaluated in this risk evaluation are summarized in Table C.2-5.

Radiocarcinogens. Some elements have isotopes which undergo a spontaneous transformation into more stable atoms. The transformation process, or radioactive decay, is usually accompanied by the emission of charged particles and gamma rays. These emissions are called radiation and are typed as alpha, beta, and gamma. Alpha and beta radiation consist of charged particles capable of ionizing nearby matter. These radiations generally have little ability to penetrate deeply into adjacent matter, and can be interdicted by skin, air, and clothing. In most cases, the emission of an alpha or beta particle from an atom is followed by a release of x-rays or gamma radiation. Depending on their

TABLE C.2-7

CANCER SLOPE FACTORS FOR CARCINOGENIC CONTAMINANTS OF CONCERN

Chemical	Oral Cancer Slope Factor [(mg/kg/day)-1]	Inhalation Cancer Slope Factor[a] [(mg/kg/day)-1]	Tumor Site		Cancer Classification	Source
			Oral	Inhalation		
Inorganics						
Arsenic	1.8b	15c	Skin, Lung	Respiratory System	A	b,c
Beryllium	4.3	8.4	Total Tumors	Lung	B2	c
Chromium (VI)	ND	41	ND	Lung	A	c
Semivolatiles						
Benzo(a)pyrene	7.3	6.1	ND	ND	B2	c
Benzo(a)anthracene	1.1	0.89	ND	ND	B2	c, d
Benzo(b)fluoranthene	0.90	0.75	ND	ND	B2	c, d
Benzo(k)fluoranthene	0.38	0.32	ND	ND	B2	c, d
Chrysene	0.032	0.027	ND	ND	B2	c, d
Dibenzo(a,h)anthracene	8.1	6.8	ND	ND	B2	c, d
Indeno(1,2,3-cd)pyrene	2.0	1.7	ND	ND	B2	c, d
Pesticides / PCBs						
Polychlorinated Biphenyls	7.7	ND	Liver	ND	B2	b
Dieldrin						

[a] Where only a unit risk for inhalation is available, the slope factor is derived by assuming a 70kg adult inhales $20m^3$ of air/day.

[b] Derived from the proposed inorganic arsenic ingestion unit risk [5×10^{-5} ($\mu g/l$)$^{-1}$]. "The uncertainties associated with ingested inorganic arsenic are such that estimates could be revised downward as much as an order of magnitude, relative to the risk estimates associated with most other carcinogens" (EPA 1993).

[c] The HEAST (1993) presented an inhalation slope factor of 50 (mg/kg-day)-1, based on absorbed dose (absorption factor of 0.3). A risk of 15 (mg/kg-day)$^{-1}$ based on ambient dose is the value used in this risk assessment.

[c] EPA IRIS database

[d] Slope factors based on relative potencies of PAH compared to benzo(a)pyrene as summarized in Table B.2-10 of the RI Report (January, 1994).

ND = No data available

energies, these radiations may have considerably more penetration power than either alpha or beta radiation and are thus more difficult to shield.

Radioactive contamination within Operable Unit 2 is characterized as low-level ionizing radiation. The principal adverse biological effects associated with ionizing radiation from radioactive substances in the environment are mutagenicity, teratogenicity, and carcinogenicity. Mutagenicity is the ability to induce genetic mutations in the nuclei of either body cells or reproductive cells. Teratogenicity is the ability to induce or increase the incidence of congenital malformations, which are permanent structural or functional deviations produced during embryonic growth and development. Carcinogenicity is the ability to produce cancer. The carcinogenicity of a radioactive isotope of an element depends on several factors including:

- The type of radiation emitted by the radioisotope
- The energy of the radiation emitted
- The radiological half-life of the isotope
- The retention and concentration characteristics of the radioisotope in the human body.

Carcinogenicity is believed to be the limiting deleterious effect at the levels of radiation dose encountered within Operable Unit 2 and has been used as the sole basis for assessing the radiation-related human health risks of a site contaminated with radionuclides (EPA 1989a).

Radiation exposures can be separated into external and internal exposures. External exposure occurs when the radionuclide is outside of the body. Because alpha and beta radiation generally have a low penetrating power, skin and air become effective radiation shields in most cases. Therefore, external exposures to gamma radiation are the primary concern at environmental levels. Internal exposure occurs after the radionuclide enters the body via inhalation or ingestion. For internal exposures, alpha and beta particles become more important because their energy is directly absorbed by living cells.

Inhalation and ingestion are the primary routes for internal exposure to radionuclides. Biologically significant exposures to alpha and beta emitters are more probable for internal exposure because the emitter is in direct contact with tissue. Once in the body, exposure depends on the absorption and retention characteristics of the radionuclide. These absorption and retention characteristics are based on the chemical form of the radionuclide in a compound and not on the isotopic form of the radionuclide.

The relationship between radiation dose and health effects is relatively well characterized for high doses (i.e., >10 rad). Hence, risk estimates are strictly applicable only to large populations exposed to high levels of radiation. Lower levels of exposure may constitute a health risk, but a direct cause and effect relationship is difficult to establish because a particular effect in a specific individual can be produced by many different processes. For low doses, health effects are presumed to occur but can only be estimated statistically. Therefore, the risk of cancer incidence from exposure to low levels of ionizing radiation must be extrapolated from incidence data at higher doses.

Under CERCLA methodology, the EPA assumes a unit intake of, or external exposure to, a radionuclide over a lifetime. The annual radiation dose equivalent from the radionuclide to each organ in each year of life is calculated. The average excess number of all types of radiation-induced fatal cancers that occur in a year is then estimated for the corresponding dose equivalents received during that year and relevant preceding years. The excess number of radiation-induced fatal cancers is derived from epidemiological data, extrapolation from high radiation doses to low doses, and hypothetical models for projecting risk through a lifetime. The relationship between cancer incidence and exposure to radioactive materials is quantified by using mathematical extrapolation models, which estimate the largest possible linear slope (within the 95 percent confidence limit) at low extrapolated doses consistent with the data. Because EPA is concerned with assessing cancer incidence, each radionuclide slope factor has been calculated by dividing the excess fatal cancer risk for that radionuclide by the mortality-to-incidence risk ratio (EPA 1989a) for the types of cancer induced by that radionuclide. This "radiocarcinogenicity slope factor" thus is characterized as the "maximum likelihood estimate of the age-averaged lifetime total excess cancer risk per unit intake or exposure". That is, the true risk to humans, although not identifiable, is not likely to exceed this upperbound estimate.

Cancer slope factors, GI absorption factors, and lung retention classifications for the radionuclides of concern are presented in Table C.2-8. The specific radionuclides of concern for each subunit in Operable Unit 2 are summarized on the list of COCs for each subunit in Sections C.3 through C.7.

Dermal Reference Doses and Cancer Slope Factors

Dermal RfD values and cancer slope factors for chemical carcinogens are derived from the corresponding oral values. In the derivation of a dermal RfD, the oral RfD is multiplied by the gastrointestinal (GI) efficiency factor, expressed as a fraction. The resulting dermal RfD is an RfD based on absorbed dose, which is the appropriate value with which to compare a dermal dose, because dermal doses are expressed as absorbed rather than exposure doses. In a similar manner, and for the same reasons, a dermal cancer slope factor is divided, rather than multiplied, by the GI adsorption efficiency because cancer slope factors are expressed as reciprocal dose. Dermal RfD values and cancer slope factors for the chemicals of concern in Operable Unit 2 are presented in Table C.2-9.

The most important consideration regarding the uncertainty associated with a dermal RfD or cancer slope factor is the accuracy of the GI absorption efficiency factor. For this reason, the toxicity profiles presented in Attachment III of the Baseline Risk Assessment contain pharmacokinetics sections in which the oral absorption data are evaluated. Where appropriate, the low (most conservative) end of the range of available GI absorption data for humans is used in the derivation of the dermal RfD or cancer slope factor. When the human data are insufficient, animal data are used. Data from high-dose experiments not used if more suitable data are available and it appears that saturation of the GI absorption process could have occurred.

When sufficient quantitative data were not located, a default GI absorption factor was used. As noted by EPA (1989a), the GI absorption of many metals from the GI tract is limited, and 0.05 is a reasonable default for metals and inorganic substances. EPA (1989a) did not recommend a separate default value for organic chemicals. A compilation of data for 19 organic chemicals presented GI absorption efficiencies of at least 0.9, indicating that organic chemicals are generally readily absorbed. The arithmetic average of the GI efficiencies for the 19 organic chemicals, 0.91368, equivalent to 0.9 when rounded to one significant figure, appears to be a reasonable default GI

TABLE C.2-8

CANCER SLOPE FACTORS FOR OPERABLE UNIT 2 RADIONUCLIDES OF CONCERN

Radionuclide	ICRP Lung Class[a]	Inhalation[b] $(pci)^{-1}$	GI Absorption[b] Factor (f_1)	Ingestion[b] $(pci)^{-1}$	Penetrating[b] External Exposure $(pci\text{-}yr/g)^{-1}$
Cs-137 + dtr	D	1.9×10^{-11}	1.0×10^{0}	2.8×10^{-11}	2.0×10^{-6}
Np-237 + dtr	W	2.9×10^{-8}	1.0×10^{-3}	2.2×10^{-10}	4.3×10^{-7}
Pu-238	Y	3.9×10^{-8}	1.0×10^{-3}	2.2×10^{-10}	2.8×10^{-11}
Ra-226 + 5 dtrs	W	3.0×10^{-9}	2.0×10^{-1}	1.2×10^{-10}	6.0×10^{-6}
Ra-226 + 8 dtrs	W	7.0×10^{-9}	2.0×10^{-1}	7.8×10^{-10}	6.0×10^{-6}
Ra-228 + dtr	W	6.9×10^{-10}	2.0×10^{-1}	1.0×10^{-10}	2.9×10^{-6}
Rn-222 + 4 dtrs	*	7.7×10^{-12}	1.0×10^{0}	1.7×10^{-12}	5.9×10^{-6}
Th-228 + 7 dtrs	Y	7.8×10^{-8}	2.0×10^{-4}	5.5×10^{-11}	5.6×10^{-6}
Th-230	Y	2.9×10^{-8}	2.0×10^{-4}	1.3×10^{-11}	5.4×10^{-11}
Th-232	Y	2.8×10^{-8}	2.0×10^{-11}	1.2×10^{-11}	2.6×10^{-11}
Th-232 + 10 dtrs	Y	1.1×10^{-7}	$2.0 \times 1\text{-}^{-1}$	1.7×10^{-10}	8.5×10^{-6}
U-234	Y	2.6×10^{-8}	5.0×10^{-2}	1.6×10^{-11}	3.0×10^{-11}
U-235 + dtr	Y	2.5×10^{-8}	5.0×10^{-2}	1.6×10^{-11}	2.4×10^{-7}
U-238 + 2 dtrs	Y	5.2×10^{-8}	5.0×10^{-2}	2.8×10^{-11}	3.6×10^{-8}

[a]Classification recommended by the ICRP for half-time for clearance from the lung. "Y" = years, "W" = weeks, "D" = days, "*" = gas.
[b]EPA, 1993b.

TABLE C.2-9

DERMAL REFERENCE DOSES AND CANCER SLOPE FACTORS FOR CHEMICAL CONTAMINANTS OF CONCERN

Chemical	Gastrointestinal Absorption Fraction	Dermal Reference Dose (mg/kg-day)	Dermal Slope Factor $(mg/kg\text{-}day)^{-1}$
Inorganics			
Arsenic	0.95[a]	2.85×10^{-4}	1.90×10^{0}
Beryllium	0.01[a]	5.00×10^{-5}	4.30×10^{2}
Chromium (VI)	0.45[b]	2.25×10^{-3}	ND
Semivolatiles			
Benzo(a)anthracene	0.43[b]	ND	ND
Benzo(a)pyrene	0.43[b]	ND	ND
Benzo(b)fluoranthene	0.43[b]	ND	ND
Benzo(b)perylene	0.43[b]	ND	ND
Benzo(k)fluoranthene	0.43[b]	ND	ND
Chrysene	0.43[b]	ND	ND
Dibenzo(a,h)anthracene	0.43[b]	ND	ND
Indeno(1,2,3-cd)pyrene	0.43[b]	ND	ND
Pesticide/PCBs			
Polychlorinated biphenyls	0.75	5.30×10^{-5}	1.03×10^{1}
Dieldrin			

[a] See the Toxicity Profile for this chemical in Attachment III, of the RI Report (January 1994).
[b] EPA 1993c, Memorandum from ECAO to EPA Region V, 7/21/93, including Attachments 1-6.
ND = Not Derived

absorption efficiency factor for organic chemicals. The default of 0.9 for GI absorption is used for organic chemicals for which quantitative data were not sufficient.

Toxicity Profiles. Toxicity profiles are included as Attachment III of the Baseline Risk Assessment for Operable Unit 2 (DOE 1993a).

C.2.2.1.4 Risk Characterization.

Risk estimates are derived by combining the results of the exposure assessment and the toxicity assessment to quantitatively estimate the carcinogenic risk and noncarcinogenic hazard associated with exposure to COCs. The potential of a COC to cause carcinogenic effects is presented as the incremental lifetime cancer risk (ILCR). Potential noncarcinogenic effects are presented as hazard quotients (HQ) or hazard indices (HI), as defined below.

Risk Characterization for Chemical Carcinogens

The risk attributed to exposure to chemical carcinogens is estimated as the probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. At low doses, the risk of developing cancer is estimated as follows (EPA 1989a):

$$\text{Risk} = (\text{CDI})(\text{SF})$$

where:

Risk	=	risk of cancer incidence, expressed as a unitless probability,
CDI	=	chronic daily intake averaged over 70 years (mg/kg-day), and
SF	=	slope factor $(\text{mg/kg-day})^{-1}$.

Risk Characterization for Radionuclide Carcinogens

Risk characterization for internal exposures to radionuclides (intake via inhalation or ingestion) is calculated as follows:

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$$Risk = (I)(SF)$$

where:

Risk	=	risk of cancer incidence, expressed as a unitless probability,
I	=	lifetime radionuclide intake (pCi), and
SF	=	slope factor $(pCi)^{-1}$.

The slope factor is either a HEAST (EPA 1993b) value for a particular radionuclide or the sum of the HEAST (EPA 1993b) slope factors for that radionuclide and its short-lived progeny to account for ingrowth during storage and/or environmental transport.

Risk characterization for external exposure to gamma-emitting radionuclides in contaminated surface soil is calculated as follows:

$$Risk = (C_s)(SF)(ED)(MF)$$

where:

Risk	=	risk of cancer incidence, expressed as a unitless probability
C_s	=	radionuclide soil concentration (pCi/g)
SF	=	radionuclide slope factor (risk/yr per pCi/g)
ED	=	exposure duration (yr)
MF	=	modifying factor, fraction of year exposed (unitless)

Risk Characterization for Noncarcinogens

The risk associated with exposure to noncarcinogenic hazardous COCs was evaluated by comparing an exposure level or intake to a subchronic reference dose (RfD). It is recognized that this methodology for assessing the human health effect for noncarcinogens does not give a measure of risk as is calculated for the carcinogens. Even so, for convenience the term "risk" will continue to be used when discussing these evaluations. The ratio of intake RfD for a single contaminant is the HQ and is defined as (EPA 1989a):

$$HQ = I/RfD$$

where:

HQ	=	hazard quotient (unitless),
I	=	intake of a chemical (mg/kg/day), and
RfD	=	reference dose (mg/kg/day).

When using this equation to estimate potential noncarcinogenic risk, the intake and RfD must be for exposures of equivalent duration (e.g., subchronic, chronic, or fewer than two weeks). For this Feasibility Study, COC exposures have been evaluated in all cases on a chronic basis, using chronic RfD values. Analogous to cancer risks, dermal noncancer risks were assessed using absorbed dose rather than intake.

In the case of simultaneous exposure of a receptor to several chemicals, an HI was calculated as the sum of the HQs by:

$$HI = I_1/RfD_1 + I_2/RfD_2 + ...I_i/RfD_i$$

where:

I_i	=	intake for the ith toxicant, and
RfD_i	=	reference dose for the ith toxicant.

An HI is an indicator of the potential for adverse effects associated with exposures to all noncarcinogenic COCs simultaneously. In effect, HIs assume dose additivity for all COCs (EPA 1989a).

C.2.2.2 Short-Term Risk

Short term risk, associated with implementation of the alternatives, is due either to transportation and/or construction activities or to contact with contaminated media.

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C.2.2.2.1 Transportation Risks.

Non-COC risks arise from physical injury via transportation of contaminated wastes during construction activities. Transportation receptors are personnel involved in transporting the waste by truck or rail to the Nevada Test Site (NTS) and to members of the public along the transportation route. Construction receptors are remedial workers directly involved with construction activities and movement of large volumes of waste.

Accidental injuries and fatalities may occur during the shipment of material to designated disposal facilities. These types of potential risk are termed transportation risks. Transportation risks associated with subunit - during the hauling of material in and out of areas within Operable Unit 2 - specific remedial alternatives are evaluated for the Active Flyash Pile, the South Field, the Inactive Flyash Pile, the Solid Waste Landfill, and the Lime Sludge Ponds in Sections C.3.3.1, C.4.3.1, C.5.3.1, C.6.3.1, and C.7.3.1, respectively.

Transportation risk is calculated using the following equation:

$$\text{Risk} = (N)(RC)(CF)$$

where:

Risk	=	risk of injury or fatality expressed as a unitless probability
N	=	number of round trips made
CF	=	mileage per round trip
RC	=	injury or fatality risk coefficient (risk/mile)

The risk coefficients presented below are used to evaluate nonradiological risks to truck drivers and rail crews and are from the RAWPA (DOE 1992a). It is important to note that the risk coefficients for truck and rail transport are not strictly comparable, since far more waste is transported per mile of rail transport than per mile of truck transport.

	Truck	Rail

- injury/mile	4.1E-08	4.6E-06
- death/mile	2.1E-09	4.6E-08

Transportation of radioactive wastes via truck and train places the general public at risk. Such risks can be of three types: 1) physical risks associated with accidents; 2) risks associated with potential exposures to radioactive wastes when sharing transportation routes with trucks or trains; 3) risks arising from potential exposures that may occur with accidents. Physical risks are calculated using the equation identified for estimation of transportation risk to truck and rail personnel directly involved in transportation of contaminated waste. Risk coefficients for truck and rail transport are not strictly comparable, since far more waste is transported per mile of rail transport than per mile of truck transport. The risk coefficients presented below are from the RAWPA (DOE, 1992a).

	Truck	Rail
- injury/mile	1.2E-07	6.8E-06
- death/mile	1.3E-07	1.8E-06

C.2.2.2.2 Construction Risks.

Accidental injuries and fatalities may occur during any remedial activity that involves construction. For the purpose of this risk evaluation, construction activities are assumed to include all tasks associated with construction of disposal cells as well as activities involving large-scale movement of soil or waste. These are highly conservative assumptions and are most useful as a measure of relative risk associated with an alternative; rather than as a measure of actual risk to a remedial worker. Although on-site disposal alternatives include construction of the on-property disposal cell, while off-property disposal alternatives utilize existing and future disposal capacity at the NTS or a permitted commercial facility each involve tasks defined as a construction activity and can be used to compare overall risk associated with each alternative. Construction activities associated with the subunit specific Operable

Unit 2 remedial alternatives are described for the Active Flyash Pile in C.3.3.1, for the South Field in Section C.4.3.1, for the Inactive Flyash Pile in Section C.5.3.1, for the Solid Waste Landfill in Section C.6.3.1, and for the Lime Sludge Ponds in Section C.7.3.1.

Construction risks are calculated using the following equation:

$$Risk = (PH)(RC)$$

where:

Risk	=	risk of injury or fatality expressed as a probability
PH	=	person-hours of construction work
RC	=	injury or fatality risk coefficient (risk/person hours)

The following risk coefficients from the RAWPA (DOE 1992a) are used to estimate the injuries and fatalities that may be associated with construction activities:

- injury/manhour 3.40E-05
- fatality/manhour 5.00E-07

C.2.2.2.3 <u>COC Risk</u>

The purpose of the assessment of COC short-term risk is to estimate the possible COC risk to nonremedial workers who are not protected by personal protective equipment or by protective measures required by the Health and Safety Plan, and to members of the public. The results of the short-term COC risk assessment provide a means of comparing the various remedial alternatives under consideration with regard to potential risk posed to nonremedial workers and to members of the public due to contact with COCs while remedial activities are ongoing. The process uses information developed during the site investigation, the RI baseline risk assessment, remedial technology screening, and alternative development process to:

- determine the COCs to which receptors may be exposed during alternative implementation;

- assess the potential for and the magnitude of contaminant transport from Operable Unit 2 sources to potential human exposure points during implementation;

- quantify potential short-term exposures to receptors under different engineering alternative scenarios; and,

- characterize the nature and magnitude of potential short-term risks associated with the different proposed remedial alternatives for the subunits of Operable Unit 2.

COC short-term risk is assessed following the methodology described in Section C.2.2.1. For the evaluation of short-term risk, receptors of concern are the trespassing youth and non-remedial worker and an off-property farmer. Table C.2-1(a) outlines the exposure scenarios for the estimation of short-term risk. Intake equations used to estimate risks during implementation of the remedial alternatives are described in the Baseline Risk Assessment and, exposure parameters and values are given in Table C.2-2(a).

Table C.2-3 summarizes the general procedure for identifying exposure point concentrations for this short-term risk evaluation. Exposure point concentrations used to estimate intake are generally the 95% Upper Confidence Limit (UCL) of COC concentration for the most highly contaminated material within each subunit. Specific COC concentrations in soil or material addressed by alternatives for each subunit are summarized in the subunit-specific sections.

C.2.2.3 Long-Term Risk

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The purpose of the assessment of long-term human health risk is to ascertain possible risk due to COC concentrations remaining at each remediated subunit after remedial action has been completed. In addition, health risks associated

with COCs migrating from treatment or containment based alternatives to groundwater are also evaluated to assess long-term protectiveness of alternatives. The results of the long-term human health COC risk assessment provide a means of comparing the various remedial alternatives with regard to potential risk posed to identified receptors after remedial action has taken place. These results also convey the effectiveness of containment-based remedies at mitigating risk.

The baseline risk assessment in the RI report presented risk information for a range of receptors under current and future land use scenarios. Land use assumptions and receptors were defined to provide managers with a range of necessary information to support informed decisions in establishing proposed remediation levels. For the evaluation of long-term risk, receptors of concern are the future expanded trespasser, future off-property farmer and a future on-property farmer. These receptors and the pathways via which they would be exposed to COCs are summarized in Table C.2-1(b). Intake equations used to estimate risks after remedial action is completed are described fully in the baseline risk assessment; and, parameter values are summarized in Table C.2-2(b).

Exposure point concentrations used to estimate intake are PRGs calculated based on the results of the baseline risk assessment of the RI as described in Section C.2.1.2. This is based on the assumption that all alternatives under consideration are designed to achieve the PRGs. Thus, COC concentrations remaining within each subunit will be no greater than, or less than PRGs. PRG concentrations are used to model the amount of particulate matter resuspended into air for the Active Flyash Pile, Inactive Flyash Pile and South Field. These results reflect characteristics inherent to each land use scenario. Future land use with continued federal ownership assumes 85 percent vegetative cover; future land use without federal ownership assumes 50 percent vegetative cover.

C.3.0 ACTIVE FLYASH PILE

C.3.1 SUMMARY OF BASELINE RISK ASSESSMENT

Risk and hazard associated with the Active Flyash Pile for receptors assuming future land-use are summarized in Section 1.7.3 of the FS report. The largest risks for all receptors are from direct contact with soil, or surface flyash material assuming future land use.

Total estimated baseline risks to the future expanded trespasser slightly exceed the 1 X 10^{-4} level due mostly to the estimated presence of beryllium in flyash material which accounted for 87% of the total risk to this receptor. Total estimated risk to the future off-property farmer slightly exceeded the 1.0E-06 level due mostly to direct exposure to the estimated future concentration of U-234 and U-238 in groundwater which accounted for approximately 65% of total risk to this receptor. The estimated presence of arsenic in flyash material deposited on homegrown produce accounted for another 12% of total risk to this receptor. Total estimated risk to the future RME on-property farmer exceeded 1.0E-03 due to RA-228 and TH-228 in surface material; and, to the presence of U-234 and U-238 in groundwater.

Concern is greatest for the potential exposures to groundwater, since many COCs in surface material are present at levels equivalent to background. Because of this, RAOs for this subunit emphasize the protection of groundwater.

All CPCs associated with a risk of greater than 1.0E-06 or an HI of greater than 0.2 for any receptor are considered to be COCs from the baseline risk assessment. Mitigation of risks attributable to these COCs is a general RAO for the remedial alternatives evaluated. PRGs are derived for the future on-property farmer; future off-property farmer; and, an expanded trespasser. Table C.3-1 summarizes the COCs and PRGs determined for these three future receptors for the Active Flyash Pile.

TABLE C.3-1.1

ACTIVE FLYASH PILE
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	NP-237	5.2E-02	*6.55E+02*	5.04E+00
		RA-226	9.4E-01	*4.27E+03*	3.72E-01
		RA-228	8.3E-03	*9.06E+03*	7.69E-01
		TH-228	4.3E-03	*2.72E+02*	3.99E-01
		U-235/236	9.7E-02	*8.49E+02*	*9.23E+00*
		U-238	4.8E-01	*4.08E+02*	*5.60E+01*
		Arsenic	2.2E-01	8.55E+02	1.95E+01
		Beryllium	9.6E+00	*4.86E+02*	2.53E-02
NON-CARCINOGENS	Soil	Arsenic	2.3E+01	N/A	N/A

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration. Numbers in italics represent PRG calculations for contaminants which do not present a risk greater than 1.0E-06 or an HI > 0.2.

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For assessing short term and long-term risk, potential exposures to all CPCs are evaluated. For assessing long-term risks potential risks due only to identified COCs are addressed. For assessing long-term risk due to groundwater exposure, only U-234, U-235/236 and U-238 are addressed.

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C.3.2 REMEDIAL ALTERNATIVES

The remedial action alternatives considered for the Active Flyash Pile (AFP), along with the No Action Alternative, are summarized in Table C.3-2. Tasks associated with construction, transportation and COC exposure have been evaluated for each of the alternatives.

Physical hazards and short-term COC exposures associated with excavation of flyash exist in all four alternatives, AFP2 through AFP5. Three of the alternatives include excavation of the flyash. This excavated flyash is disposed of off-site in one alternative, disposed of on-site without treatment in one alternative and stabilized before on-site disposal in one alternative. Only AFP5 calls for in-situ containment of the flyash.

The remaining contaminated material is also associated with physical hazards and short-term COC exposure. Three alternatives require excavation of the contaminated material which may be contacted by receptors. Only one alternative, AFP2, includes off-site disposal of the excavated contaminated material. Two alternatives require on-site disposal, while only AFP5 calls for in-situ containment of the contaminated material.

A detailed summary of alternatives AFP2 through AFP5 listing individual tasks, COC exposure potential and labor hours required to complete individual construction tasks can be found in Tables C.3-3 through C.3-5 (Attachment I). For ease of reference these tables are collected in Attachment I to this appendix. The detailed information contained in these tables is used to estimate the short-term risk associated with alternative implementation.

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TABLE C.3-2

ACTIVE FLYASH PILE ALTERNATIVES

Alternative	Major Activity
AFP1 No Action	None
AFP2 Off-site Disposal	Excavate contaminated material Excavate flyash Transportation Off-site disposal of contaminated material Off-site disposal of flyash
AFP3 On-site Disposal	Excavate contaminated material Excavate flyash Off-site disposal of contaminated material Off-site disposal of flyash
AFP4 On-site Disposal with Flyash Stabilization	Excavate contaminated material Excavate flyash Treat contaminated material Treat flyash On-site disposal of contaminated material On-site disposal of flyash
AFP5 Consolidation/Containment	In-situ containment of contaminated material In-situ containment of flyash

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C.3.3 SHORT-TERM RISK

C.3.3.1 COC Risks.

Table C.3-7 summarizes the COCs and their concentrations in the material addressed by the alternatives developed for the Active Flyash Pile. For determining short-term risks it is assumed that receptors are exposed to the most highly contaminated material for the entire exposure duration identified for that alternative. This is a very highly conservative assumption. This is because the durations of exposure to the most highly contaminated material will most likely not differ substantially among alternatives, since its volume is the same. Yet, the risk calculations assume that the concentration of COCs in all removed material is the same.

Table C.3-8(a), (b) and (c) summarize the short-term risk potentially experienced by a trespassing youth, a nonremedial worker, and an off-property farmer during implementation of the alternatives. For comparison, the short-term risk that would result if the COCs identified were present in the Active Flyash Pile at background concentrations is provided. Total short term risk associated with remedial alternatives for the AFP are 7.8E-06, 1.7E-06 and 8.7E-06 due primarily to the estimated beryllium concentration is surface soil. Total hazard index to the trespassing youth and non-remedial worker is less than 1.0. It is evident that all alternatives are associated with roughly the same degree of short- term risk to the trespassing youth, the nonremedial worker, and the off-property farmer; and, that the risk is perhaps an order of magnitude greater than background for all receptors for most alternatives.

C.3.3.2 Transportation/Construction

Table C.3-9 summarizes the total injuries and fatalities (for all workers) estimated per completed construction and construction related task for each of the remedial alternatives. In general total construction injuries were 3.0E+00 and total construction fatalities were approximately 4.0E+00. There is very little difference among the alternatives in the risk of injury or fatality.

TABLE C.3-7
CONCENTRATION OF COCs IN EXCAVATED MATERIAL
ACTIVE FLYASH PILE (pCi/g; mg/kg)*

Contaminants of Concern	AFP2/AFP3/AFP4/AFP5 ontaminated Ash Material
NP-237	4.0E-01
RA-226	4.6E+00
RA-228	3.89E+00
TH-228	3.0E+00
U-234	1.2E+01
U-235/236	3.4E+00
U-238	9.7E+00
Arsenic	7.1E+01
Beryllium	9.8E+00

* Concentrations are the 95% UCL estimated for the most highly contaminated material. They are used to estimate short-term risks to non-remedial workers, trespassers and off-property farmers during remedial action implementation.

TABLE C.3-8(a)
ACTIVE FLYASH PILE: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- TRESPASSING YOUTH

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *	
	FP2/AFP3/AFP4/AFP	BACKGROUND**
NP-237	4.9E-09	0.0E+00
RA-226	3.2E-09	
RA-228	2.5E-07	6.8E-08
TH-228	3.9E-07	1.4E-07
U-234	3.1E-08	2.4E-09
U-235/236	2.6E-08	6.3E-10
U-238	5.6E-08	5.9E-09
Arsenic	2.6E-07	2.0E-08
Beryllium	7.7E-06	4.5E-07
TOTAL RISK FOR ALTERNATIVE	**8.7E-06**	**6.8E-07**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*	
	FP2/AFP3/AFP4/AFP	BACKGROUND**
Arsenic	2.1E-02	1.7E-03
Beryllium	2.7E-02	1.7E-03
TOTAL HAZARD FOR ALTERNATIVE	**4.8E-02**	**3.4E-03**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material and assumes flyash material has been removed.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways

** Background risks/hazards based on the highest alternative exposure duration (11 months).

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TABLE C.3-8(b)
ACTIVE FLYASH PILE: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- NON-REMEDIATION WORKER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *	
	AFP2/AFP3/AFP4/AFP5	BACKGROUND**
NP-237	9.3E-09	0.0E+00
RA-226	4.8E-09	
RA-228	4.7E-07	1.3E-07
TH-228	7.5E-07	2.6E-07
U-234	5.8E-08	4.7E-09
U-235/236	5.0E-08	1.2E-09
U-238	1.1E-07	1.1E-08
Arsenic	1.3E-07	9.9E-09
Beryllium	6.2E-06	3.6E-07
TOTAL RISK FOR ALTERNATIVE	**7.8E-06**	**7.8E-07**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*	
	AFP2/AFP3/AFP4/AFP5	BACKGROUND**
Arsenic	2.8E-03	2.3E-04
Beryllium	2.2E-02	1.4E-03
TOTAL HAZARD FOR ALTERNATIVE	**2.5E-02**	**1.6E-03**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material and assumes flyash material has been removed.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (11 months).

TABLE C.3-8(c)
ACTIVE FLYASH PILE: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- OFF PROPERTY FARMER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *	
	AFP2/3/4/5	BACKGROUND**
NP-237	1.1E-08	0.0E+00
RA-226	1.3E-08	
RA-228	2.4E-09	7.2E-10
TH-228	2.1E-07	7.9E-08
U-234	2.9E-07	2.5E-08
U-235/236	7.8E-08	2.0E-09
U-238	4.6E-07	5.1E-08
Arsenic	5.4E-07	4.4E-08
Beryllium	4.2E-08	2.6E-09
TOTAL RISK FOR ALTERNATIVE	**1.7E-06**	**2.0E-07**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (11months).

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TABLE C.3-9
ACTIVE FLYASH PILE
CONSTRUCTION RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES*

INJURIES/COMPLETED TASK					FATALITES/COMPLETED TASK			
Task	AFP2	AFP3	AFP4	AFP5	AFP2	AFP3	AFP4	AFP5
Mobilization and site preparati	1.3 E-02	8.7 E-02	1.7 E-01	6.5 E-03	1.9 E-04	1.3 E-03	2.6 E-03	9.6 E-05
Excavate/load/transport waste	4.6 E-01	6.7 E-01	2.7 E-01	1.0 E+00	6.8 E-03	9.9 E-03	3.9 E-03	1.5 E-02
Site restoration	2.6 E-02	2.6 E-02	2.6 E-02	6.5 E-03	3.8 E-04	3.8 E-04	3.8 E-04	9.6 E-05
Demobilization	6.5 E-03	6.5 E-03	6.5 E-03	6.5 E-03	9.6 E-05	9.6 E-05	9.6 E-05	9.6 E-05
Construct disposal cell	NA	4.7 E-01	4.9 E-01	NA	NA	7.0 E-03	7.2 E-03	NA
Cap disposal cell	NA	2.9 E-01	6.8 E-02	3.7 E-01	NA	4.2 E-03	1.0 E-03	5.4 E-03
Total	**5.0 E-01**	**1.5 E+00**	**8.6 E-01**	**1.4 E+00**	**7.3 E-03**	**2.2 E-02**	**1.3 E-02**	**2.0 E-02**

*Construction risk calculated using total crew labor hours per task.

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Tables C.3-10(a) and C.3-10(b) summarize the risk of fatalities during transportation activities by train or truck to occupational or public sector receptors, respectively. Truck transportation injuries are 3.1E-04 for AFP3, AFP4 and AFP5 and 2.9E-03 for AFP2. Fatalities associated with truck transportation were 1.6E-05 for AFP3, AFP4 and AFP5 and 1.5E-04 for AFP2. Risk was greater for the off-site disposal option (AFP2) due to the magnitude of the waste volume transported to the Nevada Test Site and other off-site facilities. Train transportation injuries and fatalities associated with AFP2 were 6.8E-01 and 6.8E-03 respectively. Public sector train injuries and fatalities were 1.0E+00 and 2.7E-01 respectively.

C.3.4 Long-Term Risk

For the AFP, two types of soil were identified after implementation of AFP alternatives. Both exposed till and exposed GMA soil concentrations were modelled separately. The results of this modelling effort were summed to determine a representative air concentration and deposition rate for the subunit. Residual risk calculations were based on the assumption that future exposed soil concentrations would be reflective of the highest soil concentration of any soil type identified within the subunit. This results in a conservative estimate of risk that is likely to be an overestimation of risk.

For ease of reference all risk assessment results are collected in Attachment II to this Appendix. Summary tables are included here in the text. Residual risk was estimated for all alternatives. Table C.3-11 (Attachment II) summarizes the residual risk and hazard to the future expanded trespasser exposed to surface soil. Residual risks to the expanded trespasser from exposed surface soil COCs under the consolidation/containment alternative (AFP5) and on-site disposal is approximately 1.5E-05. Dermal contact to arsenic and external radiation exposure to TH-228 were the major contributors to this risk. The hazard index is less than 1.0. It is important to emphasize that these numbers are associated with uncertainties involved with calculating risk, e.g., the conservative methods used in developing slope factors that describe the relative potency of a chemical.

TABLE C.3-10(a)
ACTIVE FLYASH PILE
TRANSPORTATION RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES
(Occupational Exposure)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK				
INJURIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	8.3E-03	3.5E-02	3.4E-02	3.5E-02
Total Injuries	**8.3E-03**	**3.5E-02**	**3.4E-02**	**3.5E-02**
FATALITIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	4.3E-04	1.8E-03	1.8E-03	1.8E-03
Total Fatalities	**4.3E-04**	**1.8E-03**	**1.8E-03**	**1.8E-03**

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRAIN				
INJURIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	6.8E-01	NA	NA	NA
Total Injuries	**6.8E-01**	**0.0E+00**	**0.0E+00**	**0.0E+00**
FATALITIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	6.8E-03	NA	NA	NA
Total Injuries	**6.8E-03**	**0.0E+00**	**0.0E+00**	**0.0E+00**

NA = Not Applicable

TABLE C.3-10(b)
ACTIVE FLYASH PILE
TRANSPORTATION RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES
(Public Sector)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK				
INJURIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	2.4E-02	1.0E-01	1.0E-01	1.0E-01
Total Injuries	**2.4E-02**	**1.0E-01**	**1.0E-01**	**1.0E-01**
FATALITIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	2.6E-03	1.1E-02	1.1E-02	1.1E-02
Total Fatalities	**2.6E-03**	**1.1E-02**	**1.1E-02**	**1.1E-02**

ASH

TRANSPORTATION RISK/TRAIN				
INJURIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	1.0E+00	NA	NA	NA
Total Injuries	**1.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**
FATALITIES				
Task	AFP2	AFP3	AFP4	AFP5
Excavate/load/transport waste	2.7E-01	NA	NA	NA
Total Injuries	**2.7E-01**	**0.0E+00**	**0.0E+00**	**0.0E+00**

NA = Not Applicable

Tables C.3.1.2(a), (b) and (c) (Attachment II) summarize risk to the off-property farmer after subunit remediation. Total residual risk to this receptor across all soil and groundwater pathways is 4.1E-06 under AFP2 and 4.2E-06 under AFP5. For AFP2, arsenic exposures via air resulted in risks of 4.0E-06. Inhalation of arsenic under AFP% resulted in a risk of 2.9E-06. Total hazard index is less than 1.0.

Table C.3-13(a) and (b) summarizes the long-term risks associated with all receptors for all alternatives.

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TABLE C.3-13(b)
ACTIVE FLYASH PILE
SUMMARY OF LONG-TERM RISKS AND HAZARDS
On-Site Disposal

		Alternative 3/4			
		Expanded Trespasser		Off-Property Farmer	
Medium	Parameter	*Carcinogen*	*Non-carcinogen*	*Carcinogen*	*Non-carcinogen*
Soil	NP-237	9.9E-07		*1.9E-10*	
	RA-226	3.1E-06		*1.4E-10*	
	RA-228	1.2E-06		*2.7E-11*	
	TH-228	4.4E-06		*6.0E-09*	
	TH-232	1.3E-09		*3.3E-09*	
	U-234	1.1E-09		*1.5E-09*	
	U-235/236	*1.1E-08*		*1.2E-09*	
	U-238	*1.9E-08*		*1.4E-08*	
	Arsenic	5.6E-06	5.0E-02	4.0E-06	
Homegrown Produce (Dust Affected)	NP-237	N/A		*6.4E-12*	
	RA-226	N/A		*2.5E-11*	
	RA-228	N/A		*1.7E-11*	
	TH-228	N/A		*1.9E-11*	
	U-235/236	N/A		*3.8E-11*	
	U-238	N/A		*5.8E-12*	
	Arsenic	N/A		2.0E-09	3.9E-06
Beef/Milk (Dust Affected)	NP-237	N/A		*3.7E-14*	
	RA-226	N/A		*4.1E-12*	
	RA-228	N/A		*2.7E-12*	
	TH-228	N/A		*4.8E-09*	
	U-235	N/A		*1.4E-08*	
	U-238	N/A		*1.9E-09*	
	Arsenic	N/A		3.6E-10	6.9E-07
TOTAL		**1.5E-05**	**4.2E-02**	**4.1E-06**	**4.6E-06**

Numbers in italics represent risk calculations for contaminants not identified as COCs.
N/A=Not Applicable

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TABLE C.3-13(a)
ACTIVE FLYASH PILE
SUMMARY OF LONG-TERM RISKS AND HAZARDS
Consolidation/Containment

		Alternative 5			
		Expanded Trespasser		Off-Property Farmer	
Medium	Parameter	*Carcinogen*	*Non-carcinogen*	*Carcinogen*	*Non-carcinogen*
Soil	NP-237	9.9E-07		*1.4E-10*	
	RA-226	3.1E-06		*1.1E-10*	
	RA-228	1.2E-06		*2.1E-11*	
	TH-228	4.4E-06		*4.8E-09*	
	TH-232	1.2E-09		*2.5E-09*	
	U-234	1.0E-09		*1.2E-09*	
	U-235/236	*1.1E-08*		*1.0E-09*	
	U-238	*1.9E-08*		*1.4E-08*	
	Arsenic	4.6E-06	5.0E-02	2.9E-06	
Homegrown Produce (Dust Affected)	NP-237	N/A		*4.7E-12*	
	RA-226	N/A		*2.0E-11*	
	RA-228	N/A		*1.3E-11*	
	TH-228	N/A		*1.5E-11*	
	U-235/236	N/A		*3.8E-11*	
	U-238	N/A		*4.6E-12*	
	Arsenic	N/A		1.5E-09	2.9E-06
Beef/Milk (Dust Affected)	NP-237	N/A		*2.7E-14*	
	RA-226	N/A		*3.2E-12*	
	RA-228	N/A		*2.1E-12*	
	TH-228	N/A		*4.8E-09*	
	U-235	N/A		*1.4E-08*	
	U-238	N/A		*1.9E-09*	
	Arsenic	N/A		2.7E-10	5.1E-07
TOTAL		**1.4E-05**	**4.2E-02**	**4.1E-06**	**3.4E-06**

Numbers in italics represent risk calculations for contaminants not identified as COCs.
N/A=Not Applicable

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C.4.0 SOUTH FIELD

C.4.1 SUMMARY OF BASELINE RISK ASSESSMENT

Risk and hazard associated with the South Field for receptors assuming future land-use are summarized in Section 1.7.3 of the FS report. The largest risks for all receptors are the risks from direct contact with soil containing naturally occurring RA-228 and TH-228; naturally occurring and site-related U-234 and U-238 and some organic compounds (e.g., benzo(a)pyrene, Aroclor-1254, and Aroclor-1260).

Risks exceeding 1.0E-06 were indicated for the future expanded trespasser exposed to one or more of the following radionuclides in soil: NP-237, RA-226, RA-228, and/or TH-228. Also, risks exceeding 1.0E-06 were indicated for all future receptors exposed to groundwater; to homegrown produce (irrigated with contaminated groundwater and receiving airborne particulates); and to beef and milk (from livestock watered with contaminated groundwater and which eat contaminated feed and forage). Nearly all radiological risk is due to the estimated presence of NP-237, U-234, U-235/236 and U-238 in groundwater, which is not only directly contacted by these receptors but which also contaminates homegrown produce and livestock food products which is then ingested by receptors.

Concern is greatest for the potential direct exposure of an on-property farmer to soil contaminated with U234 and U238, and for potential exposures to groundwater contaminated with U-234, U-235/236 and U-238. Because of this, RAOs for this subunit emphasize both the removal of soil contaminated with uranium isotopes that may be directly contacted by receptors and the protection of groundwater.

All CPCs associated with a risk of greater than 1.0E-06 or an HI of greater than 0.2 for any receptor are considered to beCOCs. Mitigation of risks attributable to these COCs is a general RAO for the remedial alternatives involved.

PRGs are derived for the future on-property farmer, future off-property farmer and an expanded trespasser. Table C.4-1.1 summarizes the COCs and PRGs for future South Field receptors. For assissing short term and long term risk potential expsoures to all CPCs are evealuated. For assissing long term risks, the potential risks due only to identified COCs are evaluated. Long term risks are addressed and shown in Table C.4-20.

C.4.2 REMEDIAL ALTERNATIVES

The action alternatives considered for the South Field, along with the No Action Alternative, are summarized in Table C.4-2. Tasks associated with transportation of contaminated waste material for off-site disposal and, COC exposures have been evaluated for each of the alternatives.

Physical hazards and short-term COC exposure associated with excavation of contaminated waste material exists for all six remedial alternatives, SF2 through SF7. All alternatives include excavation of the contaminated material. Off-site disposal of this excavated contaminated material is one alternative, on-site disposal without treatment is an additional alternative and three alternatives require treatment before on-site disposal. The three treatment options -- vitrification, solidification, and soil washing -- all require some form of additional soil handling which may result in larger volumes of waste materials becoming resuspended and may increase the severity of short-term COC exposure. Vitrification and solidification have similar construction and soil handling procedures. Soil washing involves more soil handling and a greater opportunity for COC exposure through by-product handling. Only SF7 calls for in-situ containment of the material.

RCRA waste handling also presents physical hazards and chemical exposure potentials. All six action alternatives include excavation and off-site disposed of this material.

A detailed summary of alternatives SF2 through SF9 listing individual tasks, COC exposure potential and labor hours required to complete individual construction tasks can be found in Tables C.4-3 through C.4-8 (Attachment I). For

TABLE C.4-1.1

SOUTH FIELD
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	CS-137	1.2E-02	*5.4E+03*	*1.1E+00*
		NP-237	5.2E-02	*3.5E+02*	*5.0E+00*
		RA-226	9.4E-01	*2.2E+03*	*1.2E+02*
		RA-228	8.3E-03	*4.7E+03*	7.7E-01
		TH-228	4.3E-03	*1.5E+02*	4.0E-01
		TH-230	3.1E+00	*4.0E+02*	*1.1E+03*
		TH-232	3.2E+00	*4.1E+02*	*1.1E+03*
		U-234	3.2E+00	*4.4E+02*	*1.1E+03*
		U-235/236	9.7E-02	*4.6E+02*	*9.2E+00*
		U-238	4.8E-01	*2.2E+02*	*5.6E+01*
		Arsenic	2.2E-01	*6.1E+02*	*2.0E+01*
		Beryllium	2.9E-03	*1.5E+03*	2.5E-02
		Chromium	4.8E+00	*5.0E+02*	*1.5E+03*
		Benzo(a)anthracene	3.6E-01	*5.8E+02*	*4.7E+01*
		Benzo(a)pyrene	5.4E-02	5.1E+01	7.0E+00
		Benzo(b)fluoranthene	4.3E-01	*1.8E+02*	*5.7E+01*
		Benzo(k)fluoranthene	9.6E-01	*1.6E+02*	*1.3E+02*
		Dibenzo(a,h)anthracene	3.4E-02	*2.0E+00*	*6.3E+00*
		Indeno(1,2,3-cd)pyrene	2.0E-01	1.2E+04	*2.6E+01*
		Aroclor-1254	3.8E-03	*2.8E+01*	3.5E-02
		Aroclor-1260	3.8E-03	*2.5E+01*	3.5E-02
		Dieldrin	2.1E-03	*7.6E+01*	*2.0E-02*
NON-CARCINOGENS	Soil	Arsenic	2.3E+01	6.7E+04	4.1E+02
		U-TOTAL	3.7E+04	6.2E+05	7.7E+01
	Groundwater	U-TOTAL	1.7E-02	1.7E-02	

* Contaminants associated with greater than 1.0 x 10E-6 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration. Numbers in italics represent PRG calculations for contaminants which do not pose a risk of 1.0E-6 or an HI > 0.2.

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ease of reference these tables are presented as Attachment I to this appendix. The detailed information contained in these tables is used to estimate the short-term risk associated with alternative implementation.

C.4.3 SHORT-TERM RISK

C.4.3.1 COC Risks.

Table C.4-12 summarizes the COCs and their concentrations in the material addressed by the alternatives developed for the South Field. For determining short term risks it is assumed that receptors are exposed to the most highly contaminated material for the entire exposure duration identified for that alternative. This is a very highly conservative assumption.

Tables C.4-13(a), (b) and (c) summarize the short term risks associated with the trespassing youth, the non-remedial worker and the off-property farmer during remedial alternative implementation. The short term risks that would exist if the identified COCs were present in the South Field at background concentrations is presented for comparison. Total short term risks associated with the remedial alternatives for South Field are 1.2E-05, 3.2E-06 and 2.5E-06 for the trespassing youth, 1.5E-05, 4.0E-06 and 3.1E-06 and for the noneremedial worker 2.2E-05, 5.9E-06 and 4.6E-06. For the off-property farmer short term risks are 2.2E-05, 5.9E-06 and 4.6E-06. Total hazard index to all receptors is less than 1.0. It is evident that little difference exists among the alternatives regardless of the receptor.

C.4.3.2 Transportation/Construction

Table C.4-14 summarizes the total injuries and fatalities for all workers estimated per construction task for each of the remedial alternatives. Truck transportation injuries and fatalities associated with on-site disposa; activities range from 3.5E-06 to 3.5E-05 and 1.3E-06 to 1.2E-05 respectively. For off-site disposal activities risks range from 3.5E-05 to 1.2E-01 and 1.8E-06 and 1.3E-03 respectively. Train transportation injuries and fatalities associated with off-site disposal alternative ranged from 1.5E-01 to 8.6E-01 to 8.6E-04 to 1.5E-01 respectively. SF2 transportation risks

TABLE C.4-2

SOUTH FIELD ALTERNATIVES

Alternative		Major Activity
SF1	No Action	None
SF2	Off-site disposal	Excavate contaminated material Excavate RCRA waste Transportation Off-site disposal of contaminated material Off-site disposal of RCRA waste
SF3	On-site Disposal	Excavate contaminated material Excavate RCRA waste Transportation On-site disposal of contaminated material On-site disposal of RCRA waste
SF4	Vitrification and on-site disposal	Excavate contaminated material Excavate RCRA waste Treat contaminated material On-site disposal of treated contaminated material Off-site disposal of RCRA waste
SF5	Solidification and on-site disposal of solid waste	Excavate contaminated material Excavate RCRA waste Treat contaminated material Transportation On-site disposal of contaminated material Off-site disposal of RCRA waste
SF6	Soil washing of LLW and on-site disposal	Excavate contaminated material Excavate RCRA waste Transportation Treat contaminated material Off-site disposal of RCRA waste
SF7	In-situ containment	Consolidation of contaminated material In-situ containment of contaminated material

TABLE C.4-12
CONCENTRATION OF COCs IN EXCAVATED MATERIAL
SOUTH FIELD (pCi/g; mg/kg)*

Contaminants of Concern	SF2/SF3/SF4/SF5/SF6/SF7 Contaminated Fill Material
CS-137	0.692
NP-237	0.369
RA-226	9.21
RA-228	3.74
TH-228	13.4
TH-230	13.8
U-234	78.3
U-235/236	4.05
U-238	82.7
Arsenic	6.975
Beryllium	0.88
Chromium	18.008
Benzo(a)anthracene	1.1
Benzo(a)pyrene	1.8
Benzo(b)fluoranthene	1.6
Benzo(k)fluoranthene	1.6
Dibenzo(a,h)anthracene	0.44
Indeno(1,2,3-cd)pyrene	0.62
Aroclor-1254	0.43
Aroclor-1260	0.038
Dieldrin	0.097

* Concentrations are the 95% UCL estimated for the most highly contamina
They are used to estimate short-term risks to non-remedial workers, tresp
off-property farmers during remedial action implementation.

TABLE C.4-13(a)
SOUTH FIELD: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- TRESPASSING YOUTH

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *			
	SF2	SF3/SF4/SF5/SF6**	SF7	BACKGROUND**
CS-137	9.3E-08	2.5E-08	1.9E-08	5.9E-08
NP-237	1.4E-08	3.7E-09	2.9E-09	0.0E+00
RA-226	2.0E-08	5.2E-09	4.0E-09	2.6E-09
RA-228	7.3E-07	1.9E-07	1.5E-07	2.2E-07
TH-228	5.4E-06	1.4E-06	1.1E-06	4.5E-07
TH-230	1.2E-07	3.1E-08	2.4E-08	1.3E-08
U-234	6.0E-07	1.6E-07	1.2E-07	8.0E-09
U-235/236	9.5E-08	2.5E-08	2.0E-08	2.1E-09
U-238	1.5E-06	3.9E-07	3.0E-07	1.9E-08
Arsenic	5.1E-08	1.3E-08	1.0E-08	4.2E-08
Beryllium	2.1E-06	5.7E-07	4.4E-07	1.5E-06
Chromium	2.0E-07	5.2E-08	4.1E-08	1.3E-07
Benzo(a)anthracene	4.3E-09	1.1E-09	8.9E-10	0.0E+00
Benzo(a)pyrene	4.7E-08	1.2E-08	9.7E-09	0.0E+00
Benzo(b)fluoranthene	5.1E-09	1.4E-09	1.1E-09	0.0E+00
Benzo(k)fluoranthene	2.2E-09	5.8E-10	4.5E-10	0.0E+00
Dibenzo(a,h)anthracene	1.3E-08	3.4E-09	2.6E-09	0.0E+00
Indeno(1,2,3-cd)pyrene	4.4E-09	1.2E-09	9.1E-10	0.0E+00
Aroclor-1254	7.6E-07	2.0E-07	1.6E-07	0.0E+00
Aroclor-1260	6.7E-08	1.8E-08	1.4E-08	0.0E+00
Dieldrin	3.0E-07	7.9E-08	6.1E-08	0.0E+00
TOTAL RISK FOR ALTERNATIVE	**1.2E-05**	**3.2E-06**	**2.5E-06**	**2.4E-06**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*			
	SF2	SF3/SF4/SF5/SF6**	SF7**	BACKGROUND**
Arsenic	7.8E-05	7.8E-05	7.8E-05	5.4E-05
Beryllium	5.9E-07	5.9E-07	5.9E-07	9.3E-05
Chromium	1.1E-03	1.1E-03	1.1E-03	1.8E-03
Benzo(a)anthracene				0.0E+00
Benzo(a)pyrene				0.0E+00
Benzo(b)fluoranthene				0.0E+00
Benzo(k)fluoranthene				0.0E+00
Dibenzo(a,h)anthracene				0.0E+00
Indeno(1,2,3-cd)pyrene				0.0E+00
Aroclor-1254				0.0E+00
Aroclor-1260				0.0E+00
Dieldrin	6.5E-06	6.5E-06	6.5E-06	0.0E+00
TOTAL HAZARD FOR ALTERNATIVE	**1.2E-03**	**1.2E-03**	**1.2E-03**	**2.0E-03**

Exposure point concentrations based on most conservative U-238 concentraiton in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (34 months).

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TABLE C.4-13(b)
SOUTH FIELD: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- NON-REMEDIATION WORKER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *			
	SF2	SF3/SF4/SF5/SF6	SF7	BACKGROUND**
CS-137	1.8E-07	4.7E-08	3.7E-08	1.1E-07
NP-237	2.1E-08	5.6E-09	4.4E-09	0.0E+00
RA-226	1.6E-08	4.3E-09	3.3E-09	2.2E-09
RA-228	1.4E-06	3.7E-07	2.9E-07	4.3E-07
TH-228	9.8E-06	2.6E-06	2.0E-06	8.2E-07
TH-230	2.8E-08	7.5E-09	5.8E-09	3.1E-09
U-234	1.4E-07	3.8E-08	3.0E-08	1.9E-09
U-235/236	1.3E-07	3.5E-08	2.7E-08	2.9E-09
U-238	6.9E-07	1.8E-07	1.4E-07	9.0E-09
Arsenic	6.3E-09	1.7E-09	1.3E-09	5.2E-09
Beryllium	1.7E-06	4.6E-07	3.5E-07	1.2E-06
Chromium	2.9E-08	7.7E-09	6.0E-09	1.9E-08
Benzo(a)anthracene	4.3E-11	1.1E-11	8.8E-12	0.0E+00
Benzo(a)pyrene	4.8E-10	1.3E-10	9.9E-11	0.0E+00
Benzo(b)fluoranthene	5.2E-11	1.4E-11	1.1E-11	0.0E+00
Benzo(k)fluoranthene	2.2E-11	5.9E-12	4.6E-12	0.0E+00
Dibenzo(a,h)anthracene	1.3E-10	3.5E-11	2.7E-11	0.0E+00
Indeno(1,2,3-cd)pyrene	4.6E-11	1.2E-11	9.5E-12	0.0E+00
Aroclor-1254	6.0E-07	1.6E-07	1.2E-07	0.0E+00
Aroclor-1260	5.3E-08	1.4E-08	1.1E-08	0.0E+00
Dieldrin	2.4E-07	6.2E-08	4.9E-08	0.0E+00
TOTAL RISK FOR ALTERNATIVE	**1.5E-05**	**4.0E-06**	**3.1E-06**	**2.6E-06**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*			
	SF2	SF3/SF4/SF5/SF6	SF7**	BACKGROUND**
Arsenic	1.3E-07	1.3E-07	1.3E-07	8.0E-06
Beryllium	8.6E-10	8.6E-10	8.6E-10	1.4E-05
Chromium	9.0E-04	9.0E-04	9.0E-04	2.7E-04
Dieldrin	2.5E-08	2.5E-08	2.5E-08	0.0E+00
TOTAL HAZARD FOR ALTERNATIVE	**9.0E-04**	**9.0E-04**	**9.0E-04**	**2.9E-04**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (34 months).

TABLE C.4-13(c)
SOUTH FIELD: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- OFF PROPERTY FARMER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *			
	SF2	SF3/4/5/6	SF7	BACKGROUND**
CS-137	3.7E-11	9.8E-12	7.6E-12	2.4E-11
NP-237	3.0E-08	8.0E-09	6.2E-09	0.0E+00
RA-226	7.8E-08	2.1E-08	1.6E-08	1.0E-08
RA-228	7.3E-09	1.9E-09	1.5E-09	2.2E-09
TH-228	2.9E-06	7.8E-07	6.1E-07	2.5E-07
TH-230	1.1E-06	3.0E-07	2.3E-07	1.2E-07
U-234	5.7E-06	1.5E-06	1.2E-06	7.6E-08
U-235/236	2.9E-07	7.5E-08	5.9E-08	6.2E-09
U-238	1.2E-05	3.2E-06	2.5E-06	1.6E-07
Arsenic	1.7E-08	4.4E-09	3.4E-09	1.4E-08
Beryllium	1.2E-08	3.1E-09	2.4E-09	7.9E-09
TOTAL RISK FOR ALTERNATIVE	**2.2E-05**	**5.9E-06**	**4.6E-06**	**6.4E-07**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathwa

** Background risks/hazards based on the highest alternative exposure duration (34 months).

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TABLE C.4-14
SOUTH FIELD
CONSTRUCTION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES

INJURIES/CONSTRUCTION TASK						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Mobilization and site preparation	3.3E-01	3.3E-01	3.3E-01	3.3E-01	3.3E-01	3.3E-01
Excavate/load/transport waste	3.7E+00	9.8E-01	9.8E-01	9.8E-01	9.8E-01	5.7E-01
Site restoration	7.3E-01	2.0E-01	2.0E-01	2.0E-01	2.0E-01	6.0E-02
Demobilization	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01	1.6E-01
Construct disposal cell	NA	2.7E-01	2.7E-01	2.7E-01	NA	NA
Construct slurry wall	NA	NA	NA	NA	NA	NA
Cap disposal cell	NA	2.5E-01	8.9E-02	8.9E-02	NA	6.5E-01
Total Injuries	**4.9E+00**	**2.2E+00**	**2.0E+00**	**2.0E+00**	**1.7E+00**	**1.8E+00**

FATALITIES/CONSTRUCTION TASK						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Mobilization and site preparation	4.8E-03	4.8E-03	4.8E-03	4.8E-03	4.8E-03	4.8E-03
LLW transferred to staging area	5.4E-02	1.4E-02	1.4E-02	1.4E-02	1.4E-02	8.4E-03
Excavate/load/transport waste	1.1E-02	3.0E-03	3.0E-03	3.0E-03	3.0E-03	8.8E-04
Site restoration	2.4E-03	2.4E-03	2.4E-03	2.4E-03	2.4E-03	2.4E-03
Demobilization	NA	4.0E-03	4.0E-03	4.0E-03	NA	NA
Construct disposal cell	NA	NA	NA	NA	NA	NA
Cap disposal cell	NA	3.7E-03	1.3E-03	1.3E-03	NA	9.6E-03
Total Fatalities	**7.2E-02**	**3.2E-02**	**3.0E-02**	**3.0E-02**	**2.5E-02**	**2.6E-02**

NA=Not Applicable

TABLE C.4-15 (a)
SOUTH FIELD
TRUCK TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES
(Occupational Exposure)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	6.6E-02	2.4E-04	2.4E-04	2.5E-04	3.2E-05	1.8E-04
Total Injury	**6.6E-02**	**2.4E-04**	**2.4E-04**	**2.5E-04**	**3.2E-05**	**1.8E-04**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	3.4E-03	1.2E-05	1.2E-05	1.3E-05	1.6E-06	9.1E-06
Total Fatalities	**3.4E-03**	**1.2E-05**	**1.2E-05**	**1.3E-05**	**1.6E-06**	**9.1E-06**

RCRA WASTE

TRANSPORTATION RISK/TRUCK						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	3.5E-05	3.5E-05	3.5E-05	3.5E-05	3.5E-05	3.5E-05
Total Injury	**3.5E-05**	**3.5E-05**	**3.5E-05**	**3.5E-05**	**3.5E-05**	**3.5E-05**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	1.8E-06	1.8E-06	1.8E-06	1.8E-06	1.8E-06	1.8E-06
Total Fatalities	**1.8E-06**	**1.8E-06**	**1.8E-06**	**1.8E-06**	**1.8E-06**	**1.8E-06**

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRAIN						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	1.5E+01	NA	NA	NA	NA	NA
Total Transportation Injury	**1.5E+01**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	1.5E-01	NA	NA	NA	NA	NA
Total Transportation Fatalities	**1.5E-01**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**

NA=Not Applicable

TABLE C.4-15(a)
(continued)

RESIDUAL WASTE MATERIAL

TRANSPORTATION RISK/TRUCK						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	NA	NA	NA	NA	7.0E-04	NA
Total Transportation Injury	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**7.0E-04**	**0.0E+00**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Excavate/Load/Transport Waste	NA	NA	NA	NA	3.6E-05	NA
Total Transportation Fatalities	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**3.6E-05**	**0.0E+00**

NA=Not Applicable

RESIDUAL WASTE MATERIAL

TRANSPORTATION RISK/TRAIN						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	NA	NA	NA	NA	8.8E-02	NA
Total Transportation Injury	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**8.8E-02**	**0.0E+00**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport Waste	NA	NA	NA	NA	8.8E-04	NA
Total Transportation Fatalities	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**8.8E-04**	**0.0E+00**

NA=Not Applicable

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TABLE C.4-15 (b)
SOUTH FIELD
TRUCK TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES *
(Public Sector)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	1.9E-01	6.9E-04	2.4E-04	7.2E-04	9.2E-05	5.2E-04
Total Transportation Injur	**1.9E-01**	**6.9E-04**	**2.4E-04**	**7.2E-04**	**9.2E-05**	**5.2E-04**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	2.1E-02	7.5E-05	1.2E-05	7.8E-05	1.0E-05	5.7E-05
Total Transportation Fatal	**2.1E-02**	**7.5E-05**	**1.2E-05**	**7.8E-05**	**1.0E-05**	**5.7E-05**

RCRA WASTE

TRANSPORTATION RISK/TRUCK						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	1.0E-04	1.0E-04	3.5E-05	1.0E-04	1.0E-04	1.0E-04
Total Transportation Injur	**1.0E-04**	**1.0E-04**	**3.5E-05**	**1.0E-04**	**1.0E-04**	**1.0E-04**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	1.1E-05	1.1E-05	1.8E-06	1.1E-05	1.1E-05	1.1E-05
Total Transportation Fatal	**1.1E-05**	**1.1E-05**	**1.8E-06**	**1.1E-05**	**1.1E-05**	**1.1E-05**

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRAIN						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	2.3E+01	NA	NA	NA	NA	NA
Total Transportation Injur	**2.3E+01**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	6.0E+00	NA	NA	NA	NA	NA
Total Transportation Fatal	**6.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**

NA=Not Applicable

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Table C.4-15(b)
(continued)

RESIDUAL WASTE MATERIAL

TRANSPORTATION RISK/TRUCK						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	NA	NA	NA	NA	2.1E-03	NA
Total Transportation Injur	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**2.1E-03**	**0.0E+00**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Excavate/Load/Transport W	NA	NA	NA	NA	2.2E-04	NA
Total Transportation Fatal	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**2.2E-04**	**0.0E+00**

NA=Not Applicable

RESIDUAL WASTE MATERIAL

TRANSPORTATION RISK/TRAIN						
INJURIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	NA	NA	NA	NA	1.3E-01	NA
Total Transportation Injur	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**1.3E-01**	**0.0E+00**
FATALITIES/COMPLETED TASK FOR ALL WORKERS						
Task	SF2	SF3	SF4	SF5	SF6	SF7
Excavate/Load/Transport W	NA	NA	NA	NA	3.5E-02	NA
Total Transportation Fatal	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**3.5E-02**	**0.0E+00**

NA=Not Applicable

are significantly higher due to the magnitude of waste transported to the Nevada Test Site and other off-site disposal facilities.

Total construction injuries associated with all alternatives was greater than 1.0. Injuries associated with waste material excavation and loading under SF2 is 3.7E=00. Injuries associated with all other alternatives are less than 1.0. Construction fatalities associated with all alternatives are in the 2.5E-02 to 7.2E-02 range. Public sector risks are comparable to occupational risks.

C.4.4 Long-Term Risk

For ease of reference all risk assessment results are presented in Attachment II to this Appendix. Summary tables are included in this section. Residual risk was estimated for all alternatives and long-term protectiveness was assessed for South Field alternative SF7 (*in situ* containment).

Table C.4-16 (Attachment II) summarizes risk to the expanded trespasser for the consolidation/containment alternative (SF7) and on-site disposal alternatives (SF3, SF4, SF5, SF6). Total risk under all alternatives for this receptor was 5.1E-06 due primarily to the presence of RA-228 and TH-228 which are associated with risks of 2.5E-06 and 4.3E-06 respectively. In addition, chromium is associated with a risk of 1.3E-05. However, this may be on overestimation of risk since the chemical species is unknown. Tables C.4-17(a), C.4-17(b), and C.4-17(c) (Attachment II) summarize risk to the off-property farmer potentially exposed to soil, homegrown produce and animal products containing COCs, respectively for both the consolidation/containment and on-site disposal alternatives. All risks were below 1.0E-06 except those due to arsenic which is not specifically addressed by alternatives. Tables C.4-18(a), C.4-18(b), C.4-18(c), and C.4-18(d) (Attachment II) summarize risk to the on-property farmer potentially exposed to soil, groundwater, homegrown produce and animal products, respectively, following implementation of South Field alternatives SF2, SF3, SF4, SF5, SF6 or SF7. All risks due to the potential migration of uranium to groundwater were below 1.0E-06 except for some risks associated with the migration of U238 to groundwater. Risk to the on-property farmer due to estimated uranium radionuclides in groundwater , produce and livestock is slightly higher than

the risk calculated for background. Tables C.4-19(a), C.4-19(b), and C.4-19(c) (Attachment II) summarize risk to an on-property farmer following implementation of alternative SF7. The risks due to uranium radionuclides are slightly above 1.0E-06. Tables C.4-20(a), C.4-20(b) and C.4-20(c) summarize risk and hazard to an off-property farmer following implementation of SF3, SF4, SF5, SF6 and SF7. All estimated residual risks due to uranium to an off-property farmer following implementation are below 1.0E-06.

Table C.4-21 (a) and (b) summarize the long-term risks and hazards for all receptors under both the consolidation/containment altern (SF7) and on-site disposal alternatives (SF 3/4/5/6).

TABLE C.4-21(a)
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
Consolidation/Containment

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Soil	CS-137	1.7E-06		0.0E+00		0.0E+00		3.7E-05		N/A
(Alternative 7)	NP-237	9.9E-07		5.0E-09		9.5E-05		N/A		N/A
	RA-226	7.7E-08		1.6E-10		9.5E-06		1.4E-06		N/A
	RA-228	2.5E-06		3.0E-11		2.3E-04		1.4E-04		N/A
	TH-228	4.3E-06		2.9E-09		4.0E-04		2.6E-04		N/A
	TH-230	5.6E-09		2.3E-09		1.0E-06		2.1E-06		N/A
	TH-232	4.4E-09		9.7E-10		N/A		1.5E-06		N/A
	U-234	3.4E-08		3.3E-09		6.0E-06		1.4E-06		N/A
	U-235/236	4.4E-07		1.8E-10		4.1E-05		9.9E-07		N/A
	U-238	9.6E-07		8.3E-09		9.3E-05		4.4E-06		N/A
	Arsenic	6.2E-07	3.8E-03	3.7E-07		6.5E-05	6.5E-02	2.6E-05	4.9E-02	N/A
	Chromium	1.3E-05	4.1E-03	1.8E-05	7.8E-01	1.9E-03	1.7E-02	1.3E-05	9.8E-03	N/A
	Benzo(a)anthracene	0.0E+00						N/A		N/A
	Benzo(a)pyrene	1.6E-06						N/A		N/A
	Aroclor-1254	1.1E-06				9.2E-06		N/A		N/A
Groundwater	U234	N/A		1.3E-07		1.5E-07		1.5E-07		
(Alternative	U235/236	N/A		7.1E-09		1.3E-08		1.3E-08		
#7)	U238	N/A		2.5E-07		3.3E-07		3.3E-07		
Homegrown	CS-137	N/A		0.0E+00		0.0E+00		1.4E-09		N/A
Produce	NP-237	N/A		1.9E-10		3.0E-09				N/A
(Dust	RA-226	N/A		3.1E-11		3.7E-10		1.7E-09		N/A
Affected)	RA-228	N/A		2.2E-11		2.8E-10		1.3E-08		N/A
(Alternative 7)	TH-228	N/A		9.8E-12		1.3E-10		7.0E-09		N/A
	TH-230	N/A		4.8E-12		5.4E-11		2.2E-09		N/A
	U-234	N/A		9.6E-12		1.4E-10		1.9E-09		N/A
	U-235	N/A		5.6E-13		8.4E-12		1.6E-10		N/A
	U-238	N/A		2.1E-11		3.1E-10		3.4E-09		N/A
	Arsenic	N/A		2.0E-09	3.9E-06	2.3E-08	4.4E-05	6.5E-10	1.2E-06	N/A
	Chromium	N/A			4.1E-07		5.7E-06		1.5E-07	N/A
	Aroclor 1254	N/A		2.5E-11		4.0E-10				N/A

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TABLE C.4-21(a)
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
Consolidation/Containment

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Homegrown Produce (Groundwater Affected) (Alternative 7)	U-234	N/A		1.3E-07		2.2E-08		2.2E-08		2.2E-08
	U-235/236	N/A		7.1E-09		2.0E-09		2.0E-09		2.0E-09
	U-238	N/A		2.5E-07		4.9E-08		4.9E-08		4.9E-08
Beef/Milk (Dust Affected) (Alternative 7)	CS-137	N/A		*0.0E+00*		0.0E+00		5.4E-09		N/A
	NP-237	N/A		*1.1E-12*		1.1E-10				N/A
	RA-226	N/A		*5.0E-12*		4.0E-10		2.7E-10		N/A
	RA-228	N/A		*3.5E-12*		2.9E-10		2.0E-09		N/A
	TH-228	N/A		*1.8E-14*		1.6E-12		1.3E-11		N/A
	TH-230	N/A		*1.0E-14*		6.8E-13		4.6E-12		N/A
	TH-232	N/A		*4.1E-15*		3.5E-13		3.1E-12		N/A
	U-234	N/A		*2.0E-12*		1.9E-10		3.9E-10		N/A
	U-235	N/A		*1.2E-13*		1.2E-11		3.3E-11		N/A
	U-238	N/A		*4.4E-12*		4.3E-10		7.1E-10		N/A
Beef/Milk Affected) (Alternative 7)	Arsenic	N/A		*3.6E-10*	*6.9E-07*	2.7E-08	5.2E-05	1.2E-10	2.2E-07	N/A
	Chromium	N/A			*3.8E-07*		3.4E-05		1.4E-07	N/A
	Aroclor 1254	N/A		*1.2E-10*		1.3E-08				N/A
Beef/Milk (Groundwater Affected) (Alt #7)**	U-234	N/A		*2.3E-09*		5.5E-09		2.6E-09		1.3E-08
	U-235	N/A		*1.2E-10*		3.4E-10		2.3E-10		5.4E-10
	U-238	N/A		*4.3E-09*		1.0E-08		5.7E-09		1.9E-08
TOTAL (Alternative #2)		**9.5E-06**	**1.5E-02**	**4.1E-07**	**7.8E-01**	**2.8E-03**	**8.2E-02**	**4.9E-04**	**5.9E-02**	**1.1E-07**

*Long-term protectiveness represents Alternative 7 for this subunit.

**For background summaries risk calculations are independent of the alternative used for remedial action.

Numbers in italics represent summary calculations for contaminants that are not classified as COCs.

N/A = Not Applicable.

TABLE C.4-21(b)
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
On-Site Disposal

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Soil	CS-137	6.2E-07		0.0E+00		0.0E+00		3.7E-05		N/A
(Alternative 3/4/5/6)	NP-237	9.9E-07		5.2E-09		9.5E-05		N/A		N/A
	RA-226	5.3E-08		9.7E-10		9.5E-06		1.4E-06		N/A
	RA-228	2.5E-06		6.2E-11		2.3E-04		1.4E-04		N/A
	TH-228	4.3E-06		6.4E-09		4.0E-04		2.6E-04		N/A
	TH-230	2.9E-08		1.4E-08		1.0E-06		2.1E-06		N/A
	TH-232	2.8E-08		1.2E-08		N/A		1.5E-06		N/A
	U-234	2.7E-08		6.5E-08		6.0E-06		1.4E-06		N/A
	U-235/236	4.6E-07		3.3E-09		4.1E-05		9.9E-07		N/A
	U-238	9.7E-07		1.0E-07		9.3E-05		4.4E-06		N/A
	Arsenic	4.7E-07	3.8E-03	5.1E-07		6.5E-05	6.5E-02	2.6E-05	4.9E-02	N/A
	Chromium	1.3E-05	4.1E-03	2.8E-05	7.8E-01	1.9E-03	1.7E-02	1.3E-05	9.8E-03	N/A
	Benzo(a)anthracene	0.0E+00						N/A		N/A
	Benzo(a)pyrene	1.6E-06						N/A		N/A
	Aroclor-1254	5.3E-09				9.2E-06		N/A		N/A
Groundwater										
(Alternatives 3/4/5/6)	U234	N/A		1.1E-07		6.8E-07				7.3E-07
	U235/236	N/A		5.5E-09		3.6E-08				3.8E-08
	U238	N/A		2.1E-07		1.3E-06				1.4E-06
Homegrown	CS-137	N/A		2.8E-12		0.0E+00		1.4E-09		N/A
Produce	NP-237	N/A		2.0E-10		3.0E-09				N/A
(Dust Affected)	RA-226	N/A		1.8E-10		3.7E-10		1.7E-09		N/A
(Alternative 3/4/5/6)	RA-228	N/A		4.5E-11		2.8E-10		1.3E-08		N/A
	TH-228	N/A		2.1E-11		1.3E-10		7.0E-09		N/A
	TH-230	N/A		2.8E-11		5.4E-11		2.2E-09		N/A
	U-234	N/A		1.9E-10		1.4E-10		1.9E-09		N/A
	U-235	N/A		9.7E-12		8.4E-12		1.6E-10		N/A
	U-238	N/A		2.5E-10		3.1E-10		3.4E-09		N/A
	Arsenic	N/A		2.9E-09	5.5E-06	2.3E-08	4.4E-05	6.5E-10	1.2E-06	N/A
	Chromium	N/A			6.5E-07		5.7E-06		1.5E-07	N/A
	Aroclor 1254	N/A		4.6E-11		4.0E-10				N/A

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TABLE C.4-21(b)
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
On-Site Disposal

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Homegrown Produce										
(Groundwater Affected)										
(Alternatives3/4/5/6)	U-234	N/A		1.1E-07		1.0E-07				
	U-235/236	N/A		5.5E-09		5.4E-09				
	U-238	N/A		2.1E-07		2.0E-07				
Beef/Milk	CS-137	N/A		*1.1E-11*		0.0E+00		5.4E-09		N/A
(Dust Affected)	NP-237	N/A		*1.2E-12*		1.1E-10				N/A
(Alternative 3/4/5/6)	RA-226	N/A		*2.9E-11*		4.0E-10		2.7E-10		N/A
	RA-228	N/A		*7.1E-12*		2.9E-10		2.0E-09		N/A
	TH-228	N/A		*4.0E-14*		1.6E-12		1.3E-11		N/A
	TH-230	N/A		*5.9E-14*		6.8E-13		4.6E-12		N/A
	TH-232	N/A		*4.9E-14*		3.5E-13		3.1E-12		N/A
	U-234	N/A		*3.9E-11*		1.9E-10		3.9E-10		N/A
	U-235	N/A		*2.0E-12*		1.2E-11		3.3E-11		N/A
	U-238	N/A		*5.3E-11*		4.3E-10		7.1E-10		N/A
Beef/Milk	Arsenic	N/A		*5.1E-10*	*1.4E-09*	2.7E-08	5.2E-05	1.2E-10	2.2E-07	N/A
(Dust Affected)	Beryllium	N/A		*3.0E-11*	*6.0E-07*	1.8E-09	8.2E-08	1.3E-11	6.1E-10	N/A
	Aroclor 1254	N/A		*2.2E-10*		1.3E-08				N/A
	Aroclor 1260	N/A		*1.4E-10*		0.0E+00				N/A
(Groundwater Affected)										
(Alternatives 3/4/5/6)	U-234	N/A		*1.9E-09*		1.3E-08				
	U-235	N/A		*9.6E-11*		7.9E-10				
	U-238	N/A		*3.7E-09*		2.4E-08				
TOTAL (Alternatives #3/4/5/6)		**4.2E-06**	**7.9E-03**	**2.9E-05**	**7.8E-01**	**2.8E-03**	**8.2E-02**	**4.9E-04**	**9.7E-03**	**2.1E-06**

*Long-term protectiveness represents Alternative 7 for this subunit.

**For background summaries risk calculations are independent of the alternative used for remedial action.

Numbers in italics represent summary calculations for contaminants that are not classified as COCs.

N/A = Not Applicable.

C.5.0 INACTIVE FLYASH PILE

C.5.1 SUMMARY OF BASELINE RISK ASSESSMENT

Risk and hazard associated with the Inactive Flyash Pile (IFP) for receptors assuming future land-use are summarized in Section 1.7.3 of the FS report. The largest risks are from direct contact with surface soil containing the naturally occurring radioisotopes RA-228, TH-228 and U-238 and the inorganics arsenic and beryllium; and, from the estimated future on- and off-property concentrations of U234, U235/236 and U238 in groundwater.

As with the South Field, concern is greatest for the direct contact risks resulting from U-238 in soil and from the isotopes of uranium in groundwater. Risks exceeding 1.OE-06 were indicated for the future expanded trespasser exposed to one or more of the following radionuclides in soil: NP-237, RA-226, RA-228, and/or TH-228. Nearly all radiological risk due to groundwater is due to the estimated presence of NP-237, U-234, U-235/236 and U-238 which is not only assumed to be directly contacted by future receptors but which also contaminates homegrown produce and livestock food products which are then ingested by receptors.

All CPCs associated with a risk of greater than 1.0E-06 or an HI of greater than 0.2 for any receptor are identified as COCs. Mitigation of risks attributable to these COCs is a general RAO for the remedial alternatives evaluated. Attainment of PRGs is the means by which mitigation of residual risk is assessed. Risk-based PRGs are derived for the future on-property farmer; the future off-property farmer; and, an expanded trespasser. It is assumed that all alternatives achieve PRGs. Table C.5-1 summarizes the COCs and PRGs determined for these three future receptors for the IFP.

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TABLE C.5-1.1

INACTIVE FLYASH PILE
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	CS-137	1.20E-02	*5.1E+04*	*1.1E+00*
		NP-237	5.26E-02	*8.9E+02*	*5.1E+00*
		RA-226	9.55E-01	*7.6E+03*	*1.2E+02*
		RA-228	8.27E-03	*2.4E+04*	7.7E-01
		TH-228	4.29E-03	*3.4E+02*	4.0E-01
		U-235/236	9.82E-02	*1.1E+03*	*9.3E+00*
		U-238	4.76E-01	*4.7E+02*	*5.8E+01*
		Arsenic	4.64E-02	*2.1E+03*	2.0E+01
		Beryllium	2.58E-03	*1.9E+03*	2.5E-02
		Dibenzo(a,h)anthracene	5.33E-03	*7.0E+03*	*6.3E+00*
			PRG (mg/L)	PRG (mg/L)	PRG (mg/L)
NON-CARCINOGENS	Groundwater	U-Total	1.7E-02	3.2E-01	N/A

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration. Numbers in italics represent PRG calculations which do not pose a risk greaters than 1.0E-06 or HI > 0.2.

C.5.2 REMEDIAL ALTERNATIVES

Tasks associated with construction, transportation and short-term COC exposure have been evaluated for each of the seven alternatives for the IFP. These alternatives, along with the No Action alternative, are summarized in Table C.5-2.

The potential for construction and transportation hazards, as well as short-term exposure to CPCs exists for all seven action alternatives, IFP2 through IFP8. All alternatives include excavation of contaminated waste material. This excavated material is disposed of off-site in one alternative, disposed of on-site without treatment in two alternatives and treated before on-site disposal in three alternatives. The three treatment options, vitrification, solidification, and soil washing, all require some form of additional soil handling which may result in increased resuspension of contaminated dust thus increasing the severity of short-term COC exposure. Vitrification and solidification have similar construction and soil handling procedures. Soil washing involves more soil handling and a greater opportunity to COC exposure through by-product handling. Only IFP7 requires consolidation/containment of the contaminated material.

In addition to contaminated material handling, the IFP alternatives address flyash disposal. Removal of flyash results in physical hazards and short-term COC exposure. Six of the eight action alternatives require excavation of the flyash. This ash is disposed of off-site in one alternative, stabilized and disposed of on-site in four alternatives and disposed of on-site without stabilization in one alternative. Again, only IFP7 requires consolidation/containment of the noncontaminated flyash.

A detailed summary of alternatives IFP2 through IFP8 listing individual tasks, COC exposure potential and labor hours required to complete individual construction tasks can be found in Tables C.5-3 through C.5-9. For ease of reference these tables are collected in Attachment I of this appendix. The information contained in these tables is used to estimate short-term risks associated with alternative implementation.

TABLE C.5-2

INACTIVE FLYASH ALTERNATIVES

Alternative		Major Activity
IFP1	No Action	None
IFP2	Off-site disposal	Excavate contaminated material Excavate flyash Transportation Off-site disposal of contaminated material Off-site disposal of flyash
IFP3	On-site Disposal	Excavate contaminated material Transportation Excavate flyash On-site disposal of contaminated material On-site disposal of flyash
IFP4	Vitrification and on-site disposal with flyash stabilization	Excavate contaminated material Excavate flyash Treat contaminated material Treat flyash On-site disposal of contaminated material On-site disposal of treated flyash
IFP5	Solidification and on-site disposal with flyash stabilization	Excavate contaminated material Excavate flyash Treat contaminated material Treat flyash On-site disposal of contaminated material On-site disposal of flyash

TABLE C.5-2 (Continued)

INACTIVE FLYASH ALTERNATIVES

Alternative		Major Activity
IFP6	Soil washing and on-site disposal with flyash stabilization	Excavated contaminated material Excavate flyash Treat contaminated material Treat flyash On-site disposal of treated flyash On-site disposal of contaminated Off-site disposal of contaminated material off-site disposal of residuals
IFP7	Consolidated/Containment	Consolidate contaminated material In-situ containment of containment of contaminated material
IFP8	On-site disposal with flyash stabilization	Excavate contaminated material Excavate flyash Treatment of flyash On-site disposal of contaminated material On-site disposal of treated flyash

C.5.3 SHORT-TERM RISK

C.5.3.1 COC Risk.

Table C.5-11 summarizes the COCs and their concentrations in the material addressed by the alternatives developed for the Inactive Flyash Pile. For determining short-term risks, it is assumed that receptors are exposed to the most highly contaminated material for the entire exposure duration identified for that alternative. This is a very highly conservative assumption. This is because the durations of exposures to the most highly contaminated material will most likely not differ substantially among alternatives, since its volume remains the same. Yet, the risk calculations assume that the concentration of COCs in all removed material is the same.

Tables C.5-12(a), (b) and (c) summarize the short-term risk potentially experienced by a trespassing youth, a nonremedial worker and an off-property farmer during implementation of the alternatives. For comparison the short-term risk that would result if the COCs identified were present in the Inactive Flyash Pile at background concentrations is provided. Total short-term COC risk associated with off-site disposal (IFP2) for the non-remedial worker, off-property farmer and trespassing youth were estimated to be 1.0E-05, 7.0E-05 and 1.8E-05 respectively. Total short term risk associated with on-site disposal for the aforementioned receptors is 1.2E-05, 7.9E-05 and 2.1E-05 respectively. These risks were mostly due to the presence of U-238, arenic anberyllium is surfacesoil. Total hazard indices were less than 1.0. It is evident that all alternatives are associated with roughly the same degree of short- term risk to the trespassing youth, the nonremedial worker, and the off-property farmer; and, that the risk is perhaps an order of magnitude greater than background for all receptors for most alternatives.

C.5.3.2 Transportation Risk.

TABLE C.5-11
CONCENTRATION OF COCs IN EXCAVATED MATERIAL
INACTIVE FLYASH PILE (pCi/g; mg/kg)*

Contaminants of Concern	IFP2/IFP3/IFP4/IFP5/IFP6/IFP7 Contaminated Fill Material
NP-237	37.3
RA-228	2.048
TH-228	2.279
U-234	771
U-235/236	49.1
U-238	1570
Arsenic	49.7
Beryllium	1.509

* Concentrations are the 95% UCL estimated for the most highly contaminated material. They are used to estimate short-term risks to non-remedial workers, trespassers and off-property farmers during remedial action implementation.

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TABLE C.5-12(a)
INACTIVE FLYASH PILE: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- TRESPASSING YOUTH

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *		
	IFP2	P3/IFP4/IFP5/IFP6/IFP7/IF	BACKGROUND**
NP-237	6.3E-07	7.0E-07	0.0E+00
RA-228	1.8E-07	2.0E-07	1.1E-07
TH-228	4.0E-07	4.5E-07	2.2E-07
U-234	2.6E-06	2.9E-06	0.0E+00
U-235/236	5.1E-07	5.7E-07	0.0E+00
U-238	1.2E-05	1.4E-05	9.6E-09
Arsenic	1.6E-07	1.8E-07	2.2E-08
Beryllium	1.6E-06	1.8E-06	7.3E-07
TOTAL RISK FOR ALTERNATIVE	**1.8E-05**	**2.1E-05**	**1.1E-06**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*		
	IFP2	P3/IFP4/IFP5/IFP6/IFP7/IF	BACKGROUND
Arsenic	2.7E-03	2.7E-03	1.9E-03
Beryllium	4.2E-03	4.2E-03	1.7E-03
TOTAL HAZARD FOR ALTERNATIVE	**6.9E-03**	**6.9E-03**	**3.6E-03**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (17 months).

TABLE C.5-12(b)
INACTIVE FLYASH PILE: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- NON-REMEDIATION WORKER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *		
	IFP2	IFP3/IFP4/IFP5/IFP6/IFP7/IFP8	BACKGROUND**
NP-237	9.5E-07	1.1E-06	0.0E+00
RA-228	3.4E-07	3.8E-07	2.1E-07
TH-228	7.3E-07	8.3E-07	4.1E-07
U-234	6.3E-07	7.1E-07	0.0E+00
U-235/236	7.1E-07	8.1E-07	0.0E+00
U-238	5.8E-06	6.5E-06	4.5E-09
Arsenic	2.0E-08	2.3E-08	2.7E-09
Beryllium	1.3E-06	1.5E-06	5.9E-07
TOTAL RISK FOR ALTERNATIVE	**1.0E-05**	**1.2E-05**	**1.2E-06**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*		
	IFP2	IFP3/IFP4/IFP5/IFP6/IFP7/IFP8	BACKGROUND
Arsenic	2.0E-03	2.0E-03	2.3E-04
Beryllium	3.4E-03	3.4E-03	1.4E-03
TOTAL HAZARD FOR ALTERNATIVE	**5.4E-03**	**5.4E-03**	**1.6E-03**

Exposure point concentrations based on most contaminated U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.
** Background risks/hazards based on the highest alternative exposure duration (17 months).

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TABLE C.5-12(c)
INACTIVE FLYASH PILE: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- OFF-PROPERTY FARMER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *		
	IFP3/IFP4/IFP5/IFP6/IFP7/IFP8/IFP9	IFP2**	BACKGROUND**
NP-237	1.3E-06	1.2E-06	0.0E+00
RA-228	1.8E-09	1.5E-09	1.1E-09
TH-228	2.2E-07	1.9E-07	1.2E-07
U-234	2.5E-05	2.2E-05	0.0E+00
U-235/236	1.5E-06	1.3E-06	0.0E+00
U-238	1.0E-04	8.9E-05	7.9E-08
Arsenic	5.2E-08	4.6E-08	6.9E-09
Beryllium	8.8E-09	7.8E-09	4.0E-09
TOTAL RISK FOR ALTERNATIVE	**1.3E-04**	**1.1E-04**	**2.1E-07**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (17 months).

Table C.5-13 summarizes the total injuries and fatalities (for all workers) estimated per construction tasks for each of the remedial alternatives. In general construction injuries were 3.0E + 00 and total construction fatalities were approximately 4.0E+00.

Tables C.5-14(a) and (b) summarize the potential for injuries and fatalities involved in the transportation of waste removed from the Inactive Flyash Pile area. Occupational injuries and fatalites from truck transportation were 3.1E-04 for AFP3, AFP4 and AFP5 and 2.9E-03 for AFP2. Fatalities associated with truck transportaiton were 1.6E-05 for AFP3, AFP4 and AFP5 and 1.5E-04 for AFP2. Risk was greater fro the off-site disposal option (AFP2) due to waste volume transported to the Nevada Test Site and other off-site disposal facilities. Train transportation injuries and fatalities associated with FP2 were 6.8E-01 and 6.8E-03 respectively. Public sector truck injuries and fatalities were 9.1E-04 for on-site disposal options and 8.5E-03 for off-site disposal options. Public sector train injuries and fatalities were 1.0E+00 and 2.7E-01 respectively.

C.5.4 Long-Term Risk

For ease of reference all risk assessment results are collected in Attachment II to this Appendix. Summary tables are included here in the text.

Residual risk is the risk remaining at the remediated subunit after the alternative has been implemented. For the IFP two soil types were identified with the remediated subunit; exposed till and exposed GMA. As indicated previously, exposure point concentrations used to calculate residual risk were selected based on the highest concentration in identifed soil types. Hence, estimated risks may be an overestimation of the actual risk associated with the subunit.

Table C.5-15 (Attachment II) summarizes risk to the expanded trespasser potentially exposed to COCs following implementation of alternatives IFP3, IFP4, IFP5, IFP6, IFP7 or IFP8. Total residual risk for this receptor is 4.7E-06 due mostly to estmated concentrations of arsenic and TH-228 in expsoed soil which has an associated risk of 1.6E-06

TABLE C.5-13
(continued)

FATALITIES/CONSTRUCTION TASK FOR ALL WORKERS							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Mobilization and site preparation	4.8E-03	4.8E-03	3.6E-03	3.6E-03	3.6E-03	4.8E-03	3.6E-03
Excavate/load/transport waste	2.4E-02	2.0E-02	2.0E-02	2.7E-02	2.7E-02	2.7E-02	2.7E-02
Site restoration	3.8E-03	1.9E-03	1.9E-03	1.9E-03	1.9E-03	1.9E-03	1.9E-03
Demobilization	3.8E-03	1.9E-03	1.9E-03	1.9E-03	1.9E-03	1.9E-03	1.9E-03
Construct disposal cell	NA	5.9E-03	5.4E-03	5.4E-03	NA	NA	5.4E-03
Cap treatment cell	NA	7.8E-03	3.9E-03	3.9E-03	NA	4.8E-03	3.9E-03
Total Construction Injuries	**3.6E-02**	**4.3E-02**	**3.7E-02**	**4.4E-02**	**3.5E-02**	**4.1E-02**	**4.4E-02**

NA=Not Applicable

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TABLE C.5-13
INACTIVE FLYASH PILE
CONSTRUCTION RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES

INJURIES/CONSTRUCTION TASK FOR ALL WORKERS							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Mobilization and site preparation	3.3E-01	3.3E-01	2.4E-01	2.4E-01	2.4E-01	3.3E-01	2.4E-01
Excavate/load/transport waste	1.6E+00	1.4E+00	1.4E+00	1.8E+00	1.8E+00	1.8E+00	1.8E+00
Site restoration	2.6E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01
Demobilization	2.6E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01	1.3E-01
Construct disposal cell	NA	4.0E-01	3.7E-01	3.7E-01	NA	NA	3.7E-01
Cap disposal cell	NA	5.3E-01	2.6E-01	2.6E-01	NA	3.3E-01	2.6E-01
Total Construction Injuries	**2.5E+00**	**2.9E+00**	**2.5E+00**	**3.0E+00**	**2.4E+00**	**2.8E+00**	**3.0E+00**

NA=Not Applicable

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TABLE C.5-14 (a)
INACTIVE FLYASH PILE
TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES
(Occupational Exposure)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK							
INJURIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	2.4E-02	2.7E-02	2.7E-02	1.3E-03	1.8E-04	7.5E-04	6.6E-02
Total Injuries	**2.4E-02**	**2.7E-02**	**2.7E-02**	**1.3E-03**	**1.8E-04**	**7.5E-04**	**6.6E-02**
FATALITIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	1.2E-03	1.4E-03	1.4E-03	6.5E-05	9.0E-06	3.9E-05	3.4E-03
Total Fatalities	**1.2E-03**	**1.4E-03**	**1.4E-03**	**6.5E-05**	**9.0E-06**	**3.9E-05**	**3.4E-03**

TRANSPORTATION RISK/TRAIN							
INJURIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	4.9E+00	NA	NA	NA	9.0E-02	NA	NA
Total Injuries	**4.9E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**9.0E-02**	**0.0E+00**	**0.0E+00**
FATALITIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	4.9E-02	NA	NA	NA	9.0E-04	NA	NA
Total Fatalities	**4.9E-02**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**9.0E-04**	**0.0E+00**	**0.0E+00**

TABLE C.5-14 (a)
(continued)

RESIDUAL WASTE MATERIAL
TRANSPORTATION RISK/TRUCK

INJURIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	NA	NA	NA	NA	2.0E-03	NA	NA
Total Injuries	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**2.0E-03**	**0.0E+00**	**0.0E+00**

FATALITIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	NA	NA	NA	NA	1.0E-04	NA	NA
Total Fatalities	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**1.0E-04**	**0.0E+00**	**0.0E+00**

NA=Not Applicable

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TABLE C.5-14 (b)
INACTIVE FLYASH PILE
TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES
(Public Sector)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK							
INJURIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	7.1E-02	8.0E-02	8.0E-02	3.7E-03	5.2E-04	2.2E-03	1.9E-01
Total Injuries	**7.1E-02**	**8.0E-02**	**8.0E-02**	**3.7E-03**	**5.2E-04**	**2.2E-03**	**1.9E-01**
FATALITIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	7.7E-03	8.7E-03	8.7E-03	4.0E-04	5.6E-05	2.4E-04	2.1E-02
Total Fatalities	**7.7E-03**	**8.7E-03**	**8.7E-03**	**4.0E-04**	**5.6E-05**	**2.4E-04**	**2.1E-02**

TRANSPORTATION RISK/TRAIN							
INJURIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	7.2E+00	NA	NA	NA	1.3E-01	NA	NA
Total Injuries	**7.2E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**1.3E-01**	**0.0E+00**	**0.0E+00**
FATALITIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	1.9E+00	NA	NA	NA	3.5E-02	NA	NA
Total Fatalities	**1.9E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**3.5E-02**	**0.0E+00**	**0.0E+00**

NA=Not Applicable

TABLE C.5-14(b)
(continued)

RESIDUAL WASTE

TRANSPORTATION RISK/TRUCK							
INJURIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	NA	NA	NA	NA	5.7E-03	NA	NA
Total Injuries	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**5.7E-03**	**0.0E+00**	**0.0E+00**
FATALITIES							
Task	IF2	IF3	IF4	IF5	IF6	IF7	IF8
Excavate/Load/Transport Waste	NA	NA	NA	NA	6.2E-04	NA	NA
Total Fatalities	**0.0E+00**	**0.0E+00**	**0.0E+00**	**0.0E+00**	**6.2E-04**	**0.0E+00**	**0.0E+00**

NA=Not Applicable

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and 2.1E-06 respectively. Risks due to all other potentially exposed contaminant concentraitons was below 1.0E-06. Total hazard index for this receptor is less than 1.0.

Table C.5-16 (a), (b) and (c) summarizes residual risk and hazard to the off-property farmer. Although there were no soil COCs associated with the off-property farmer for this subunit in the baseline risk assessment, residuals risks were calculated to determine if potentially exposed soil would result in an unacceptable risk to this receptor. Total residual risk associated with soil and groundwater exposure routes is 3.6E-06, due primarily to future estimated concentrations of arsenic in exposed soil.

Tables C.5-17 (a), (b) and (c) (Attachment II) summarize risk to the on property farmer exposed to U-234, U-235/236 and U-238 in groundwater and groundwater affected produce and animal products following implementation of on-site remedial alternatives (IFP 3/4/5/6) and consolidation/containment (IFP7). Risks to this receptor are estimated to only slightly exceed the 1.0E-06 level.

Tables C.5-18 (a), (b) and (c) (Attachment II) summarize risk to the off-property farmer exposed to potentially contaminated groundwater and groundwater affected produce and animal products following implementation of on-site disposal alternatives (IFP 3/4/5/6) and consolidation/containment of flyash (IFP7). All residual risks to this receptor are below 1.0E-06. Table C.5-19 summarizes the residual risk for all receptors as well as demonstrating the long-term protectiveness of alternative 7.

TABLE C.5-19
INACTIVE FLYASH PILE
SUMMARY OF LONG-TERM RISKS AND HAZARDS
Alternative 3/4/5/6/7/8

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen
Soil	CS-137	*0.0E+00*		*0.0E+00*	
	NP-237	*3.6E-08*		*2.7E-10*	
	RA-226	*8.4E-09*		*1.5E-10*	
	RA-228	9.5E-07		*2.3E-11*	
	TH-228	2.1E-06		*2.4E-09*	
	TH-230	*1.6E-09*		*3.0E-09*	
	TH-232	*4.7E-10*		*7.5E-10*	
	U-234	*8.9E-10*		*1.4E-09*	
	U-235/236	*8.7E-09*		*9.6E-11*	
	U-238	*2.5E-08*		*3.5E-09*	
	Arsenic	1.6E-06	3.4E-03	*2.6E-06*	
Groundwater (Alternative 7)	U-234	N/A		3.6E-07	
	U-235/236	N/A		1.3E-07	
	U-238	N/A		1.2E-08	
Groundwater (Alternative 2/3/4/5/6)	U-234			1.1E-07	
	U-235/236			5.5E-09	
	U-238			2.1E-07	
Homegrown Produce (Dust Affected)	CS-137	N/A		*0.0E+00*	
	NP-237	N/A		*9.6E-15*	
	RA-226	N/A		*2.7E-14*	
	RA-228	N/A		*1.5E-14*	
	TH-228	N/A		*7.5E-15*	
	TH-230	N/A		*6.0E-15*	
	TH-232	N/A		*1.4E-15*	
	U-234	N/A		*3.8E-15*	
	U-235/236	N/A		*2.7E-16*	
	U-238	N/A		*8.4E-15*	
	Arsenic	N/A		*1.4E-09*	*2.7E-06*
Homegrown Produce (Groundwater Affected) Alternative 7	U-234	N/A		5.4E-08	
	U-235/236	N/A		1.9E-08	
	U-238	N/A		1.8E-09	

TABLE C.5-19
(continued)

		Alternative 3/4/5/6/7/8			
		Expanded Trespasser		Off-Property Farmer	
Medium	Parameter	*Carcinogen*	*Non-Carcinogen*	*Carcinogen*	*Non-Carcinogen*
Homegrown	U-234	N/A		1.6E-08	
Produce	U-235/236	N/A		8.2E-10	
(Groundwater	U-238	N/A		3.1E-08	
Affected)		N/A			
Alternative 3/4/5/6		N/A			
Beef/Milk	CS-137	N/A		*0.0E+00*	
(Dust	NP-237	N/A		*5.6E-17*	
Affected)	RA-226	N/A		*4.4E-15*	
	RA-228	N/A		*2.3E-15*	
	TH-228	N/A		*1.4E-17*	
	TH-230	N/A		*1.2E-17*	
	TH-232	N/A		*3.0E-18*	
	U-234	N/A		*7.9E-16*	
	U-235	N/A		*5.7E-17*	
	U-238	N/A		*1.8E-15*	
	Arsenic	N/A		*2.5E-10*	*4.7E-07*
Beef/Milk	U-234	N/A		6.3E-09	
(Groundwater	U-235/236	N/A		2.3E-09	
Affected)	U-238	N/A		2.2E-10	
Alternative 7					
Beef/Milk	U-234	N/A		1.9E-09	
(Groundwater	U-235/236	N/A		9.6E-11	
Affected)	U-238	N/A		3.7E-09	
Alternative 3/4/5/6					
TOTAL		**4.7E-06**	**3.4E-03**	***3.6E-06***	***3.1E-06***

*Background summary risk calculations are independent of the alternative used for remedial action.
Numbers in italics represent risk calculations for contaminants that were not COCs for the identified receptor.
N/A=Not Applicable
N/D=No Data

C.6.0 SOLID WASTE LANDFILL

C.6.1 SUMMARY OF BASELINE RISK ASSESSMENT

Risk and hazards associated with the Solid Waste Landfill for receptors assuming future land use are summarized in Section 1.7.3 of the FS report. Assuming current land use, exposures of the trespassing youth to RA-228 and TH-228 contributed to a risk which barely exceeded 1.0E-06 . Risks to future receptors were restricted to soil pathways for on-property receptors and were well within the 1.0E-06 to 1.0E-06 risk range. About 96% of the radiological risk was attributable to estimated external radiation from NP-237, RA-228, TH-228, U-234 and U-238 for all receptors.

Concern is greatest for the isotopes of uranium since they may be present at levels above naturally occurring background. Groundwater is predicted to be unimpacted by contamination at the Solid Waste Landfill.

Table C.6-1 summarizes the COCs and PRGs determined for the Solid Waste Landfill. For assessing short-term risk, potential exposures to all CPCs are evaluated. For estimating residual risk COCs are presumed to be present at the PRG for the identified receptor, or the unremediated soil concentration. In the event the calculated PRG is more stringent than current background concentrations, the background is selected as the PRG. Derivation of risk-based PRGs is discussed in detail in Attachment III.

C.6.2 REMEDIAL ALTERNATIVES

Tasks associated with construction, transportation are evaluated for each of the alternatives for the Solid Waste Landfill (SWL). These alternatives, along with the No Action alternative, are summarized in Table C.6-2.

Both construction and transportation hazards, as well as short-term COC exposure associated with excavation of contaminated waste material exist for all of action alternatives, SWL2 through SWL4. Two alternatives call for

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1 of 2

TABLE C.6-1.1

SOLID WASTE LANDFILL
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	CS-137	1.20E-02	*5.34E+04*	*1.1E+00*
		NP-237	5.29E-02	*4.00E+03*	*5.0E+00*
		PU-238	9.15E-01	*3.08E+03*	*1.8E+02*
		RA-226	9.63E-01	*2.31E+04*	*1.2E+02*
		RA-228	8.27E-03	*4.76E+04*	7.7E-01
		TH-228	4.30E-03	*1.68E+03*	4.0E-01
		TH-230	6.80E+00	*4.56E+03*	*1.8E+03*
		U-234	6.59E+00	*5.01E+03*	*1.6E+03*
		U-235/236	9.89E-02	*5.22E+03*	*9.3E+00*
		U-238	5.62E-01	*2.51E+03*	5.8E+01
		Arsenic	2.19E-01	*8.03E+02*	*2.0E+01*
		Beryllium	2.86E-03	*1.43E+03*	2.5E-02
		Chromium	1.43E+01	*5.76E+03*	*3.9E+03*
		Benzo(a)pyrene	5.52E-02	*5.29E+02*	*7.0E+00*
		Benzo(b)fluoranthene	4.41E-01	*1.35E+03*	*5.7E+01*
		Dibenzo(a,h)anthracene	4.97E-02	*4.80E+02*	*6.3E+00*
		Indeno(1,2,3-cd)pyrene	1.64E-01	*5.34E+01*	*2.6E+01*
NON-CARCINOGENS	Surface Soil	Arsenic	2.35E+01	*6.65E+05*	*4.1E+02*
		U-Total	3.29E+01	*6.56E+06*	7.7E+01

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration. Numbers in italics represent PRG calculations for contaminants that do not pose a risk greater than 1.0E-06 or an HI > 0.2.

TABLE C.6-2

SOLID WASTE LANDFILL ALTERNATIVES

Alternative	Major Activity
SWL1 No Action	None
SWL2 Off-site disposal	Excavate contaminated material Transportation Off-site disposal of contaminated material
SWL3 On-site disposal	Excavate contaminated material On-site disposal of contaminated material
SWL4 Consolidation/containment and off-site disposal	Consolidated contaminant material Excavate some contaminated material Transportation Off-site disposal of some contaminant material In-situ containment of remaining contaminated material

excavation of contaminated material with options for either on-site or off-site disposal of the excavated material. Alternative SWL4 assumes most of the materials present at the SWL will be consolidated/contained with a small amount transported off-site for disposal.

A detailed summary of alternatives SWL2 through SWL4 listing individual construction tasks, transportation parameters and COC exposure potential and labor hours required to complete individual construction tasks can be found in Tables C.6-3 through C.6-5. For ease of reference, these tables are collected in Attachment I of this appendix. Information contained in these tables is used to estimate the short-term risk associated with alternative implementation.

C.6.3 SHORT-TERM RISK

C.6.3.1 COC Risk.

Table C.6-6 summarizes the COCs and their concentrations in the material addressed by the alternatives developed for the Solid Waste Landfill. For determining short-term risks it is assumed that receptors are exposed to the most highly contaminated material for the entire exposure duration identified for that alternative. This is a very highly conservative assumption. This is because the durations of exposures to the most highly contaminated material will most likely not differ substantially among alternatives, since its volume remains the same.

Table C.6-7(a), (b) and (c) summarize the short-term risk potentially experienced by a trespassing youth, a nonremedial worker, and an off-property farmer during implementation of the alternatives. For comparison, the short-term risk that would result if the COCs identified were present in the Solid Waste Landfill at background concentrations is provided. Short term risks potentially experienced by the non-remediaiton worker, off-property farmer and trespassing youth during implementation of of SWL2 are 1.9E-06, 7.5E-06 and 2.0E-06 respectively. Short term risk associated with SWL 3 for the above receptors is 4.2E-07, 1.6E-06 and 4.3E-07; for SWL4 2.5E-07,

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TABLE C.6-6
CONCENTRATION OF COCs IN EXCAVATED MATERIAL
SOLID WASTE LANDFILL (pCi/g; mg/kg)*

Contaminants of Concern	SWL2/SWL3/SWL4 Contaminated Fill Material
CS-137	0.38
NP-237	1.67
PU-238	0.433
RA-226	2.26
RA-228	3.15
TH-228	1.983
TH-230	15.96
U-234	54.179
U-235/236	3.78
U-238	98.45
Arsenic	7.062
Beryllium	1.065
Chromium	20.489
Benzo(a)anthracene	0
Benzo(a)pyrene	13
Benzo(b)fluoranthene	15
Dibenzo(a,h)anthracene	3
Indeno(1,2,3-cd)pyrene	6.5

*Concentrations are the 95% UCL estimated for the most highly contaminated material. They are used to estimate short-term risks to non-remedial workers, trespassers and off-property farmers during remedial action implementation.

TABLE C.6-7(a)
SOLID WASTE LANDFILL: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- TRESPASSING YOUTH

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *			
	SWL2	SWL3	SWL4	BACKGROUND**
CS-137	1.7E-08	3.8E-09	2.3E-09	2.0E-08
NP-237	2.2E-08	4.7E-09	2.8E-09	0.0E+00
PU-238	1.8E-09	3.9E-10	2.3E-10	0.0E+00
RA-226	1.6E-09	3.5E-10	2.1E-10	8.8E-10
RA-228	2.1E-07	4.5E-08	2.7E-08	7.5E-08
TH-228	2.7E-07	5.8E-08	3.5E-08	1.5E-07
TH-230	4.6E-08	1.0E-08	6.0E-09	4.3E-09
U-234	1.4E-07	3.1E-08	1.8E-08	2.7E-09
U-235/236	3.0E-08	6.5E-09	3.9E-09	7.0E-10
U-238	8.4E-08	1.8E-08	1.1E-08	8.8E-10
Arsenic	4.8E-08	1.1E-08	6.3E-09	4.0E-08
Beryllium	8.8E-07	1.9E-07	1.1E-07	4.9E-07
Chromium	7.6E-08	1.7E-08	9.9E-09	4.3E-08
Benzo(a)pyrene	1.1E-07	2.5E-08	1.5E-08	0.0E+00
Benzo(b)fluoranthene	1.6E-08	3.5E-09	2.1E-09	0.0E+00
Dibenzo(a,h)anthracene	2.9E-08	6.4E-09	3.8E-09	0.0E+00
Indeno(1,2,3-cd)pyrene	1.6E-08	3.4E-09	2.1E-09	0.0E+00
TOTAL RISK FOR ALTERNATIVE	**2.0E-06**	**4.3E-07**	**2.6E-07**	**8.3E-07**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*			
	SWL2	SWL3	SWL4	BACKGROUND**
Arsenic	1.6E-03	1.6E-03	1.6E-03	1.9E-06
Beryllium	3.7E-03	3.7E-03	3.7E-03	6.1E-04
Chromium	2.6E-04	2.6E-04	2.6E-04	0.0E+00
TOTAL HAZARD FOR ALTERNATIVE	**5.5E-03**	**5.5E-03**	**5.5E-03**	**6.1E-04**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (11.5 months).

TABLE C.6-7(b)
SOLID WASTE LANDFILL: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- NON-REMEDIATION WORKER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *			
	SWL2	SWL3	SWL4	BACKGROUND**
CS-137	3.3E-08	7.2E-09	4.3E-09	3.9E-08
NP-237	3.3E-08	7.1E-09	4.2E-09	0.0E+00
PU-238	4.0E-10	8.8E-11	5.3E-11	0.0E+00
RA-226	1.3E-09	2.9E-10	1.8E-10	7.3E-10
RA-228	4.0E-07	8.7E-08	5.2E-08	1.4E-07
TH-228	4.9E-07	1.1E-07	6.4E-08	2.8E-07
TH-230	1.1E-08	2.4E-09	1.4E-09	1.0E-09
U-234	3.4E-08	7.3E-09	4.4E-09	6.4E-10
U-235/236	4.2E-08	9.1E-09	5.5E-09	9.8E-10
U-238	1.6E-07	3.4E-08	2.0E-08	1.7E-09
Arsenic	2.1E-08	4.7E-09	2.8E-09	1.8E-08
Beryllium	7.1E-07	1.5E-07	9.2E-08	4.0E-07
Chromium	1.1E-08	2.4E-09	1.5E-09	6.3E-09
Benzo(a)pyrene	1.2E-09	2.5E-10	1.5E-10	0.0E+00
Benzo(b)fluoranthene	1.7E-10	3.6E-11	2.2E-11	0.0E+00
Dibenzo(a,h)anthracene	3.0E-10	6.6E-11	3.9E-11	0.0E+00
Indeno(1,2,3-cd)pyrene	1.6E-10	3.5E-11	2.1E-11	0.0E+00
TOTAL RISK FOR ALTERNATIVE	**1.9E-06**	**4.2E-07**	**2.5E-07**	**8.9E-07**

NONCARCINOGENIC HAZARD

Contaminant of Concern	Total Hazard*			
	SWL2	SWL3	SWL4	BACKGROUND**
Arsenic	2.8E-04	2.8E-04	2.8E-04	2.8E-07
Beryllium	2.4E-03	2.4E-03	2.4E-03	9.0E-05
Chromium	1.4E-05	1.4E-05	1.4E-05	0.0E+00
TOTAL HAZARD FOR ALTERNATIVE	**2.7E-03**	**2.7E-03**	**2.7E-03**	**9.1E-05**

Exposure point concentrations based onmost conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (11.5 months).

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TABLE C.6-7(c)
SOLID WASTE LANDFILL: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- OFF-PROPERTY FARMER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *			
	SWL2	SWL3	SWL4	BACKGROUND**
CS-137	6.9E-12	1.5E-12	9.0E-13	8.0E-12
NP-237	4.6E-08	1.0E-08	6.0E-09	0.0E+00
PU-238	1.6E-08	3.5E-09	2.1E-09	0.0E+00
RA-226	6.5E-09	1.4E-09	8.4E-10	3.5E-09
RA-228	2.1E-09	4.5E-10	2.7E-10	7.5E-10
TH-228	1.5E-07	3.2E-08	1.9E-08	8.3E-08
TH-230	4.4E-07	9.6E-08	5.7E-08	4.1E-08
U-234	1.3E-06	2.9E-07	1.7E-07	2.6E-08
U-235/236	9.0E-08	2.0E-08	1.2E-08	2.1E-09
U-238	4.9E-06	1.1E-06	6.4E-07	5.3E-08
Arsenic	5.7E-08	1.2E-08	7.4E-09	4.6E-08
Beryllium	4.8E-09	1.0E-09	6.2E-10	2.7E-09
Chromium	4.5E-07	9.7E-08	5.8E-08	2.5E-07
Benzo(a)pyrene	4.2E-08	9.2E-09	5.5E-09	0.0E+00
Benzo(b)fluoranthene	6.0E-09	1.3E-09	7.8E-10	0.0E+00
Dibenzo(a,h)anthracene	1.1E-08	2.4E-09	1.4E-09	0.0E+00
Indeno(1,2,3-cd)pyrene	5.9E-09	1.3E-09	7.7E-10	0.0E+00
TOTAL RISK FOR ALTERNATIVE	**7.5E-06**	**1.6E-06**	**9.8E-07**	**5.1E-07**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (11.5 months).

TABLE C.6-8
SOLID WASTE LANDFILL
CONSTRUCTION RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES*

	INJURIES			FATALITIES		
Task	SWL2	SWL3	SWL4	SWL2	SWL3	SWL4
Mobilization and site preparation	3.3E-01	3.3E-01	3.3E-01	4.8E-03	4.8E-03	4.8E-03
Excavate/load/transport waste	1.3E+00	1.3E-01	6.2E-01	1.8E-02	1.9E-03	9.0E-03
Site Restoration	4.1E-01	8.2E-02	NA	6.0E-03	1.2E-03	NA
Demobilization	1.6E-01	1.6E-01	1.5E-01	2.4E-03	2.4E-03	2.3E-03
Construct disposal cell	NA	6.5E-02	NA	NA	9.6E-04	NA
Cap disposal cell	NA	1.6E-01	3.3E-01	NA	2.4E-03	4.8E-03
Total Construction Injury	**2.1E+00**	**9.3E-01**	**1.4E+00**	**3.2E-02**	**1.4E-02**	**2.1E-02**

*Total construction injury calculated using total crew labor hours needed to complete task.
NA=Not Applicable

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TABLE C.6-9(a)
SOLID WASTE LANDFILL
TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES*
(OCCUPATIONAL EXPOSURE)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK			
INJURIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	4.0E-02	1.1E-04	4.5E-05
			0.0E+00
Total Injury	**4.0E-02**	**1.1E-04**	**4.5E-05**
FATALITIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	2.0E-03	5.8E-06	2.3E-06
			0.0E+00
Total Fatality	**2.0E-03**	**5.8E-06**	**2.3E-06**

TRANSPORTATION RISK/TRAIN			
INJURIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	5.0E+00	N/A	NA
Total Injury	**5.0E+00**	**0.0E+00**	**0.0E+00**
FATALITIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	5.0E-02	N/A	NA
Total Fatality	**5.0E-02**	**0.0E+00**	**0.0E+00**

NA=Not Applicable

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TABLE C.6-9(b)
SOLID WASTE LANDFILL
TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES*
(PUBLIC EXPOSURE)

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK			
INJURIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	4.0E-02	1.1E-04	4.5E-05
Total Injury	**4.0E-02**	**1.1E-04**	**4.5E-05**
FATALITIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	2.0E-03	5.8E-06	2.3E-06
Total Fatality	**2.0E-03**	**5.8E-06**	**2.3E-06**

TRANSPORTATION RISK/TRAIN			
INJURIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	5.0E+00	N/A	NA
Total Injury	**5.0E+00**	**0.0E+00**	**0.0E+00**
FATALITIES			
Task	SWL2	SWL3	SWL4
Excavate/Load/Transport Waste	5.0E-02	N/A	NA
Total Fatalities	**5.0E-02**	**0.0E+00**	**0.0E+00**

NA=Not Applicable

9.8E-07 and 2.6E-07 respectively. It is evident that the risk is in most cases close to or within the background range for all receptors for most alternatives.

C.6.3.2 Transportation/Construction Risk.

Table C.6-8 summarizes the total injuries and fatalities for all workers estimated per construction tasks for each of the remedial alternatives. There is very little difference between the alternatives in either measure, since the alternatives involve either a degree of excavation or of waste packaging that contributes to a similar degree of hazard.

Table C.6-9 summarizes the risk of injuries and fatalities among occupational or public sectors receptors associated with transportation. Truck transportation injuries and fatalities associated with all remedial alternatives ranged from 5.7E-04 to 2.2E-02 and 5.9E-06 to 1.1E-03 respectively. The off-site remedial opiton was associated with the greater risk since it involved transport of larger volumes of waste. Again, very little difference exists among alternatives.

C.6.4 Long-Term Risk

Long-term risk due to COCs present at the remediated Solid Waste Landfill were not estimated since all alternatives eliminate any potential exposures to surface soil, and groundwater is not impacted.

C.7.0 LIME SLUDGE PONDS

C.7.1 SUMMARY OF THE BASELINE RISK ASSESSMENT

Risk and hazard associated with the Lime Sludge Pond (LSP) for receptors assuming future land-use are summarized in Section 1.7.4 of the FS report. Risks due to COCs in groundwater across all pathways did not exceed 1 x 10^{-6} for the off-property resident farmer. Total risk associated with surface soil exposures for this receptor did not exceed the 1.0E-06. Risks associated with the future expanded trespasser exceeded 1 x 10^{-06} due primarily to direct contact with surface soil containing the radionuclides RA-228, TH-228 and U-238 and to the presence of some PAHs.

Table C.7-1(a) and 7-1(b) summarize the COCs and PRGs determined for the Lime Sludge Ponds.

C.7.2 REMEDIAL ALTERNATIVES

Tasks associated with construction and transportation and short-term exposure are evaluated for each of four remedial alternatives. These alternatives, along with the No Action Alternative, are summarized in Table C.7-2.

Both physical hazards and chemical exposure associated with excavation of contaminated waste material exists for all remedial alternatives, LSP2 through LSP5. All alternatives include some excavation of contaminated material. This excavated material is disposed of off-site in one alternative, and two alternatives require on-site disposal without prior treatment. LSP4 involves in-situ containment of the majority of the contaminated material.

Physical hazards are associated with excavation of lime sludge. Three alternatives require excavation of the lime sludge. LSP2 includes off-site disposal of the excavated lime sludge. LSP3 requires on-site disposal and the LSP8

TABLE C.7-1.1

LIME SLUDGE PONDS
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Soil	CS-137	1.20E-02	*3.0E+05*	*1.1E+00*
		NP-237	5.28E-02	*6.0E+03*	*5.0E+00*
		RA-226	9.60E-01	*5.0E+04*	*1.2E+02*
		RA-228	8.27E-03	*1.6E+05*	7.7E-01
		TH-228	4.29E-03	*2.3E+03*	4.0E-01
		TH-230	5.62E+00	*6.2E+03*	*1.7E+03*
		U-234	5.61E+00	*6.9E+03*	*1.6E+03*
		U-235/236	9.86E-02	*7.2E+03*	*9.3E+00*
		U-238	5.46E-01	*3.5E+03*	5.8E+01
		Arsenic	2.22E-01	*1.3E+04*	*2.0E+01*
		Beryllium	2.86E-03	*1.1E+04*	2.5E-02
		Aroclor-1254	3.82E-03	*1.6E+03*	3.5E-02
		Benzo(a)anthracene	3.68E-01		*4.7E+01*
		Benzo(a)pyrene	5.51E-02	*2.7E+03*	*7.0E+00*
		Benzo(b)fluoranthene	4.39E-01	*7.4E+03*	*5.7E+01*
		Dibenzo(a,h)anthracene	4.96E-02	*2.5E+03*	*6.3E+00*
		Indeno(1,2,3-cd)pyrene	2.03E-01	*1.9E+05*	*2.6E+01*
NON-CARCINOGENS	Soil	U-TOTAL	2.43E+02	*3.7E+07*	7.7E+01

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration. Numbers in italics represent PRG calculations for contaminants that do not pose a risk greater than 1.0E-06

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TABLE C.7-2

LIME SLUDGE PONDS ALTERNATIVES

Alternative		Major Activity
LSP1	No Action	None
LSP2	Off-site disposal	Excavate contaminated material Transportation Off-site disposal of contaminated material Off-site disposal of sludge
LSP3	On-site disposal	Excavate contaminated material Transportation On-site disposal of contaminated material
LSP4	In-situ containment	Consolidate Contaminated Material Excavate some contaminated material Off-site disposal of some contaminated material In-situ containment of contaminated material
LSP5	On-site disposal of LLW and stabilization and on-site disposal of lime sludge	Excavate contaminated material Excavate sludge Treatment of sludge On-site disposal of LLW On-site disposal of treated sludge

alternative requires on-site disposal of the lime sludge following stabilization. Only one alternative calls for in-situ containment (LSP4).

A detailed summary of alternatives LSP2 through LSP5 listing individual construction tasks, COC exposure potential and labor hours required to complete individual construction tasks can be found in Tables C.7-3 through C.7-6. For ease of reference, these tables are collected in Attachment I of this appendix. The information contained in these tables is used to estimate the short-term risk associated with alternative implementation.

C.7.3 SHORT-TERM RISK

C.7.3.1 COC Risk.

Table C.7-10 summarizes the COCs and their concentrations in the material addressed by the alternatives developed for the Lime Sludge Pond. For determining short-term risks, it is assumed that receptors are exposed to the most highly contaminated material for the entire exposure duration identified for that alternative. This is a very highly conservative assumption. This is because the durations of exposures to the most highly contaminated material will most likely not differ substantially among alternatives, since its volume is the same.

Table C.7-11(a), (b) and (c) summarize the short-term risk potentially experienced by a trespassing youth, a nonremedial worker and an off-property farmer during implementation of the alternatives. For comparison the short term-risk that would result if the COCs identified were present at background concentrations is provided. Short term risks associated with implementation of LSP2 are 1.3E-06, 1.2E-06 and 2.4E-06 respectively; for LSP3 2.1E-06, 7.7E-07, and 1.5E-06; and LSP5 3.9E-05, 3.3E-07 and 6.5E-07. Short term risks associated with LSP5 were less than 1.0E-06. Hence, short term risk for all alternatives is equal to or less than background for all receptors for most alternatives.

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C.7.3.2 Transportation/Construction Risk.

TABLE C.7-10
CONCENTRATION OF COCs IN EXCAVATED MATERIAL
LIME SLUDGE PONDS (pCi/g; mg/kg)*

Contaminants of Concern	LSP2/LSP3/LSP4/LSP5 Contaminated Surface Soil
RA-228	1.75
TH-228	2.91
TH-230	44.8
U-238	71.388
Arsenic	7.379
Beryllium	1.588
Aroclor-1254	0.59
Benzo(a)pyrene	0.1

* Concentrations are the 95% UCL estimated for the most highly contaminated material. They are used to estimate short-term risks to non-remedial workers, trespassers and off-property farmers during remedial action implementation.

TABLE C.7-11(a)
LIME SLUDGE PONDS: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- TRESPASSING YOUTH

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *				
	LSP2	LSP3	LSP4	LSP5	BACKGROUND**
RA-228	5.5E-08	8.7E-08	3.7E-08	1.6E-06	1.9E-06
TH-228	1.9E-07	3.0E-07	1.3E-07	5.5E-06	3.7E-06
TH-230	6.2E-08	9.8E-08	4.2E-08	1.8E-06	1.1E-07
U-238	2.1E-07	3.2E-07	1.4E-07	6.0E-06	1.6E-07
Arsenic	2.4E-08	3.8E-08	1.6E-08	7.1E-07	9.8E-07
Beryllium	6.3E-07	9.8E-07	4.2E-07	1.8E-05	1.2E-05
Aroclor-1254	1.7E-07	2.6E-07	1.1E-07	4.9E-06	0.0E+00
Benzo(a)pyrene	4.2E-10	6.6E-10	2.8E-10	1.2E-08	0.0E+00
TOTAL RISK FOR ALTERNATIVE	**1.3E-06**	**2.1E-06**	**9.0E-07**	**3.9E-05**	**1.9E-05**

Contaminant of Concern	Total Hazard*				
	LSP2	LSP3	LSP4	LSP5	BACKGROUND**
Arsenic	7.9E-04	7.9E-04	7.9E-04	7.9E-04	4.6E-06
Beryllium	4.4E-03	4.4E-03	4.4E-03	4.4E-03	1.5E-03
TOTAL HAZARD FOR ALTERNATIVE	**5.2E-03**	**5.2E-03**	**5.2E-03**	**5.2E-03**	**1.5E-03**

Exposure point concentrations based onmost conservative U-238 concentraiton in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (28 months).

TABLE C.7-11(b)
LIME SLUDGE PONDS: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- NON-REMEDIATION WORKER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *				
	LSP2	LSP3	LSP4	LSP5	BACKGROUND**
RA-228	1.1E-07	6.8E-08	2.9E-08	1.3E-06	3.5E-07
TH-228	3.4E-07	2.2E-07	9.4E-08	4.1E-06	6.7E-07
TH-230	1.5E-08	9.5E-09	4.1E-09	1.8E-07	2.5E-09
U-238	9.6E-08	6.1E-08	2.6E-08	1.1E-06	7.4E-09
Arsenic	1.1E-08	6.8E-09	2.9E-09	1.3E-07	4.3E-08
Beryllium	5.0E-07	3.2E-07	1.4E-07	6.0E-06	9.7E-07
Aroclor-1254	1.3E-07	8.5E-08	3.7E-08	1.6E-06	0.0E+00
Benzo(a)pyrene	4.3E-12	2.7E-12	1.2E-12	5.1E-11	0.0E+00
TOTAL RISK FOR ALTERNATIVE	**1.2E-06**	**7.7E-07**	**3.3E-07**	**1.4E-05**	**2.0E-06**

Contaminant of Concern	Total Hazard*				
	LSP2	LSP3	LSP4	LSP5	BACKGROUND**
Arsenic	2.9E-04	2.9E-04	2.9E-04	2.9E-04	6.8E-07
Beryllium	3.6E-03	3.6E-03	3.6E-03	3.6E-03	2.2E-04
TOTAL HAZARD FOR ALTERNATIVE	**3.9E-03**	**3.9E-03**	**3.9E-03**	**3.9E-03**	**2.2E-04**

Exposure point concentrations based on most conservative U-238 concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (28 months).

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TABLE C.7-11(c)
LIME SLUDGE PONDS: SURFACE SOIL
SHORT-TERM RISKS ASSOCIATED WITH REMEDIAL ALTERNATIVES -- OFF-PROPERTY FARMER

CARCINOGENIC RISK

Contaminant of Concern	Total Carcinogenic Risk *				
	LSP2	LSP3	LSP4	LSP5	BACKGROUND**
RA-228	5.5E-10	3.5E-10	1.5E-10	2.8E-09	1.8E-09
TH-228	1.0E-07	6.6E-08	2.8E-08	5.3E-07	2.0E-07
TH-230	5.9E-07	3.8E-07	1.6E-07	3.0E-06	1.0E-07
U-238	1.7E-06	1.1E-06	4.6E-07	8.6E-06	1.3E-07
TOTAL RISK FOR ALTERNATIVE	**2.4E-06**	**1.5E-06**	**6.5E-07**	**1.2E-05**	**4.3E-07**

Exposure point concentrations based on most conservative concentration in contaminated waste material.

* Total carcinogenic risk and total hazard represents a summation of risk and summation of hazard across all applicable soil pathways.

** Background risks/hazards based on the highest alternative exposure duration (28 months).

TABLE C.7-12
LIME SLUDGE PONDS
CONSTRUCTION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES

TOTAL INJURIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Mobilization and site preparation	3.3E-01	3.3E-01	3.3E-01	3.3E-01
Excavate/load/transport waste	6.0E-01	1.9E-01	6.5E-02	1.5E+00
Site restoration	1.6E-01	1.6E-01	6.5E-02	1.6E-01
Demobilization	NA	1.6E-01	6.5E-02	1.6E-01
Construct cell	NA	8.2E-02	NA	8.2E-02
Cap cell	NA	5.9E-02	NA	1.2E-01
Total Injury	**1.1E+00**	**9.8E-01**	**5.2E-01**	**2.4E+00**

TOTAL FATALITES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Mobilization and site preparation	4.8E-03	4.8E-03	4.8E-03	4.8E-03
Excavate/load/transport waste	8.8E-03	2.8E-03	9.6E-04	2.2E-02
Site restoration	2.4E-03	2.4E-03	9.6E-04	2.4E-03
Demobilization	NA	2.4E-03	9.6E-04	2.4E-03
Construct cell	NA	1.2E-03	NA	1.2E-03
Cap cell	NA	8.7E-04	NA	1.8E-03
Total Fatality	**1.6E-02**	**1.4E-02**	**7.7E-03**	**3.5E-02**

NA=Not Applicable

TABLE C.7-13(a)
LIME SLUDGE PONDS
TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES*
Occupational

CONTAMINATED WASTE MATERIAL

TRANSPORTATION RISK/TRUCK				
TOTAL INJURIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Excavate/Load/Transport Waste	1.8E-02	9.4E-05	1.1E-03	7.4E-05
Total Injury	**1.8E-02**	**9.4E-05**	**1.1E-03**	**7.4E-05**
TOTAL FATALITIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Excavate/Load/Transport Waste	9.1E-04	4.8E-06	5.5E-05	3.8E-06
Total Fatality	**9.1E-04**	**4.8E-06**	**5.5E-05**	**3.8E-06**

EXEMPTED WASTE

TRANSPORTATION RISK/TRUCK				
TOTAL INJURIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Excavate/Load/Transport Waste	NA	NA	NA	7.4E-05
Total Injury	**0.0E+00**	**0.0E+00**	**0.0E+00**	**7.4E-05**
TOTAL FATALITIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Excavate/Load/Transport Waste	NA	NA	NA	3.8E-06
Total Fatality	**0.0E+00**	**0.0E+00**	**0.0E+00**	**3.8E-06**

NA=Not Applicable

TABLE C.7-13(b)
LIME SLUDGE PONDS
TRANSPORTATION RISK ASSOCIATED WITH REMEDIAL ALTERNATIVES
Public Sector

LOW LEVEL WASTE/IMPACTED SOIL

TRANSPORTATION RISK/TRUCK				
TOTAL INJURIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Excavate/Load/Transport Waste	5.2E-02	2.8E-04	1.1E-03	2.2E-04
Total Injury	5.2E-02	2.8E-04	1.1E-03	2.2E-04
TOTAL FATALITIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Excavate/Load/Transport Waste	5.7E-03	3.0E-05	5.5E-05	2.4E-05
Total Fatality	5.7E-03	3.0E-05	5.5E-05	2.4E-05
TRANSPORTATION RISK/TRAIN				
TOTAL INJURIES/COMPLETED TASK				
Task	LS2	LS3	LS4	LS5
Excavate/Load/Transport Waste	2.6E+00	NA	NA	NA
Total Injury	2.6E+00	0.0E+00	0.0E+00	0.0E+00
FATALITIES				
Task	LS2	LS3	LS5	LS5
Excavate/Load/Transport Waste	6.8E-01	NA	NA	NA
Total Fatality	6.8E-01	0.0E+00	0.0E+00	0.0E+00

NA=Not Applicable

Table C.7-12 summarizes the total injuries and fatalities (for all workers) estimated per construction task for each of the remedial alternatives. In general, total construction injuries ranged from 5.2E-01 to 2.4E + 00 and total construction fatalities ranged from 7.7E-03 to 3.5E-02. Alternatives associated with the greatest amount of material excavation, packaging and movement were associated with the greatest potential for injury. Fatalities are about equally likely for all alternatives.

Tables C.7-13 (a) and (b) summarize the potential for injuries and fatalities involved in the transportation of waste removed from the Lime Sludge Pond area. In general, total transportation injuries for occupational exposures and public sector exposures ranged from 1.3E-04 to 1.8E-02 and 3.9E-04 to 5.2E-02 respectively. Total transportation fatalities under the aforementioned exposure scenarios were 4.0E-05 to 5.7E-03 and 6.4E-06 to 9.1E-04 respectively. Train transportation was an option for alternative LSP5. Injuries and fatalities to rail workers associated with this option is 1.3E-04 and 6.9E-06 respectively. Injuries and fatalities to the public are 3.9E-04 and 4.3E-05 respectively.

C.7.4 Long-Term Risk

Long-term risk due to COCs present at the remediated Lime Sludge Ponds were not estimated since all alternatives eliminate any potential exposures to surface soil, and groundwater is not impacted.

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C.8.0 LONG-TERM PROTECTIVENESS OF ON-SITE DISPOSAL CELL

The preferred alternative for all subunits involves placement of contaminated wastes in a common on-site disposal cell. This cell is described in detail in Section 5.2.3 of the FS report and very generally in Section C.2.1 of this appendix. For the purpose of assessing the long-term protectiveness of this alternative, groundwater modeling was utilized to determine U-234, U-235/236 and U-238 concentrations immediately below the disposal cell and at the site downgradient fence line. Based on ODAST modeling results, which demonstrate contaminant loading concentrations into the Great Miami Aquifer, maximum U-234, U-235/236 and U-238 concentrations on-site and at the FEMP fenceline is zero. Hence, the on-site disposal cell is adequately protective.

ATTACHMENT I

Relevant Information for Alternatives

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Table C.6-3 Relevant Information, Solid Waste Landfill, Alternative 2
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Table C.7-3 Relevant Information, Lime Sludge Ponds, Alternative 2
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TABLE C.3-3 ACTIVE FLYASH PILE ALTERNATIVE 2

Alternative AFP2 - Active Flyash Pile
Off-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duratio (days)	Total Crew (person)	Total Crew Labor Hour (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total In Place Volume (ash) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	Total Volume (ash) Transported (Truck) (cubic yards)	One-way Distance Transported (Truck (miles)
Mobilization and Site Preparation	Y	64	1	384	6					
* Excavate/ Load/ Transport Contaminated Material	Y	176	10	13,620	8	10,300	65,000	11,845	68,250	111
Contaminated Material Transferred to Staging Area	Y	63	14	7,083	8					
Radiologic Testing of Soil (in place)	Y	63	1	128	2					
Contaminated Material Packaging and Testing	Y	69	6	3,291	8					
Drying Contaminated Material	Y	69	8	274	0.50					
Water Collection During Excavation	Y	32	1	16	0.50					
Verification Sampling	Y	8	3	183	8					
Site Restoration	N	16	6	768	8					
Demobilization	N	32	1	192	6					

Assumptions:

Density (soil)(lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Load Capacity (max 48,000 lb/truck)(soil)(lb/truck)=	48,000	540 cubic feet/truck	20 cubic yards/truck
Load Capacity (max 48,000 lb/truck)(ash)(lb/truck)=	29,700	540 cubic feet/truck	20 cubic yards/truck
Maximum Truck Capacity (lb)=	80,000		
Weight of Truck + Trailer (lb)=	32,000		
Weight of ISO Container (lb)=	5,000		
Weight of IBC Container (lb)=	900		
Number of ISO Containers/Truck =	1		
IBC Container (82 cubic feet)(lb soil /container)=	8200		
IBC Containers per ISO Container=	4		
ISO Containers per Railcar=	3		
Non-exclusiveTrain Capacity (10 Railcars/trip)(tons/trip)=	492		
(cubic yards/trip)	364		
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from Active Fly Ash Pile to staging area	
Distance from train to NTS (miles)	111		
Distance to exempt waste disposal facility (miles)=	25		

Alternative has been developed to achieve PRGs associated with the on-property and off-property resident farmer and assumes future land use under private ownership

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.3-3 ACTIVE FLYASH PILE ALTERNATIVE 2

Alternative AFP2 - Active Flyash Pile (continued)

One-way Distance (ash) Transported (Truck) (miles)	Total Numbe of Trucks	Total Number of Trucks (ash)	Total Volume Transported (Railcar) (cubic yards)	One-way Distance Transported (Railcar) (miles/trip)	Total Number of Trains
25	914	3,413	11,845	2,275	33

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TABLE C.3-4 ACTIVE FLYASH PILE ALTERNATIVE 3

Alternative AFP3 - Active Flyash Pile
On-Site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)
Mobilization and Site Preparation	Y	64	5	2,560	8			
* Excavate/ Load/ Transport Contaminated Material	Y	176	14	19,712	8	71,700	75,955	111
Contaminated Material Transferred to Staging Area	Y	176	1	356	2			
Water Collection During Excavation	Y	32	1	16	0.50			
Verification Sampling	N	13	3	301	8			
Construct Disposal Cell	N	54	32	13,926	8			
Load Disposal Cell	Y	176	2	2,816	8			
Cap Disposal Cell	Y	50	21	8,422	8			
Site Restoration	N	16	6	768	8			
Demobilization	N	32	1	192	8			

Assumptions:

Density (soil)(lb/cubic feet) =	135		
Density (ash)(lb/cubic feet) =	65		
Density (contaminated material)(lb/cubic foot)=	72		
(65,000 cy ash, 6,700 cy soil)			
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (contaminated material)(%)=	6	540 cubic feet/truck	20 cubic yards/truck
Load Capacity (max 48,000 lb/truck)(contaminated material) (lb/truck	38,632	540 cubic feet/truck	20 cubic yards/truck
Maximum Truck Capacity (lb)=	80,000		
Weight of Truck + Trailer (lb)=	32,000		
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from Active Fly Ash Pile to staging area	
Distance to on-site disposal cell (miles)	1		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

TABLE C.3-4 ACTIVE FLUSH PILE ALTERNATIVE 3

Total Number of Trucks
3,798

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TABLE C.3-5 ACTIVE FLYASH PILE ALTERNATIVE 4

Alternative AFP4 - Active Flyash Pile
On-Site Disposal with Flyash Stabilization

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume (LLW) Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	Total Number of Trucks
Mobilization and Site Preparation	Y	64	10	5,120	8				
* Excavate/ Load/ Transport Contaminated Material	Y	176	6	7,866	8	71,600	75,798	111	3,790
Water Collection During Excavation	Y	32	1	16	0.50				
Verification Sampling	Y	7	3	158	8				
Stabilize Flyash	Y	108	8	6,881	8				
Transport Solidified Flyash	Y	176	1	1,124	8				
Transport Contaminated Material	Y	176	1	1,124	8				
Construct Disposal Cell	N	56	32	14,336	8				
Load Disposal Cell	Y	176	1	1,124	8				
Cap Disposal Cell	Y	12	21	1,995	8				
Site Restoration	N	16	6	768	8				
Demobilization	N	32	1	192	8				

Assumptions:

Density (soil)(lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Density (contaminated material)(lb/cubic foot)=	59		
(71,600 cy ash, 6,700 cy soil)			
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (contaminated material)(%)=	6		
Load Capacity (max 48,000 lb/truck)(contaminated material)(lb/tr	31,820	540 cubic feet/truck	20 cubic yards/truck
Maximum Truck Capacity (lb)=	80,000		
Weight of Truck + Trailer (lb)=	32,000		
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from Active Fly Ash Pile to staging area	
Distance to on-site disposal cell (miles)	1		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

TABLE C.3-6 ACTIVE FLYASH PILE ALTERNATIVE 5

Alternative AFP5 - Active Flyash Pile Consolidation/Containment

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	32	1	192	6		
* Excavate/Consolidate Contaminated Material	Y	176	21	29,568	8	71,700	75,955
Water Collection During Excavation and Long-term Dewatering	Y	64	1	32	0.50		
Verification Sampling	Y	13	3	314	8		
Cap Consolidated Contaminated Material	Y	64	21	10,752	8		
Site Restoration	N	16	3	192	4		
Demobilization	N	32	1	192	6		

Assumptions:

Density (soil)(lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Density (contaminated material)(lb/cubic foot)=	59		
(65,000 cy ash, 6,700 cy soil)			
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (contaminated material)(%)=	6		
Load Capacity (max 48,000 lb/truck)(contaminated material)(lb/truc	31,971	540 cubic feet/truck	20 cubic yards/truck
Maximum Truck Capacity (lb)=	80,000		
Weight of Truck + Trailer (lb)=	32,000		
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from Active Fly Ash Pile to staging area	
Distance to on-site disposal cell (miles)	1		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported. For transported distances less than 1 mile, calculated values use a 1 mile value.

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TABLE C.3-6 ACTIVE FLYASH PILE ALTERNATIVE 5

One-way Distance Transported (Truck) (miles)	Total Number of Trucks
111	3,798

TABLE C.4-3 SOUTH FIELD ALTERNATIVE 2

Alternative SF2 - South Field
Off-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hrs)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total In Place Volume (RCRA) (cubic yards)	Total Volume Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10			
* Excavate/ Load/ Transport Contaminated Material	Y	544	20	108,800	10	233,400	300	268,410
Contaminated Material Transferred to Staging Area	Y	544	4	21,760	10			
Radiologic Testing of Soil (in place)	Y	544	6	32,640	10			
Contaminated Material Packaging and Testing	Y	544	30	163,200	10			
Drying Contaminated Material	Y	180	3	5,400	10			
Water Collection During Excavation and Long-term Dewatering	Y	16	3	480	10			
Verification Sampling	Y	544	4	21,760	10			
Site Restoration	N	144	15	21,600	10			
Demobilization	N	32	15	4,800	10			

Assumptions:

Density (lb/cubic feet)	100		
Expansion Factor (%)	15		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	50000	540 cubic feet/truck	20 cubic yards/truck
IBC Container (82 cubic feet)(lb soil /container)=	8200		
IBC Containers per ISO Container=	4		
ISO Containers per Railcar=	3		
Non-exclusiveTrain Capacity (10 Railcars/trip)(tons/trip)=	492		
(cubic yards/trip)	364		
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from South Field to area of interest	
Distance to on-site disposal cell (miles)	1		
Distance from train to NTS (miles)	111		
Distance to RCRA Treatment and Disposal facility (miles)	25		

Alternative has been developed to achieve PRGs associated with the on-property and off-property resident farmer and assumes future land use under private ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.4-3 SOUTH FIELD ALTERNATIVE 2

Total Volume (RCRA) Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	One-way Distance (RCRA) Transported (Truck) (miles)	Total Number of Trucks	Total Number of Trucks (RCRA)	Two-way Distance Transported RCRA (Truck Volume) (miles)	Total Volume Transported (Railcar) (cubic yards)	One-way Distance Transported (Railcar) (miles/trip)	Total Number of Trains
345	111	25	13,421	17	865	268,410	2,212	736

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TABLE C.4-4 SOUTH FIELD ALTERNATIVE 3

Alternative SF3 - South Field
On-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hrs)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total In Place Volume (RCRA) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10		
* Excavate/ Load/ Transport Contaminated Material	Y	144	20	28,800	10	50,200	300
Contaminated Material Transferred to Staging Area	Y	144	4	5,760	10		
Radiologic Testing of Soil (in place)	Y	144	6	8,640	10		
Water Collection During Excavation and Long-term Dewatering	Y	48	3	1,440	10		
Verification Sampling	Y	144	4	5,760	10		
Construct Disposal Cell	N	40	20	8,000	10		
Load Disposal Cell	Y	144	4	5,760	10		
Cap Disposal Cell	Y	37	20	7,434	10		
Site Restoration	N	40	15	6,000	10		
Demobilization	N	32	15	4,800	10		

Assumptions:

Density (lb/cubic feet)	100		
Expansion Factor (%)	15		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	50000	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from South Field to area of interest	
Distance to on-site disposal cell (miles)	1		
Distance to RCRA Treatment and Disposal Facility (miles)	25		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.4-4 SOUTH FIELD ALTERNATIVE 3

Total Volume Transported (Truck) (cubic yards)	Total Volume (RCRA) Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	One-way Distance (RCRA) Transported (Truck) (miles)	Total Number of Trucks	Total Number of Trucks (RCRA)	Two-way Distance Transported RCRA (Truck Volume) (miles)
57,730	345	1	25	2,887	17	865

TABLE C.4-5 SOUTH FIELD ALTERNATIVE 4

Alternative SF4 - South Field
Vitrification and On-site Disposal

TASK	Potential Exposure to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hrs)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total In Place olume (RCRA (cubic yards)	Total Volume Transported (Truck) (cubic yards)	Total Volume (RCRA) Transported (Truck) (cubic yards)	One-way Distance (LLW) Transported (Truck) (miles)
Mobilization and Site Preparation	Y	64	15	9,600	10					
* Excavate/ Load/ Transport Contaminated Material	Y	144	20	28,800	10	50,200	300	57,730	345	1
Contaminated Material Transferred to Staging/Stockpile Area	Y	144	4	5,760	10					
Radiologic Testing of Soil (in place)	Y	144	6	8,640	10					
Feed Preparation (Drying, Crushing, and Blending)	Y	144	2	2,880	10					
Vitrify Contaminated Material	Y	144	25	86,400	24					
Make Additions to Feed (Sand, Limestone, Soda Ash, Boric Acid)	N	144	2	2,880	10					
Treat Off-Gas	N	144	1	1,440	10					
Drum Vitrified Contaminated Material	N	144	3	4,320	10					
Transport Drummed Contaminated Material	N	144	3	4,320	10					
Water Collection During Excavation and Long-term Dewatering	Y	48	4	1,767	10					
Verification Sampling	Y	144	4	5,760	10					
Construct Disposal Cell	N	40	20	8,000	10					
Load Disposal Cell	N	144	5	7,200	10					
Cap Disposal Cell	Y	13	20	2,629	10					
Site Restoration	N	40	15	6,000	10					
Demobilization	N	32	15	4,800	10					

Assumptions:

Density (lb/cubic feet)	100		
Expansion Factor (%)	15		
Truck Capacity (max 50,000 lb/truck)(lb/truck) =	50000	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from South Field to area of interest	
Distance to on-site disposal cell (miles)	1		
Distance to RCRA Treatment and Disposal Facility (miles)	25		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile
In-situ soil is transported by truck to stockpile location

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.4-5 SOUTH FIELD ALTERNATIVE 4

One-way Distance (RCRA) Transported (Truck) (miles)	Total Number of Trucks	Total Number of Trucks (RCRA)
25	2,887	17

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TABLE C.4-6 SOUTH FIELD ALTERNATIVE 5

Alternative SF5 - South Field
Solidification and On-site Disposal

TASK	Potential Exposure to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total In Place Volume (RCRA) (cubic yards)	Total Volume ransported (Truck (cubic yards)	Total Volume (RCRA) Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10				
* Excavate/ Load/ Transport Contaminated Material	Y	144	20	28,800	10	52,200	300	60,030	345
Contaminated Material Transferred to Staging/Stockpile Area	Y	144	4	5,760	10				
Radiologic Testing of Soil (in place)	Y	144	6	8,736	10				
Feed Preparation (Shredder)	Y	144	2	2,880	10				
Solidify Contaminated Material	Y	144	10	14,400	10				
Make Additions to Feed (Cement)	N	144	1	1,440	10				
Treat Off-Gas (Carbon Cannisters)	N	144	5	1,440	2				
Transport Solidified Contaminated Material	N	144	3	4,320	10				
Water Collection During Excavation and Long-term Dewatering	Y	48	3	1,440	10				
Verification Sampling	Y	144	4	5,760	10				
Construct Disposal Cell	N	40	20	8,000	10				
Load Disposal Cell	N	144	5	7,200	10				
Cap Disposal Cell	N	13	20	2,629	10				
Site Restoration	N	40	15	6,000	10				
Demobilization	N	32	15	4,800	10				

Assumptions:

Density(lb/cubic feet)	100		
Expansion Factor (%)	15		
Truck Capacity (max 50,000 lb/truck)(lb/truck) =	50000	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from South Field to area of interest	
Distance to on-site disposal cell (miles)	1		
Distance to RCRA Treatment and Disposal Facility (miles)	25		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.4-6 SOUTH FIELD ALTERNATIVE 5

One-way Distance Transported (Truck) (miles)	One-way Distance (RCRA) Transported (Truck) (miles)	Total Number of Trucks	Total Number of Trucks (RCRA)
1	25	3,002	17

000230

TABLE C.4-7 SOUTH FIELD ALTERNATIVE 6

Alternative SF6 - South Field
Soil Washing and On-Site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total In Place Volume (RCRA) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	Total Volume (Residuals) Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10				
* Excavate/ Load/ Transport Contaminated Material	Y	144	20	28,800	10	6,700	300	7,705	1,541
Contaminated Material Transferred to Staging/Stockpile Area	Y	144	4	5,760	10				
Radiologic Testing of Soil (in place)	Y	144	6	8,756	10				
Feed Preparation (Sizing)	Y	144	2	2,880	10				
Soil Washing	Y	144	10	14,400	10				
By-product Handling (Supernatant, Filtrate)	Y	144	10	2,880	2				
Transport Washed Soil to Fill Site	N	144	5	7,200	10				
Water Collection During Excavation and Long-term Dewatering	Y	48	3	1,440	10				
Verification Sampling	Y	144	4	5,760	10				
Site Restoration	N	40	15	6,000	10				
Demobilization	N	32	15	4,800	10				

Assumptions:

Density (lb/cubic feet)	100	
Expansion Factor (%)	15	
Truck Capacity (max 50,000 lb/truck)(lb/truck) =	50000	540 cubic feet/truck; 20 cubic yards/truck
IBC Container (82 cubic feet)(lb soil /container) =	8200	
IBC Containers per ISO Container =	4	
ISO Containers per Railcar =	3	
Non-exclusiveTrain Capacity (10 Railcars/trip)(tons/trip) =	492	
(cubic yards/trip)	364	
Distance from excavation to:		
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from South Field to area of interest
Distance to on-site disposal cell (miles)	1	
Distance from train to NTS (miles)	111	
Distance to RCRA Treatment and Disposal Facility (miles)	25	
Percent of excavated volume transported to NTS(%) as residuals	20	

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.4-7 SOUTH FIELD ALTERNATIVE 6

Total Volume (RCRA) Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	One-way Distance (Residuals) Transported (Truck) (miles)	One-way Distance (RCRA) Transported (Truck) (miles)	Total Number of Trucks	Total Number of Trucks (Residuals)	Total Number of Trucks (RCRA)	Total Residuals Volume Transported (Railcar) (cubic yards)	One-way Distance Transported (Railcar) (miles/trip)	Total Number of Trains
545	1	111	25	385	77	17	1,541	2,212	4

TABLE C.4-8 SOUTH FIELD ALTERNATIVE 7

Alternative SF7 - South Field
In-situ Containment

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10	
* Excavate/ Consolidate Contaminated Material	Y	112	15	16,800	10	37,800
Water Collection During Excavation and Long-term Dewatering	Y	48	3	1,440	10	
Install Cap	Y	96	20	19,200	10	
Site Restoration	N	9	20	1,752	10	
Demobilization	N	32	15	4,800	10	

Assumptions:

Density (lb/cubic feet)	100		
Expansion Factor (%)	15		
Truck Capacity (max 50,000 lb/truck)(lb/truck) =	50000	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	1000	Maximum distance from South Field to area of interest	
Distance to on-site disposal cell (miles)	1		
Distance to RCRA Treatment and Disposal Facility (miles)	25		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.4-8 SOUTH FIELD ALTERNATIVE 7

Total In Place Volume (RCRA) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	Total Volume (RCRA) Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	One-way Distance (RCRA) Transported (Truck) (miles)	Total Number of Trucks (LLW)	Total Number of Trucks (RCRA)
300	43,470	345	1	25	2,174	17

TABLE C.5-3 INACTIVE FLYASH PILE ALTERNATIVE 2

Alternative IFP2 - Inactive Flyash Pile
Off-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (people)	Total Crew Labor Hours (hr)	aximum Anticipate Exposure (hr/day/person)	Total In Place olume (Contaminated Material (cubic yards)	Total In Place Volume (ash) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	Total Volume (ash) Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10				
* Excavate/ Load/ Transport Contaminated Material	Y	240	20	48,000	10	78,600	24,300	87,592	25,515
Contaminated Material Transferred to Staging Area	Y	240	4	9,600	10				
Radiologic Testing of Soil (in place)	Y	240	6	14,400	10				
Contaminated Material Packaging and Testing	Y	240	30	72,000	10				
Drying Contaminated Material	Y	83	6	2,504	5				
Water Collection During Excavation	Y	83	3	2,504	10				
Verification Sampling	Y	240	4	9,600	10				
Site Restoration	N	64	12	7,680	10				
Demobilization	N	64	12	7,680	10				

Assumptions:

Density (soil)lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Density of Contaminated Material (19,300 cy fly ash, 59,300 cy soil)(lb/cubi	89		
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (Contaminated Material)(%)=	11		
Load Capacity (max 48,000 lb/truck)(contaminated material)(lb/truck)=	48,000	540 cubic feet/truck	cubic yards/truck
Load Capacity (max 48,000 lb/truck)(ash)(lb/truck)=	29,700	540 cubic feet/truck	cubic yards/truck
Maximum Truck Capacity (lb)=	80,000		
Weight of Truck + Trailer (lb)=	32,000		
Weight of ISO Container (lb)=	5,000		
Weight of IBC Container (lb)=	900		
Number of ISO Containers/Truck =	1		
IBC Container (82 cubic feet)(lb contaminated material /container)=	7294		
IBC Containers per ISO Container=	4		
ISO Containers per Railcar=	3		
Non-exclusiveTrain Capacity (10 Railcars/trip)(tons/trip)=	438		
(cubic yards/trip)	364	Maximum distance from Inactive Fly Ash Pile to staging area	
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (miles))	2		
Distance from train to NTS (miles)	111		
Distance to exempt waste disposal facility (miles)	25		

Alternative developed to meet PRGs for both future on-property and off-property resident farmer with private ownership of land for LLW and ARARs for exempted waste.

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

000235

TABLE C.5-3 INACTIVE FLYASH PILE ALTERNATIVE 2

(continued)

TASK	One-way Distance Transported (Truck) (miles)	One-way Distance (ash) Transported (Truck) (miles)	Total Number of Trucks	Total Number of Trucks (ash)	Total Volume Transported (Railcar) (cubic yards)	One-way Distance Transported (Railcar) (miles/trip)	Total Number of Trains
Mobilization and Site Preparation							
* Excavate/ Load/ Transport Contaminated Material	113	27	2,630	1,276	87,592	2,212	240
Contaminated Material Transferred to Staging Area							
Radiologic Testing of Soil (in place)							
Contaminated Material Packaging and Testing							
Drying Contaminated Material							
Water Collection During Excavation							
Verification Sampling							
Site Restoration							
Demobilization							

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TABLE C.5-4 INACTIVE FLYASH PILE ALTERNATIVE 3

Alternative IFP3 - Inactive Flyash Pile
On site Disposal

TASK	Potential Exposure to Contaminants (Y/N)	Estimated Duratio (days)	Total Crew (person)	Total Crew Labor Hours (hr)	aximum Anticipate Exposure (hr/day/person)	Total In Place olume (Contaminated Material (cubic yards)	Total Volume Transported (Truck (cubic yards)	One-way Distance Transported (Truck) (miles)	Total Number of Trucks
Mobilization and Site Preparation	Y	64	15	9,600	10				
* Excavate/ Load/ Transport Contaminated Material	Y	272	15	40,800	10	100,400	111,100	111	3,017
Contaminated Material Transferred to Staging Area	Y	272	4	10,880	10				
Radiologic Testing of Soil (in place)	Y	272	9	23,416	10				
Drying Contaminated Material	Y	272	4	10,880	10				
Water Collection During Excavation and Long-Term Dewatering	Y	64	3	1,920	10				
Verification Sampling	N	272	4	10,880	10				
Construct Disposal Cell	N	72	16	11,782	10				
Load Disposal Cell	Y	272	5	13,600	10				
Cap Disposal Cell	Y	103	15	15,516	10				
Site Restoration	N	32	12	3,840	10				
Demobilization	N	32	12	3,840	10				

Assumptions:

Density (soil)lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Density of Contaminated Material (43,600 cy fly ash, 56,800 cy soil)(lb/	80		
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (Contaminated Material)(%)=	11		
Load Capacity (max 48,000 lb/truck)(Contaminated Material)(lb/truck)=	43,447	540 cubic feet/truck	cubic yards/truck
Maximum Truck Capacity (lb)=	80,000		
Weight of Truck + Trailer (lb)=	32,000		
Distance from excavation to:			
Stockpile, treatment or staging area (miles))	2	Maximum distance from Inactive Fly Ash Pile to staging area	
On-site disposal cell (miles)	1		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

000234

TABLE C.5-5 INACTIVE FLYASH PILE ALTERNATIVE 4

Alternative IFP4 - Inactive Flyash Pile
Vitrification and On-site Disposal with Flyash Stabilization

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material (cubic yards)	Total Volume Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	11	7,200	10		
* Excavate/ Load/ Transport Contaminated Material	Y	272	15	40,800	10	100,400	111,100
Contaminated MaterialTransferred to Staging Area	Y	272	4	10,880	10		
Radiologic Testing of Soil (in place)	Y	272	6	16,320	10		
Feed Preparation (Drying, Crushing and Blending)	Y	272	2	5,440	10		
Vitrify Contaminated Material	Y	272	60	163,200	10		
Make Additions to Feed (Sand, Limestone, Soda Ash, Boric Acid)	N	272	2	5,440	10		
Treat Off-Gas	N	272	1	2,720	10		
Drum Vitrified Material	N	272	3	8,160	10		
Transport Drummed Material	N	272	3	8,160	10		
Water Collection During Excavation and Long-term Dewatering	Y	64	3	1,920	10		
Verification Sampling	N	272	4	10,974	10		
Stabilize Flyash	Y	294	8	23,515	10		
Transport Stabilized Flyash	N	294	2	5,879	10		
Construct Disposal Cell	N	72	15	10,800	10		
Load Disposal Cell	N	272	6	15,602	10		
Cap Disposal Cell	Y	52	15	7,781	10		
Site Restoration	N	32	12	3,840	10		
Demobilization	N	32	12	3,840	10		

Assumptions:

Density (soil)lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Density of Contaminated Material (43,600 cy fly ash, 56,800 cy soil)(	80		
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (Contaminated Material)(%)=	11		
Load Capacity (max 48,000 lb/truck)(Contaminated Material)(lb/truck	43,447	540 cubic feet/truck	cubic yards/truck
Maximum Truck Capacity (lb)=	80,000		
Weight of Truck + Trailer (lb)=	32,000		
Distance from excavation to:			
Stockpile, treatment or staging area (miles))	2	Maximum distance from Inactive Fly Ash Pile to staging area	
On-site disposal cell (miles)	1		
Distance from site to exempt or solid waste disposal site(miles)	25		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

TABLE C.5-5 INACTIVE FLYASH PILE ALTERNATIVE 4

One-way Distance Transported (Truck) (miles)	Total Number of Trucks
111	3,017

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TABLE C.5-6 INACTIVE FLYASH PILE ALTERNATIVE 5

Alternative IFP5 - Inactive Flyash Pile
Solidification and On-site Disposal with Flyash Stabilization

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	11	7,200	10		
* Excavate/ Load/ Transport Contaminated Material	Y	272	20	54,400	10	104,800	116,160
Contaminated Material Transferred to Staging Area	Y	272	4	10,880	10		
Radiologic Testing of Soil (in place)	Y	272	6	15,843	10		
Feed Preparation (Shredder)	Y	272	2	5,440	10		
Make Additions to Feed (Cement)	N	272	2	5,440	10		
Solidification	Y	272	10	27,200	10		
Treat Off-Gas (Carbon Cannisters)	N	272	1	2,814	10		
Transport Solidified Contaminated Material	N	272	3	8,160	10		
Water Collection During Excavation and Long-term Dewatering	Y	64	3	1,920	10		
Verification Sampling	N	272	4	10,880	10		
Stabilize Flyash	Y	294	8	23,342	10		
Transport Stabilized Flyash	N	294	2	5,879	10		
Construct Disposal Cell	N	72	15	10,800	10		
Load Disposal Cel	N	272	4	10,880	10		
Cap Disposal Cell	N	52	15	7,781	10		
Site Restoration	N	32	12	3,840	10		
Demobilization	N	32	12	3,840	10		

Assumptions:

Density (soil)lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Density of Contaminated Material (43,600 cy fly ash, 61,200 cy soil)(lb	81		
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (Contaminated Material)(%)=	11		
Truck Capacity (max 50,000 lb/truck)(Contaminated Material)(lb/truck)	43,890	540 cubic feet/truck	cubic yards/truck
Distance from excavation to:			
Stockpile, treatment or staging area (miles))	2	Maximum distance from Inactive Fly Ash Pile to staging area	
On-site disposal cell (miles)	1		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

TABLE C.5-6 INACTIVE FLYASH PILE ALTERNATIVE 5

One-way Distance Transported (Truck) (miles)	Total Number of Trucks
3	5,808

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TABLE C.5-7 INACTIVE FLYASH PILE ALTERNATIVE 6

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Alternative IFP6 - Inactive Flyash
Soil Washing and On-Site Disposal with Flyash Stabilization

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	One-way Distance (Residuals) Transported (Truck) (miles)	Total Number of Trucks
Mobilization and Site Preparation	Y	64	11	7,200	10					
* Excavate/ Load/ Transport Contaminated Material	Y	272	20	54,400	10	14,600	16,156	3	111	808
Contaminated Material Transferred to Staging Area	Y	272	4	10,880	10					
Radiologic Testing of Soil (in place)	Y	272	6	16,792	10					
Feed Preparation Sizing	Y	272	2	5,440	10					
Soil Washing	Y	272	10	27,200	10					
By-product Handling (Supernatant, Filtrate)	Y	272	2	5,440	10					
Transport Washed Soil to Fill Site	N	272	5	13,600	10					
Water Collection During Excavation and Long-term Dewatering	Y	64	3	1,920	10					
Verification Sampling	N	272	4	10,880	10					
Stabilize Flyash	Y	350	8	28,037	10					
Transport Stabilized Flyash	N	350	2	7,009	10					
Construct Disposal Cell	N	72	15	10,800	10					
Load Disposal Cell	Y	272	4	10,880	10					
Cap Disposal Cell	Y	72	15	10,800	10					
Site Restoration	N	32	12	3,840	10					
Demobilization	N	32	12	3,840	10					

Assumptions:

Density (soil)lb/cubic feet) =	100	
Density (ash)(lb/cubic feet) =	55	
Density of Contaminated Material (43,600 cy flyash, 56,800 cy soil)	80	
Expansion Factor (soil)(%)=	15	
Expansion Factor (ash)(%)=	5	
Expansion Factor (Contaminated Material)(%)=	11	
Truck Capacity (max 50,000 lb/truck)(Contaminated Material)(lb/tru	43,447	540 cubic feet/truck cubic yards/truck
IBC Container (82 cubic feet)(lb soil /container)=	6598	
IBC Containers per ISO Container=	4	
ISO Containers per Railcar=	3	
Non-exclusiveTrain Capacity (10 Railcars/trip)(tons/trip)=	396	
(cubic yards/trip)	364	
Distance from excavation to:		
Stockpile, treatment or staging area (miles))	2	Maximum distance from Inactive Fly Ash Pile to staging area
On-site disposal cell (miles)	1	
Distance from train to NTS (miles)	111	
Percent of excavated volume transported to NTS as residuals (%)	20	

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

TABLE C.5-7 INACTIVE F[illegible]SH PILE ALTERNATIVE 6

Total Number of Trucks (Residuals)	otal Residuals Volum Transported (Railcar) (cubic yards)	One-way Distance Transported (Railcar) (miles/trip)	Total Number of Trains
215	3,231	2,212	9

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TABLE C.5-8 INACTIVE FLYASH PILE ALTERNATIVE 7

Alternative IFP7 - Inactive Flyash Pile
Consolidation/Containment of Contaminated Material

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck (cubic yards)	One-way Distance Transported (Truck) (miles)
Mobilization and Site Preparation	Y	64	15	9,600	10			
* Excavate/ Load/ Transport Contaminated Material	Y	272	20	54,400	10	100,400	111,100	2
Contaminated Material Transferred to Staging Area	Y	272	4	10,880	10			
Radiologic Testing of Soil (in place)	Y	272	6	16,792	10			
Contaminated Material Packaging and Testing	Y	272	30	81,600	10			
Drying Contaminated Material	Y	104	3	3,133	10			
Water Collection During Excavation and Long-term Dewatering	Y	104	3	3,133	10			
Verification Sampling	N	272	4	10,880	10			
Cap Consolidated/Contained Contaminated Material	Y	64	15	9,600	10			
Site Restoration	N	32	12	3,840	10			
Demobilization	N	32	12	3,840	10			

Assumptions:

Density (soil)lb/cubic feet) =	100		
Density (ash)(lb/cubic feet) =	55		
Density of Contaminated Material (43,600 cy fly ash, 56,800 cy soil)(l	80		
Expansion Factor (soil)(%)=	15		
Expansion Factor (ash)(%)=	5		
Expansion Factor (Contaminated Material)(%)=	11		
Truck Capacity (max 50,000 lb/truck)(Contaminated Material)(lb/truc	43,447	540 cubic feet/truck	cubic yards/truck
Distance from excavation to:			
Stockpile, treatment or staging area (miles))	2	Maximum distance from Inactive Fly Ash Pile to staging area	

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

000244

TABLE C.5-8 INACTIVE ASH PILE ALTERNATIVE 7

Total Number of Trucks
5,555

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TABLE C.5-9 INACTIVE FLYASH PILE ALTERNATIVE 8

Alternative IFP8 - Inactive Flyash Pile
On-Site Disposal with Flyash Stabilization

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Average Labor Hours/Person (hr/person)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	One-way Distance (LLW)* Transported (Truck) (miles)	Total Number of Trucks
Mobilization and Site Preparation	Y	64	11	7,200	640	10				
* Excavate/ Load/ Transport Contaminated Material	Y	272	20	54,400	2,720	10	104,800	115,720	111	7,288
Contaminated Material Transferred to Staging Area	Y	272	4	10,880	2,720	10				
Radiologic Testing of Soil (in place)	Y	272	6	16,792	2,720	10				
Drying Contaminated Material	Y	83	3	2,438	830	10				
Water Collection During Excavation and Long-term Dewatering	Y	64	3	1,920	640	10				
Verification Sampling	N	272	4	10,880	2,720	10				
Stabilize Flyash	Y	294	8	23,515	2,939	10				
Transport Stabilized Flyash	N	294	2	5,879	2,939	10				
Construct Disposal Cell	N	72	15	10,800	720	10				
Load Disposal Cell	Y	272	4	10,880	2,720	10				
Cap Disposal Cell	Y	52	15	7,781	519	10				
Site Restoration	N	32	12	3,840	320	10				
Demobilization	N	32	12	3,840	320	10				

Assumptions:

Density (soil)lb/cubic feet) =	100			
Density (ash)(lb/cubic feet) =	55			
Density of Contaminated Material (48,000 cy fly ash, 68,600 cy soil)(lb/	79			
Expansion Factor (soil)(%)=	15			
Expansion Factor (ash)(%)=	5			
Expansion Factor (Contaminated Material)(%)=	10			
Load Capacity(max 48,000 lb/truck)(Contaminated Material)(lb/truck)=	42,870	540 cubic feet/truck	20	cubic yards/truck
Maximum Truck Capacity (lb)=	80,000			
Weight of Truck + Trailer (lb)=	32,000			
Distance from excavation to:				
Stockpile, in-situ cap, treatment or staging area (miles))	2	Maximum distance from Inactive Fly Ash Pile to staging area		
On-site disposal cell(miles)	1			

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

000256

TABLE C.6-3 SOLID WASTE LANDFILL ALTERNATIVE 2

Alternative SWL2 - Solid Waste Landfill
Off-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10		
* Excavate/ Load/ Transport Contaminated Material	Y	184	20	36,800	10	79,300	87,230
Contaminated Material Transferred to Staging Area	Y	184	4	7,360	10		
Radiologic Testing of Soil (in place)	Y	184	6	11,040	10		
Contaminated Material Packaging and Testing	Y	184	30	55,200	10		
Drying Contaminated Material	Y	21	6	619	5		
Water Collection During Excavation	Y	21	3	619	10		
Verification Sampling	Y	184	6	11,040	10		
Site Restoration	N	80	15	12,000	10		
Demobilization	N	32	15	4,800	10		

Assumptions:

Density (lb/cubic feet) =	100		
Expansion Factor (%)=	10		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	50000	540 cubic feet/truck	20 cubic yards/truck
IBC Container (82 cubic feet)(lb soil /container)=	8200		
IBC Containers per ISO Container=	4		
ISO Containers per Railcar=	3		
Non-exclusiveTrain Capacity (10 Railcars/trip)(tons/trip)=	492		
(cubic yards/trip)	364		
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	600	Maximum distance from edge of SWL to area of interest	
Distance from train to NTS (miles)	111		
Distance to solid waste disposal site(miles)	25		

Alternative developed to meet PRGs for both future on-property and off-property resident farmer with private ownership of land

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.6-3 SOLID WASTE LANDFILL ALTERNATIVE 2

One-way Distance Transported (Truck) (miles)	Total Number of Trucks	Total Volume Transported (Railcar) (cubic yards)	One-way Distance Transported (Railcar) (miles/trip)	Total Number of Trains
111	4,362	87,230	2,275	239

TABLE C.6-4 SOLID WASTE LANDFILL ALTERNATIVE 3

Alternative SWL3 - Solid Waste Landfill
On-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10		
* Excavate/ Load/ Transport Contaminated Material	Y	40	9	3,778	10	15,900	17,490
Contaminated Material Transferred to Staging Area	Y	40	5	2,156	10		
Drying Contaminated Material	Y	40	5	2,156	10		
Radiologic Testing of Soil (in place)	Y	40	6	2,400	10		
Water Collection During Excavation	Y	32	3	960	10		
Verification Sampling	Y	40	4	1,600	10		
Construct Disposal Cell	N	16	12	1,920	10		
Load Treatment Cell	Y	40	5	2,000	10		
Cap Treatment Cell	Y	40	12	4,800	10		
Site Restoration	N	16	15	2,400	10		
Demobilization	N	32	15	4,800	10		

Assumptions:

Density (lb/cubic feet) =	100		
Expansion Factor (%)=	10		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	50000	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment area (ft)	380	Diagonal of SWL	
Distance to on-site disposal cell (miles)	2		

Alternative developed to meet PRGs for an expanded tresspasser and off-property resident farmer with Federal ownership of land

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.8-4 SOLID WASTE LANDFILL ALTERNATIVE 3

One-way Distance Transported (Truck) (miles)	Total Number of Trucks
2	875

TABLE C.6-5 SOLID WASTE LANDFILL ALTERNATIVE 4

Alternative SWL4 - Solid Waste Landfill Consolidation/Containment

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)
Mobilization and Site Preparation	Y	64	15	9,600	10
Excavate/ Consolidate Contaminated Material	Y	90	20	18,096	10
Contaminated Material Transferred to Staging Area	Y	90	4	3,619	10
Radiologic Testing of Soil (in place)	Y	90	3	2,335	10
Water Collection During Excavation	Y	32	3	960	10
Verification Sampling	Y	90	4	3,619	10
Cap Consolidated Waste	N	64	15	9,600	10
Demobilization	N	32	15	4,500	10

Assumptions:

Density (lb/cubic feet) =	100		
Expansion Factor (%)=	10		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	50000	540 cubic feet/truck	20
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	380	Diagonal of SWL	

Alternative developed to meet PRGs for an expanded tresspasser and off-property resident farmer with Federal ownership of land

For calculations, distances are approximated to the nearest mile. For distances less than 1 mile, calculations use a 1 mile value.

* Transportation risks are calculated only for total volume of contaminated material excavated and transported. Only 50 cubic yards of material are transported to the NTS.

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TABLE C.6-5 SOLID WASTE LANDFILL ALTERNATIVE 4

Total In Place Volume Requiring Movement for Consolidation (Contaminated Material) (cubic yards)	Total In Place Volume Requiring Relocation Off-Site (cubic yards)	Total Volume Transporte for Consolidation (Truck) (cubic yards)	Total Volume Transported Off-Site(Truck) (cubic yards)	One-way Distance Transported for Consolidation(Truck) (miles)	Total Number of Trucks (LLW)
10,000	30	11,000	33	1	550

cubic yards/truck

TABLE C.7-3 LIME SLUDGE POND ALTERNATIVE 2

Alternative LSP2 - Lime Sludge Pond
Off-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)
Mobilization and Site Preparation	Y	64	15	9,600	10		
Excavate/ Load/ Transport Contaminated Material	Y	88	20	17,600	10	35,500	39,175
Contaminated Material Transferred to Staging Area	Y	106	4	4,224	10		
Radiologic Testing of Soil (in place)	Y	106	6	6,336	10		
Contaminated Material Packaging and Testing	Y	106	30	31,680	10		
Drying Contaminated Material	Y	46	3	1,392	10		
Water Collection During Excavation	Y	46	3	1,392	10		
Verification Sampling	Y	106	4	4,224	10		
Site Restoration	N	32	15	4,800	10		
Demobilization	N	32	15	4,800	10		

Assumptions:

Density (soil)(lb/cubic feet) =	100		
Density (sludge)(lb/cubic feet) =	55		
Density (contaminated material) (16,500 cy sludge +19,000 cy soil)(lb/cubi	79		
Expansion Factor (soil)(%)=	15		
Expansion Factor (sludge)(%)=	5		
Expansion Factor (contaminated material)(%)=	10		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	50,000	540 cubic feet/truck	20 cubic yards/truck
IBC Container (82 cubic feet)(lb soil /container)=	8200		
IBC Containers per ISO Container=	4		
ISO Containers per Railcar=	3		
Non-exclusiveTrain Capacity (10 Railcars/trip)(tons/trip)=	492		
(cubic yards/trip)	461		
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	330	Maximum distance from edge of LS to area of interest	
Distance from train to NTS (miles)	111		

Alternative has been developed to achieve PRGs associated with the on-property and off-property resident farmer and assumes future land use under private ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated and transported

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TABLE C.7-3 LIME SLUDGE POND ALTERNATIVE 2

Alternative LS2 - Lime Sludge Pond (continued)

One-way Distance Transported (Truck) (miles)	Total Number of Trucks	Total Volume Transported (Railcar) (cubic yards)	One-way Distance Transported (Railcar) (miles/trip)	Total Number of Trains
111	1,959	39,175	2,212	85

TABLE C.7-4 LIME SLUDGE POND ALTERNATIVE 3

Alternative LSP3- Lime Sludge Pond
On-site Disposal

TASK	Potential Exposure to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	Total Number of Trucks
Mobilization and Site Preparation	Y	64	15	9,600	10				
* Excavate/ Load/ Transport Contaminated Material	Y	56	10	5,600	10	16,600	17,851	1	893
Contaminated Material Transferred to Staging Area	Y	56	4	2,240	10				
Drying Contaminated Material	Y	56	4	2,240	10				
Radiologic Testing of Soil (in place)	Y	56	6	3,360	10				
Water Collection During Excavation	Y	32	3	960	10				
Verification Sampling	Y	56	4	2,240	10				
Construct Disposal Cell	N	16	15	2,400	10				
Load Disposal Cell	Y	56	4	2,240	10				
Cap Disposal Cell	Y	12	15	1,740	10				
Site Restoration	N	32	15	4,800	10				
Demobilization	N	32	15	4,800	10				

Assumptions:

Density (soil)(lb/cubic feet) =	100		
Density (sludge)(lb/cubic feet) =	55		
Density (contaminated material)(lb/cubic foot)=	66		
(16,500 cy sludge, 5,600 cy soil)			
Expansion Factor (soil)(%)=	15		
Expansion Factor (sludge/exempt)(%)=	5		
Expansion Factor(contaminated material)(%)=	8		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	35,857	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	330	Maximum distance from edge of LS to area of interest	
Distance to on-site disposal cell (miles)	1		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated or transported

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TABLE C.7-5 LIME SLUDGE POND ALTERNATIVE 4

Alternative LSP4 - Lime Sludge Pond
In-situ Containment and Off-site Disposal

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hours (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)	Total Number of Trucks
Mobilization and Site Preparation	Y	64	15	9,600	10				
* Excavate/ Load/ Transport Contaminated Material	Y	24	8	1,920	10	100	115	2,275	6
Contaminated Material Transferred to Staging Area	Y	24	1	240	10				
Radiologic Testing of Soil (in place)	Y	24	3	720	10				
Contaminated Material Packaging and Testing	Y	24	12	2,880	10				
Drying Contaminated Material	Y	24	2	240	5				
Water Collection During Excavation	Y	24	2	240	5				
Verification Sampling	Y	24	2	480	10				
Spread/Compact/Cap Sludge	Y	70	12	8,432	10				
Site Restoration	N	32	6	1,920	10				
Demobilization	N	32	6	1,920	10				

Assumptions:

Density (soil)(lb/cubic feet) =	100		
Density (sludge)(lb/cubic feet) =	55		
Expansion Factor (soil)(%)=	15		
Expansion Factor (sludge/exempt)(%)=	5		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	50,000	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	330	Maximum distance from edge of LS to area of interest	

Alternative has been developed to achieve PRGs associated with the off-site resident farmer and assumes future land use under federal ownership.

This containment option does not involve loading of solid waste into trucks during consolidation procedure

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of each excavated waste requiring relocation

Off-site disposal of berm material (soil) uses trucks only for transportation to the NTS

TABLE C.7-6 LIME SLU[illegible] POND ALTERNATIVE 5

Alternative LSP5 - Lime Sludge Pond
On-site Disposal with Lime Sludge Stabilization

TASK	Potential Exposures to Contaminants (Y/N)	Estimated Duration (days)	Total Crew (person)	Total Crew Labor Hour (hr)	Maximum Anticipated Exposure (hr/day/person)	Total In Place Volume (Contaminated Material) (cubic yards)	Total Volume (LLW/Impacted Soil) Transported (Truck) (cubic yards)	One-way Distance Transported (Truck) (miles)
Mobilization and Site Preparation	Y	64	15	9,600	10			
* Excavate/ Load/ Transport Contaminated Material	Y	448	10	44,800	10	18,200	14,040	1
Contaminated MaterialTransferred to Staging Area	Y	448	4	17,920	10			
Drying Contaminated Material	Y	448	4	17,920	10			
Radiologic Testing of Soil (in place)	Y	448	6	26,880	10			
Water Collection During Excavation	Y	32	3	960	10			
Verification Sampling	Y	448	4	17,920	10			
Stabilize Sludge	Y	448	8	35,840	10			
Transport Stabilized Sludge	N	448	2	8,960	10			
Construct Disposal Cell	N	16	15	2,400	10			
Load Disposal Cell	Y	193	4	7,738	10			
Cap Disposal Cell	Y	24	15	3,600	10			
Site Restoration	N	32	15	4,800	10			
Demobilization	N	32	15	4,800	10			

Assumptions:

Density (soil)(lb/cubic feet) =	100		
Density (sludge)(lb/cubic feet) =	55		
Density (contaminated material)(lb/cubic foot)=	66		
(18,100 cy sludge, 5,600 cy soil)			
Expansion Factor (soil)(%)=	15		
Expansion Factor (sludge/exempt)(%)=	5		
Expansion Factor(contaminated material)(%)=	7		
Truck Capacity (max 50,000 lb/truck)(lb/truck)=	35,442	540 cubic feet/truck	20 cubic yards/truck
Distance from excavation to:			
Stockpile, in-situ cap, treatment or staging area (ft)	330	Maximum distance from edge of LS to area of interest	
Distance to on-site disposal cell (miles)	1		

Alternative has been developed to achieve PRGs associated with the off-property resident farmer and assumes future land use under federal ownership.

For calculations, distances are approximated to the nearest mile

* Transportation risks are calculated only for total volume of contaminated material excavated or transported

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TABLE C.7-6 LIME SLUDGE POND ALTERNATIVE 5

One-way Distance (Exempt) Transported (Truck) (miles)	Total Number of Trucks
1	702

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ATTACHMENT II

Intake and Risk/Hazard Results

TABLE C.3-11(a)
ACTIVE FLYASH PILE
EXPANDED TRESPASSER: SOIL
Consolidation/Containment
CARCINOGENIC RISK

Radiation Risk

Inhalation/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
NP-237	1.01E-06	3.3E-03	2.9E-08	9.5E-11
RA-226	7.54E-06	2.5E-02	3.0E-09	7.4E-11
RA-228	6.12E-06	2.0E-02	6.9E-10	1.4E-11
TH-228	1.22E-05	4.0E-02	7.8E-08	3.1E-09
TH-230	1.77E-05	5.8E-02	2.9E-08	1.7E-09
TH-232	8.78E-06	2.9E-02	2.8E-08	8.0E-10
U-234	7.61E-06	2.5E-02	2.6E-08	6.4E-10
U-235/236	8.95E-05	2.9E-01	2.5E-08	7.3E-09
U-238	7.46E-06	2.4E-02	5.2E-08	1.3E-09
			Total Pathway:	1.5E-08

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
NP-237	5.00E+00	1.2E+02	2.2E-10	2.7E-08
RA-226	1.14E+00	2.8E+01	1.2E-10	3.4E-09
RA-228	9.00E-01	2.2E+01	1.0E-10	2.2E-09
TH-228	1.74E+00	4.3E+01	5.5E-11	2.3E-09
TH-230	2.67E+00	6.5E+01	1.3E-11	8.5E-10
TH-232	1.20E+00	2.9E+01	1.2E-11	3.5E-10
U-234	1.00E+00	2.5E+01	1.6E-11	3.9E-10
U-235/236	3.40E-02	8.3E-01	1.6E-11	1.3E-11
U-238	1.05E+00	2.6E+01	2.8E-11	7.2E-10
			Total Pathway:	3.7E-08

Chemical Risk

Inhalation/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	7.45E-05	1.9E-07	1.5E+01	2.9E-06
			Total Pathway:	2.9E-06

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	6.20E+00	1.5E-07	1.8E+00	2.6E-07
			Total Pathway:	2.6E-07

Total Rad + Chem 2.9E-06

Total Rad + Chem 3.0E-07

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TABLE C.3-11(a) (continued)

Consolidation/Containment

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil

Not Applicable

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Conc'n (pCi/g)	Intake	SF(c)	Risk	Total
NP-237	5.00E+00	2.2E+00	4.3E-07	9.6E-07	9.9E-07
RA-226	1.14E+00	5.1E-01	6.0E-06	3.1E-06	3.1E-06
RA-228	9.00E-01	4.0E-01	2.9E-06	1.2E-06	1.2E-06
TH-228	1.74E+00	7.8E-01	5.6E-06	4.4E-06	4.4E-06
TH-230	2.67E+00	1.2E+00	5.4E-11	6.5E-11	2.6E-09
TH-232	1.20E+00	5.4E-01	2.6E-11	1.4E-11	1.2E-09
U-234	1.00E+00	4.5E-01	3.0E-11	1.3E-11	1.0E-09
U-235/236	3.40E-02	1.5E-02	2.4E-07	3.7E-09	1.1E-08
U-238	1.05E+00	4.7E-01	3.6E-08	1.7E-08	1.9E-08

Total Pathway: 9.6E-06

Chemical Risk

Dermal Contact/Soil

Compound	ABS	Intake	SF(derm)	Risk
Arsenic	1.0E-03	5.7E-08	1.8E+00	1.0E-07

Total Pathway: 1.0E-07

External Radiation/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk	Total
					3.3E-06

Total Pathway: 0.0E+00

Total Rad + Chem 1.0E-07

Total Rad + Chem: 9.6E-06 *Total:* 1.3E-05

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TABLE C.3-11(a) (continued)

Consolidation/Containment

NONCARCINOGENIC HAZARD

Radiation Hazard

Inhalation/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	HQ
NP-237	1.01E-06	3.3E-03		
RA-226	7.54E-06	2.5E-02		
RA-228	6.12E-06	2.0E-02		
TH-228	1.22E-05	4.0E-02		
TH-230	1.77E-05	5.8E-02		
TH-232	8.78E-06	2.9E-02		
U-234	7.61E-06	2.5E-02		
U-235/236	8.95E-05	2.9E-01		
U-238	7.46E-06	2.4E-02		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	HQ
NP-237	5.00E+00	1.2E+02		
RA-226	1.14E+00	2.8E+01		
RA-228	9.00E-01	2.2E+01		
TH-228	1.74E+00	4.3E+01		
TH-230	2.67E+00	6.5E+01		
TH-232	1.20E+00	2.9E+01		
U-234	1.00E+00	2.5E+01		
U-235/236	3.40E-02	8.3E-01		
U-238	1.05E+00	2.6E+01		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	HQ
Arsenic	7.45E-05	9.6E-07		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	HQ
Arsenic	6.20E+00	6.6E-07	3.0E-04	2.2E-03

Total Pathway: 1.2E-02

Total Rad + Chem 0.0E+00

Total Rad + Chem 1.2E-02

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TABLE C.3-11(a) (continued)

Consolidation/Containment

NONCARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	HQ	
Not Applicable	NP-237	2.2E+00			
	RA-226	5.1E-01			
	RA-228	4.0E-01			
	TH-228	7.8E-01			
	TH-230	1.2E+00			
	TH-232	5.4E-01			
	U-234	4.5E-01			
	U-235/236	1.5E-02			
	U-238	4.7E-01			
Total Pathway:	0.0E+00	Total Pathway:		0.0E+00	

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	RfD(derm)	HQ	Compound	Intake	RfD(o)	HQ	
Arsenic	2.4E-06	2.9E-04	8.4E-03					1.1E-02
Total Pathway:			1.5E-02	Total Pathway:			0.0E+00	
Total Rad + Chem			1.5E-02	Total Rad + Chem			0.0E+00	*Total:* 2.7E-02

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TABLE C.3.11(b)
RISKS DUE TO BACKGROUND
FUTURE, EXPANDED TRESPASSER
ACTIVE FLYASH PILE: SOIL
CARCINOGENIC RISK

Radiation Risk

Inhalation/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
RA-226	1.26E-05	4.1E-02	3.0E-09	1.2E-10
RA-228	1.17E-05	3.8E-02	6.9E-10	2.6E-11
TH-228	1.15E-05	3.7E-02	7.8E-08	2.9E-09
TH-230	1.54E-05	5.0E-02	2.9E-08	1.5E-09
TH-232	1.11E-05	3.6E-02	2.8E-08	1.0E-09
U-234	1.07E-05	3.5E-02	2.6E-08	9.1E-10
U-235/236	9.06E-07	2.9E-03	2.5E-08	7.4E-11
U-238	1.11E-05	3.6E-02	5.2E-08	1.9E-09
			Total Pathway:	8.4E-09

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
RA-226	0.27	6.5E+00	1.2E-10	7.8E-10
RA-228	0.36	8.7E+00	1.0E-10	8.7E-10
TH-228	0.29	7.2E+00	5.5E-11	4.0E-10
TH-230	0.40	9.9E+00	1.3E-11	1.3E-10
TH-232	0.40	9.8E+00	1.2E-11	1.2E-10
U-234	0.29	7.1E+00	1.6E-11	1.1E-10
U-235/236	0.44	1.1E+01	1.6E-11	1.7E-10
U-238	0.30	7.3E+00	2.8E-11	2.1E-10
			Total Pathway:	2.8E-09

Chemical Risk

Inhalation/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	5.95E-08	1.5E-10	1.5E+01	2.3E-09
			Total Pathway:	2.3E-09

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	0.06	1.2E-09	1.8E+00	2.2E-09
			Total Pathway:	2.2E-09

Total Rad + Chem 1.1E-08

Total Rad + Chem 5.0E-09

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TABLE C.3-11(b) (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil				External Radiation/Soil				Total
				Compound	Intake	SF(e)	Risk	
				RA-226	1.2E-01	6.0E-06	7.2E-07	7.2E-07
				RA-228	1.6E-01	2.9E-06	4.6E-07	4.6E-07
				TH-228	1.3E-01	5.6E-06	7.4E-07	7.4E-07
				TH-230	1.8E-01	5.4E-11	9.8E-12	1.6E-09
				TH-232	1.8E-01	2.6E-11	4.7E-12	1.1E-09
				U-234	1.3E-01	3.0E-11	3.9E-12	1.0E-09
				U-235/236	2.0E-01	2.4E-07	4.7E-08	4.7E-08
				U-238	1.3E-01	3.6E-08	4.8E-09	6.9E-09
		Total Pathway:	0.0E+00			Total Pathway:	2.0E-06	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	5.9E-10	1.8E+00	1.1E-09					5.6E-09
		Total Pathway:	1.1E-09			Total Pathway:	0.0E+00	
		Total Rad + Chem	1.1E-09				2.0E-06	*Total:* 2.0E-06

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TABLE C.3-11(b) (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Inhalation/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	HQ
RA-226	1.26E-05	4.1E-02		
RA-228	1.17E-05	3.8E-02		
TH-228	1.15E-05	3.7E-02		
TH-230	1.54E-05	5.0E-02		
TH-232	1.11E-05	3.6E-02		
U-234	1.07E-05	3.5E-02		
U-235/236	9.06E-07	2.9E-03		
U-238	1.11E-05	3.6E-02		
			Total Pathway:	0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	HQ
RA-226	0.27	6.5E+00		
RA-228	0.36	8.7E+00		
TH-228	0.29	7.2E+00		
TH-230	0.40	9.9E+00		
TH-232	0.40	9.8E+00		
U-234	0.29	7.1E+00		
U-235/236	0.44	1.1E+01		
U-238	0.30	7.3E+00		
			Total Pathway:	0.0E+00

Chemical Hazard

Inhalation/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	HQ
Arsenic	5.95E-08	7.7E-10		
			Total Pathway:	0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	HQ
Arsenic	0.06	6.9E-09	3.0E-04	2.3E-05
			Total Pathway:	2.3E-05

Total Rad + Chem	0.0E+00
Total Rad + Chem	2.3E-05

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TABLE C.3-11(b) (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil		External Radiation/Soil				Total
		Compound	Intake	RfD(e)	HQ	
		RA-226	1.2E-01			
		RA-228	1.6E-01			
		TH-228	1.3E-01			
		TH-230	1.8E-01			
		TH-232	1.8E-01			
		U-234	1.3E-01			
		U-235/236	2.0E-01			
		U-238	1.3E-01			
Total Pathway:	0.0E+00	Total Pathway:			0.0E+00	

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	RfD(derm)	HQ	Compound	Intake	RfD(o)	HQ	
Arsenic	2.5E-08	2.9E-04	8.6E-05					1.1E-04
Total Pathway:			8.6E-05	Total Pathway:			0.0E+00	
Total Rad + Chem			8.6E-05	Total Rad + Chem			0.0E+00	*Total:* 1.1E-04

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TABLE C.3-12(a)
ACTIVE FLYASH PILE
OFF-PROPERTY FARMER: SURFACE SOIL/AIR
Consolidation/Containment
CARCINOGENIC RISK

Radiation Risk					
Inhalation/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
NP-237	4.08E-08	4.7E-03	2.9E-08	1.4E-10	1.4E-10
RA-226	3.22E-07	3.7E-02	3.0E-09	1.1E-10	1.1E-10
RA-228	2.63E-07	3.0E-02	6.9E-10	2.1E-11	2.1E-11
TH-228	5.28E-07	6.1E-02	7.8E-08	4.8E-09	4.8E-09
TH-230	7.58E-07	8.8E-02	2.9E-08	2.5E-09	2.5E-09
TH-232	3.83E-07	4.4E-02	2.8E-08	1.2E-09	1.2E-09
U-234	3.34E-07	3.9E-02	2.6E-08	1.0E-09	1.0E-09
U-235	4.66E-06	5.4E-01	2.5E-08	1.4E-08	1.4E-08
U-238	3.23E-07	3.7E-02	5.2E-08	1.9E-09	1.9E-09
			Total Pathway:	2.5E-08	2.5E-08

Chemical Risk					
Inhalation/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	3.01E-06	2.0E-07	1.5E+01	2.9E-06	2.9E-06
Beryllium	2.01E-06	1.3E-07	8.4E+00	1.1E-06	1.1E-06
U-Total	1.29E-07	8.4E-09			
			Total Pathway:	4.4E-06	

Total Chem 4.4E-06 | *Total:* 4.4E-06

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TABLE C.3-12(a)(continued)

Consolidation/Containment

NONCARCINOGENIC HAZARD

Radiation Hazard					
Inhalation/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	Hazard	
NP-237	4.08E-08				
RA-226	3.22E-07				
RA-228	2.63E-07				
TH-228	5.28E-07				
TH-230	7.58E-07				
TH-232	3.83E-07				
U-234	3.34E-07				
U-235/236	4.66E-06				
U-238	3.23E-07				
			Total Pathway:	0.0E+00	

Chemical Hazard				
Inhalation/Soil				
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	3.01E-06	2.0E-07		
Beryllium	2.01E-06	1.3E-07		
			Total Pathway:	0.0E+00

Total Chem 0.0E+00 | *Total:* 0.0E+00

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TABLE C.3-12(a)
ACTIVE FLYASH PILE
OFF-PROPERTY FARMER: SURFACE SOIL/AIR
On-Site Disposal
CARCINOGENIC RISK

Radiation Risk					
Inhalation/Soil					Total
Compound	onc'n in Air (pCi/m3	Intake	SF(i)	Risk	
NP-237	5.57E-08	6.5E-03	2.9E-08	1.9E-10	1.9E-10
RA-226	4.11E-07	4.8E-02	3.0E-09	1.4E-10	1.4E-10
RA-228	3.33E-07	3.9E-02	6.9E-10	2.7E-11	2.7E-11
TH-228	6.64E-07	7.7E-02	7.8E-08	6.0E-09	6.0E-09
TH-230	9.67E-07	1.1E-01	2.9E-08	3.3E-09	3.3E-09
TH-232	4.77E-07	5.5E-02	2.8E-08	1.5E-09	1.5E-09
U-234	4.12E-07	4.8E-02	2.6E-08	1.2E-09	1.2E-09
U-235	4.66E-06	5.4E-01	2.5E-08	1.4E-08	1.4E-08
U-238	4.05E-06	4.7E-01	5.2E-08	2.4E-08	2.4E-08
			Total Pathway:	5.0E-08	5.0E-08

Chemical Risk					
Inhalation/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	4.11E-06	2.7E-07	1.5E+01	4.0E-06	4.0E-06
Beryllium	1.76E-07	1.1E-08	8.4E+00	9.6E-08	9.6E-08
U-Total	2.34E-06	1.5E-07			
			Total Pathway:	4.1E-06	
			Total Chem	4.2E-06	*Total:* 4.2E-06

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TABLE C.3-12(a)(continued)

On-Site Disposal

NONCARCINOGENIC HAZARD

Radiation Hazard					
Inhalation/Soil					Total
Compound	onc'n in Air (pCi/m	Intake	RfD(i)	Hazard	
NP-237	5.57E-08				
RA-226	4.11E-07				
RA-228	3.33E-07				
TH-228	6.64E-07				
TH-230	9.67E-07				
TH-232	4.77E-07				
U-234	4.12E-07				
U-235/236	4.66E-06				
U-238	4.05E-06				
			Total Pathway:	0.0E+00	

Chemical Hazard				
Inhalation/Soil				
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	4.11E-06	2.7E-07		
Beryllium	1.76E-07	1.1E-08		
			Total Pathway:	0.0E+00

Total Chem 0.0E+00 | *Total:* 0.0E+00

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TABLE C.3-12(b)
ACTIVE FLYASH PILE
OFF-PROPERTY FARMER: HOME GROWN PRODUCE
Consolidation/Containment
CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
NP-237	1.42E-05	2.1E-02	2.2E-10	4.7E-12	4.7E-12
RA-226	1.10E-04	1.6E-01	1.2E-10	2.0E-11	2.0E-11
RA-228	9.00E-05	1.3E-01	1.0E-10	1.3E-11	1.3E-11
TH-228	1.80E-04	2.7E-01	5.5E-11	1.5E-11	1.5E-11
TH-230	2.58E-04	3.9E-01	1.3E-11	5.0E-12	5.0E-12
TH-232	1.30E-04	1.9E-01	1.2E-11	2.3E-12	2.3E-12
U-234	1.14E-04	1.7E-01	1.6E-11	2.7E-12	2.7E-12
U-235/236	1.63E-03	2.4E+00	1.6E-11	3.8E-11	3.8E-11
U-238	1.11E-04	1.7E-01	2.8E-11	4.6E-12	4.6E-12
			Total Pathway:	1.1E-10	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	1.03E-06	8.6E-10	1.8E+00	1.5E-09	1.5E-09
Beryllium	4.36E-08	3.6E-11	4.3E+00	1.6E-10	1.6E-10
U-Total	6.91E-07	5.8E-10			
			Total Pathway:	1.7E-09	
			Total Rad + Chem	1.8E-09	*Total:* 1.8E-09

TABLE C.3-12(b) (continued)

Consolidation/Containment
NONCARCINOGENIC HAZARD

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
NP-237	1.4E-05				
RA-226	1.1E-04				
RA-228	9.0E-05				
TH-228	1.8E-04				
TH-230	2.6E-04				
TH-232	1.3E-04				
U-234	1.1E-04				
U-235/236	1.6E-03				
U-238	1.1E-04				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	1.03E-06	8.6E-10	3.0E-04	2.9E-06	2.9E-06
Beryllium	4.4E-08	3.6E-11	5.0E-03	7.3E-09	7.3E-09
U-Total	6.9E-07	5.8E-10	3.0E-03	1.9E-07	1.9E-07
			Total Pathway:	3.6E-06	
			Total Rad + Chem	3.6E-06	*Total:* 3.6E-06

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TABLE C.3-12(b)
ACTIVE FLYASH PILE
OFF-PROPERTY FARMER: HOME GROWN PRODUCE
On-Site Disposal
CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
NP-237	1.93E-05	2.9E-02	2.2E-10	6.4E-12	6.4E-12
RA-226	1.40E-04	2.1E-01	1.2E-10	2.5E-11	2.5E-11
RA-228	1.13E-04	1.7E-01	1.0E-10	1.7E-11	1.7E-11
TH-228	2.26E-04	3.4E-01	5.5E-11	1.9E-11	1.9E-11
TH-230	3.28E-04	4.9E-01	1.3E-11	6.4E-12	6.4E-12
TH-232	1.62E-04	2.4E-01	1.2E-11	2.9E-12	2.9E-12
U-234	1.41E-04	2.1E-01	1.6E-11	3.4E-12	3.4E-12
U-235/236	1.63E-03	2.4E+00	1.6E-11	3.8E-11	3.8E-11
U-238	1.38E-04	2.1E-01	2.8E-11	5.8E-12	5.8E-12
			Total Pathway:	1.2E-10	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	1.40E-06	1.2E-09	1.8E+00	2.0E-09	2.0E-09
Beryllium	5.93E-08	5.0E-11	4.3E+00	2.1E-10	2.1E-10
U-Total	8.04E-07	6.7E-10			
			Total Pathway:	2.3E-09	
			Total Rad + Chem	2.4E-09	*Total:* 2.4E-09

TABLE C.3-12(b) (continued)

On-Site Disposal

NONCARCINOGENIC HAZARD

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
NP-237	1.9E-05				
RA-226	1.4E-04				
RA-228	1.1E-04				
TH-228	2.3E-04				
TH-230	3.3E-04				
TH-232	1.6E-04				
U-234	1.4E-04				
U-235/236	1.6E-03				
U-238	1.4E-04				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	1.40E-06	1.2E-09	3.0E-04	3.9E-06	3.9E-06
Beryllium	5.9E-08	5.0E-11	5.0E-03	9.9E-09	9.9E-09
U-Total	8.0E-07	6.7E-10	3.0E-03	2.2E-07	2.2E-07
			Total Pathway:	4.1E-06	
			Total Rad + Chem	4.1E-06	*Total:* 4.1E-06

TABLE C.3-12(c)

ACTIVE FLYASH PILE

OFF-PROPERTY FARMER: BEEF AND MILK (DUST AFFECTED)

Consolidation/Containment

CARCINOGENIC RISK

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
NP-237	4.96E-08	9.1E-05	2.2E-10	2.0E-14	NP-237	4.51E-09	3.3E-05	2.2E-10	7.3E-15	2.7E-14
RA-226	1.78E-06	3.3E-03	1.2E-10	3.9E-13	RA-226	3.21E-06	2.4E-02	1.2E-10	2.8E-12	3.2E-12
RA-228	1.41E-06	2.6E-03	1.0E-10	2.6E-13	RA-228	2.54E-06	1.9E-02	1.0E-10	1.9E-12	2.1E-12
TH-228	6.38E-08	1.2E-04	5.5E-11	6.4E-15	TH-228	5.32E-08	3.9E-04	5.5E-11	2.1E-14	2.8E-14
TH-230	1.01E-07	1.8E-04	1.3E-11	2.4E-15	TH-230	8.38E-08	6.2E-04	1.3E-11	8.0E-15	1.0E-14
TH-232	5.08E-08	9.3E-05	1.2E-11	1.1E-15	TH-232	4.23E-08	3.1E-04	1.2E-11	3.7E-15	4.9E-15
U-234	1.48E-06	2.7E-03	1.6E-11	4.4E-14	U-234	4.45E-06	3.3E-02	1.6E-11	5.2E-13	5.7E-13
U-235	2.12E-05	3.9E-02	1.6E-11	6.1E-13	U-235	6.37E-05	4.7E-01	1.6E-11	7.3E-12	7.9E-12
U-238	1.44E-06	2.6E-03	2.8E-11	7.4E-14	U-238	4.32E-06	3.2E-02	2.8E-11	8.9E-13	9.6E-13
			Total Pathway:	1.4E-12				Total Pathway:	1.3E-11	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	1.33E-07	1.4E-10	1.8E+00	2.4E-10	Arsenic	3.98E-09	1.6E-11	1.8E+00	2.9E-11	2.7E-10
Beryllium	2.83E-09	2.9E-12	4.3E+00	1.2E-11	Beryllium	2.55E-12	1.0E-14	4.3E+00	4.5E-14	1.3E-11
U-Total	5.31E-09	5.5E-12			U-Total	1.59E-08	6.5E-11			
			Total Pathway:	2.5E-10				Total Pathway:	2.9E-11	
			Total Rad + Chem	2.5E-10				Total Rad + Chem	4.2E-11	*otal:* 2.9E-10

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TABLE C.3-12(c) (continued)

OFF-PROPERTY FARMER: BEEF AND MILK (DUST AFFECTED)

Consolidation/Containment

NONCARCINOGENIC HAZARD

Radiation Hazard

Ingestion/Beef				Ingestion/Milk				Total
Compound	Intake	RfD(o)	Hazard	Compound	Intake	RfD(o)	Risk	
NP-237				NP-237				
RA-226				RA-226				
RA-228				RA-228				
TH-228				TH-228				
TH-230				TH-230				
TH-232				TH-232				
U-234				U-234				
U-235				U-235/236				
U-238				U-238				
		Total Pathway:	0.0E+00			Total Pathway:	0.0E+00	

Chemical Hazard

Ingestion/Beef				Ingestion/Milk				
Compound	Intake	RfD(o)	Hazard	Compound	Intake	RfD(o)	Risk	
Arsenic	1.4E-10	3.0E-04	4.5E-07	Arsenic	1.6E-11	3.0E-04	5.5E-08	5.1E-07
Beryllium	2.9E-12	5.0E-03	5.8E-10	Beryllium	1.0E-14	5.0E-03	2.1E-12	5.8E-10
U-Total	5.5E-12	3.0E-03	1.8E-09	U-Total	6.5E-11	3.0E-03	2.2E-08	2.4E-08
		Total Pathway:	5.0E-07			Total Pathway:	7.7E-08	

Total Rad + Chem 5.0E-07 Total Rad + Chem 7.7E-08 *Total:* 5.8E-07

TABLE C.3-12(c)

ACTIVE FLYASH PILE

OFF-PROPERTY FARMER: BEEF AND MILK (DUST AFFECTED)

On-Site Disposal

CARCINOGENIC RISK

Radiation Risk

Ingestion/Beef

Compound	Conc'n in Beef (pCi/kg	Intake	SF(o)	Risk
NP-237	6.73E-08	1.2E-04	2.2E-10	2.7E-14
RA-226	2.27E-06	4.2E-03	1.2E-10	5.0E-13
RA-228	1.78E-06	3.3E-03	1.0E-10	3.3E-13
TH-228	8.00E-08	1.5E-04	5.5E-11	8.1E-15
TH-230	1.28E-07	2.3E-04	1.3E-11	3.1E-15
TH-232	6.32E-08	1.2E-04	1.2E-11	1.4E-15
U-234	1.83E-06	3.4E-03	1.6E-11	5.4E-14
U-235	2.12E-05	3.9E-02	1.6E-11	6.1E-13
U-238	6.37E-04	1.2E+00	2.8E-11	3.3E-11

Total Pathway: 3.4E-11

Ingestion/Milk

Compound	onc'n in Milk (pCi/L	Intake	SF(o)	Risk
NP-237	6.12E-09	4.5E-05	2.2E-10	9.9E-15
RA-226	4.09E-06	3.0E-02	1.2E-10	3.6E-12
RA-228	3.20E-06	2.3E-02	1.0E-10	2.3E-12
TH-228	6.66E-08	4.9E-04	5.5E-11	2.7E-14
TH-230	1.07E-07	7.8E-04	1.3E-11	1.0E-14
TH-232	5.27E-08	3.9E-04	1.2E-11	4.6E-15
U-234	5.50E-06	4.0E-02	1.6E-11	6.5E-13
U-235	6.37E-05	4.7E-01	1.6E-11	7.3E-12
U-238	2.01E-04	1.5E+00	2.8E-11	4.1E-11

Total Pathway: 5.5E-11

Total
3.7E-14
4.1E-12
2.7E-12
3.5E-14
1.3E-14
6.0E-15
7.0E-13
7.9E-12
7.4E-11

Chemical Risk

Ingestion/Beef

Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk
Arsenic	1.80E-07	1.8E-10	1.8E+00	3.2E-10
Beryllium	3.85E-09	4.0E-12	4.3E+00	1.7E-11
U-Total	6.17E-09	6.3E-12		

Total Pathway: 3.4E-10

Ingestion/Milk

Compound	onc'n in Milk (mg/L	Intake	SF(o)	Risk
Arsenic	5.40E-09	2.2E-11	1.8E+00	3.9E-11
Beryllium	3.46E-12	1.4E-14	4.3E+00	6.1E-14
U-Total	1.85E-08	7.6E-11		

Total Pathway: 3.9E-11

Total
3.6E-10
1.7E-11

Total Rad + Chem 3.8E-10

Total Rad + Chem 9.4E-11

Total: 4.7E-10

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TABLE C.3-12(c) (continued)

OFF-PROPERTY FARMER: BEEF AND MILK (DUST AFFECTED)

On-Site Disposal

NONCARCINOGENIC HAZARD

Radiation Hazard

Ingestion/Beef					Ingestion/Milk					Total
Compound	n in Beef (p	Intake	RfD(o)	Hazard	Compound	n in Milk (	Intake	RfD(o)	Risk	
NP-237	6.7E-08				NP-237	6.1E-09				
RA-226	2.3E-06				RA-226	4.1E-06				
RA-228	1.8E-06				RA-228	3.2E-06				
TH-228	8.0E-08				TH-228	6.7E-08				
TH-230	1.3E-07				TH-230	1.1E-07				
TH-232	6.3E-08				TH-232	5.3E-08				
U-234	1.8E-06				U-234	5.5E-06				
U-235	2.1E-05				U-235/236	6.4E-05				
U-238	6.4E-04				U-238	2.0E-04				
			Total Pathway:	0.0E+00				Total Pathway:	0.0E+00	

Chemical Hazard

Ingestion/Beef					Ingestion/Milk					
Compound	n in Beef (	Intake	RfD(o)	Hazard	Compound	n in Milk (	Intake	RfD(o)	Risk	
Arsenic	1.8E-07	1.8E-10	3.0E-04	6.2E-07	Arsenic	5.40E-09	2.2E-11	3.0E-04	7.4E-08	6.9E-07
Beryllium	3.8E-09	4.0E-12	5.0E-03	7.9E-10	Beryllium	3.46E-12	1.4E-14	5.0E-03	2.8E-12	7.9E-10
U-Total	6.2E-09	6.3E-12	3.0E-03	2.1E-09	U-Total	1.85E-08	7.6E-11	3.0E-03	2.5E-08	2.7E-08
			Total Pathway:	6.2E-07				Total Pathway:	9.9E-08	
			Total Rad + Chem	6.2E-07				Total Rad + Chem	9.9E-08	*Total:* 7.2E-07

TABLE C.4-16

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

Consolidation/Containment

Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	0.0E+00	0.0E+00	1.9E-11	0.0E+00
NP-237	3.2E-05	1.0E-01	2.9E-08	3.0E-09
RA-226	7.2E-06	2.3E-02	3.0E-09	7.0E-11
RA-228	6.6E-06	2.1E-02	6.9E-10	1.5E-11
TH-228	5.5E-06	1.8E-02	7.8E-08	1.4E-09
TH-230	9.6E-06	3.1E-02	2.9E-08	9.1E-10
TH-232	5.1E-06	1.6E-02	2.8E-08	4.6E-10
U-234	2.1E-05	6.8E-02	2.6E-08	1.8E-09
U-235/236	1.3E-06	4.1E-03	2.5E-08	1.0E-10
U-238	2.7E-05	8.7E-02	5.2E-08	4.5E-09

Total Pathway: 1.2E-08

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	1.9E+00	4.7E+01	2.8E-11	1.3E-09
NP-237	5.0E+00	1.2E+02	2.2E-10	2.7E-08
RA-226	9.2E+00	2.3E+02	1.2E-10	2.7E-08
RA-228	1.9E+00	4.8E+01	1.0E-10	4.8E-09
TH-228	1.7E+00	4.2E+01	5.5E-11	2.3E-09
TH-230	1.4E+01	3.4E+02	1.3E-11	4.4E-09
TH-232	1.3E+01	3.2E+02	1.2E-11	3.8E-09
U-234	7.8E+01	1.9E+03	1.6E-11	3.1E-08
U-235/236	4.1E+00	9.9E+01	1.6E-11	1.6E-09
U-238	5.7E+01	1.4E+03	2.8E-11	3.9E-08

Total Pathway: 1.4E-07

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	5.4E-05	1.4E-07	1.5E+00	2.1E-07
Beryllium	3.4E-06	8.7E-09	8.4E+00	7.3E-08
Chromium	1.2E-04	3.1E-07	4.1E+01	1.3E-05
U-TOTAL	1.1E-04	2.9E-07		
Benzo(a)pyrene	3.9E-05	1.0E-07	6.1E+00	6.2E-07
Aroclor-1254	2.3E-07	5.8E-10		

Total Pathway: 1.4E-05

Total Rad + Chem 1.4E-05

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	7.6E+00	1.5E-07	1.8E+00	2.6E-07
Beryllium	8.8E-01	1.7E-08	4.3E+00	7.4E-08
Chromium	2.0E+01	3.9E-07		
U-TOTAL	3.0E+02	5.8E-06		
Benzo(a)pyrene	7.0E+00	1.4E-07	7.3E+00	1.0E-06
Aroclor-1254	3.5E-02	6.8E-10	7.7E+00	5.3E-09

Total Pathway: 1.3E-06

Total Rad + Chem 1.5E-06

000380

TABLE C.4-16(continued)

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

Consolidation/Containment

Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	8.5E-01	2.0E-06	1.7E-06	1.7E-06
	NP-237	2.2E+00	4.3E-07	9.6E-07	9.9E-07
	RA-226	4.1E+00	1.2E-08	4.9E-08	7.7E-08
	RA-228	8.7E-01	2.90E-06	2.5E-06	2.5E-06
	TH-228	7.6E-01	5.6E-06	4.3E-06	4.3E-06
	TH-230	6.2E+00	5.4E-11	3.3E-10	5.6E-09
	TH-232	5.8E+00	2.6E-11	1.5E-10	4.4E-09
	U-234	3.5E+01	3.0E-11	1.1E-09	3.4E-08
	U-235/236	1.8E+00	2.4E-07	4.3E-07	4.4E-07
	U-238	2.6E+01	3.6E-08	9.2E-07	9.6E-07
Total Pathway: 0.0E+00	Total Pathway: 1.1E-05				

Chemical Risk

Dermal Contact/Soil					External Radiation/Soil				
Compound	ABS	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	1.0E-03	7.9E-08	1.8E+00	1.5E-07					6.2E-07
Beryllium	1.0E-02	9.1E-08	4.30E+02	3.9E-05					3.9E-05
Chromium	1.0E-02	2.1E-06							1.3E-05
U-TOTAL	1.0E-02	3.1E-05							
Benzo(a)pyrene			1.70E+01						1.6E-06
Aroclor-1254	3.0E-01	1.1E-07	1.03E+01	1.1E-06					1.1E-06
Total Pathway:				4.1E-05	Total Pathway:			0.0E+00	
Total Rad + Chem				4.1E-05	Total Rad + Chem			1.1E-05	6.7E-05

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TABLE C.4-16(continued)

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

Consolidation/Containment

Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Intake	RfD(i)	Hazard
CS-137	0.0E+00		
NP-237	1.0E-01		
RA-226	2.3E-02		
RA-228	2.1E-02		
TH-228	1.8E-02		
TH-230	3.1E-02		
TH-232	1.6E-02		
U-234	6.8E-02		
U-235/236	4.1E-03		
U-238	8.7E-02		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Intake	RfD(o)	Hazard
CS-137	4.7E+01		
NP-237	1.2E+02		
RA-226	2.3E+02		
RA-228	4.8E+01		
TH-228	4.2E+01		
TH-230	3.4E+02		
TH-232	3.2E+02		
U-234	1.9E+03		
U-235/236	9.9E+01		
U-238	1.4E+03		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Intake	RfD(i)	Hazard
Arsenic	7.0E-07		
Beryllium	4.4E-08		
Chromium	1.6E-06		
U-TOTAL	1.5E-06		
Benzo(a)pyrene	5.1E-07		
Aroclor-1254	2.9E-09		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Intake	RfD(o)	Hazard
Arsenic	8.2E-07	3.0E-04	2.7E-03
Beryllium	9.4E-08	5.0E-03	1.9E-05
Chromium	2.1E-06	5.0E-03	4.3E-04
U-TOTAL	3.2E-05	3.0E-03	1.1E-02
Benzo(a)pyrene	7.5E-07		
Aroclor-1254	3.8E-09		

Total Pathway: 1.4E-02

Total Rad + Chem. 1.4E-02

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TABLE C.4-16(continued)

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

Consolidation/Containment

Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	8.5E-01			
	NP-237	2.2E+00			
	RA-226	4.1E+00			
	RA-228	8.7E-01			
	TH-228	7.6E-01			
	TH-230	6.2E+00			
	TH-232	5.8E+00			
	U-234	3.5E+01			
	U-235/236	1.8E+00			
	U-238	2.6E+01			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				Total
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	3.1E-07	2.9E-04	1.1E-03					3.8E-03
Beryllium	3.6E-07	5.0E-05	7.2E-03					7.3E-03
Chromium	8.2E-06	2.3E-03	3.6E-03					4.1E-03
U-TOTAL	1.2E-04	1.5E-04	8.1E-01					8.3E-01
Benzo(a)pyrene								
Aroclor-1254	4.3E-07							
Total Pathway:			8.3E-01	Total Pathway:			0.0E+00	
Total Rad + Chem			8.3E-01	Total Rad + Chem			0.0E+00	*Total:* 8.4E-01

000483

TABLE C.4-16

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

On-Site Disposal

Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3	Intake	SF(i)	Risk
CS-137	5.1E-06	1.7E-02	1.9E-11	3.2E-13
NP-237	3.4E-05	1.1E-01	2.9E-08	3.2E-09
RA-226	7.1E-05	2.3E-01	3.0E-09	6.9E-10
RA-228	1.7E-05	5.5E-02	6.9E-10	3.8E-11
TH-228	1.5E-05	4.8E-02	7.8E-08	3.8E-09
TH-230	1.1E-04	3.4E-01	2.9E-08	9.9E-09
TH-232	9.7E-05	3.2E-01	2.8E-08	8.8E-09
U-234	5.9E-04	1.9E+00	2.6E-08	5.0E-08
U-235/236	3.0E-05	9.9E-02	2.5E-08	2.5E-09
U-238	4.5E-04	1.4E+00	5.2E-08	7.5E-08
			Total Pathway:	1.5E-07

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	6.9E-01	1.7E+01	2.8E-11	4.7E-10
NP-237	5.0E+00	1.2E+02	2.2E-10	2.7E-08
RA-226	9.2E+00	2.3E+02	1.2E-10	2.7E-08
RA-228	1.9E+00	4.8E+01	1.0E-10	4.8E-09
TH-228	1.7E+00	4.2E+01	5.5E-11	2.3E-09
TH-230	1.4E+01	3.4E+02	1.3E-11	4.4E-09
TH-232	1.3E+01	3.2E+02	1.2E-11	3.8E-09
U-234	7.8E+01	1.9E+03	1.6E-11	3.1E-08
U-235/236	4.1E+00	9.9E+01	1.6E-11	1.6E-09
U-238	5.7E+01	1.4E+03	2.8E-11	3.9E-08
			Total Pathway:	1.4E-07

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Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	5.4E-05	1.4E-07	1.5E+00	2.1E-07
Beryllium	3.4E-06	8.7E-09	8.4E+00	7.3E-08
Chromium	1.2E-04	3.1E-07	4.1E+01	1.3E-05
U-TOTAL	1.1E-04	2.9E-07		
Benzo(a)py	3.9E-05	1.0E-07	6.1E+00	6.2E-07
Aroclor-12	2.3E-07	5.8E-10		
			Total Pathway:	1.4E-05
			Total Rad + Chem	1.4E-05

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	7.6E+00	1.5E-07	1.8E+00	2.6E-07
Beryllium	8.8E-01	1.7E-08	4.3E+00	7.4E-08
Chromium	2.0E+01	3.9E-07		
U-TOTAL	3.0E+02	5.8E-06		
Benzo(a)py	7.0E+00	1.4E-07	7.3E+00	1.0E-06
Aroclor-12	3.5E-02	6.8E-10	7.7E+00	5.3E-09
			Total Pathway:	1.3E-06
			Total Rad + Chem	1.5E-06

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TABLE C.4-16(continued)

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

On-Site Disposal

Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	3.1E-01	2.0E-06	6.2E-07	6.2E-07
	NP-237	2.2E+00	4.3E-07	9.6E-07	9.9E-07
	RA-226	4.1E+00	1.2E-08	4.9E-08	5.3E-08
	RA-228	8.7E-01	2.90E-06	2.5E-06	2.5E-06
	TH-228	7.6E-01	5.6E-06	4.3E-06	4.3E-06
	TH-230	6.2E+00	5.4E-11	3.3E-10	2.9E-08
	TH-232	5.8E+00	2.6E-11	1.5E-10	2.8E-08
	U-234	3.5E+01	3.0E-11	1.1E-09	2.7E-08
	U-235/236	1.8E+00	2.4E-07	4.3E-07	4.6E-07
	U-238	2.6E+01	3.6E-08	9.2E-07	9.7E-07
Total Pathway: 0.0E+00	Total Pathway: 9.8E-06				

Chemical Risk

Dermal Contact/Soil					External Radiation/Soil				
Compound	ABS	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	1.0E-03	7.9E-08	1.6E-07	1.2E-14					4.7E-07
Beryllium	1.0E-02	9.1E-08	1.72E-06	1.6E-13					1.5E-07
Chromium	1.0E-02	2.1E-06							1.3E-05
U-TOTAL	1.0E-02	3.1E-05							
Benzo(a)pyrene			3.17E-07						1.6E-06
Aroclor-1254	3.0E-01	1.1E-07	9.10E-10	9.9E-17					5.3E-09
Total Pathway:				1.7E-13	Total Pathway:			0.0E+00	
Total Rad + Chem				1.7E-13	Total Rad + Chem			9.8E-06	2.5E-05

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TABLE C.4-16(continued)

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

On-Site Disposal

Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	5.1E-06	1.7E-02		
NP-237	3.4E-05	1.1E-01		
RA-226	7.1E-05	2.3E-01		
RA-228	1.7E-05	5.5E-02		
TH-228	1.5E-05	4.8E-02		
TH-230	1.1E-04	3.4E-01		
TH-232	9.7E-05	3.2E-01		
U-234	5.9E-04	1.9E+00		
U-235/236	3.0E-05	9.9E-02		
U-238	4.5E-04	1.4E+00		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.69	1.7E+01		
NP-237	5.00	1.2E+02		
RA-226	9.21	2.3E+02		
RA-228	1.94	4.8E+01		
TH-228	1.70	4.2E+01		
TH-230	13.80	3.4E+02		
TH-232	12.90	3.2E+02		
U-234	78.30	1.9E+03		
U-235/236	4.05	9.9E+01		
U-238	57.00	1.4E+03		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Compound	Intake	RfD(i)	Hazard
Arsenic	5.44E-05	7.0E-07		
Beryllium	3.37E-06	4.4E-08		
Chromium	1.21E-04	1.6E-06		
U-TOTAL	1.13E-04	1.5E-06		
Benzo(a)pyrene	3.94E-05	5.1E-07		
Aroclor-1254	2.25E-07	2.9E-09		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	7.64	8.2E-07	3.0E-04	2.7E-03
Beryllium	0.88	9.4E-08	5.0E-03	1.9E-05
Chromium	19.90	2.1E-06	5.0E-03	4.3E-04
U-TOTAL	297.00	3.2E-05	3.0E-03	1.1E-02
Benzo(a)pyrene	7.00	7.5E-07		
Aroclor-1254	0.04	3.8E-09		

Total Pathway: 1.4E-02

Total Rad + Chem 1.4E-02

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TABLE C.4-16

SOUTH FIELD

EXPANDED TRESPASSER: RESIDUAL SURFACE SOIL

On-Site Disposal

Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil

Not applicable

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(e)	Hazard
CS-137	0.69	3.1E-01		
NP-237	5.00	2.2E+00		
RA-226	9.21	4.1E+00		
RA-228	1.94	8.7E-01		
TH-228	1.70	7.6E-01		
TH-230	13.80	6.2E+00		
TH-232	12.90	5.8E+00		
U-234	78.30	3.5E+01		
U-235/236	4.05	1.8E+00		
U-238	57.00	2.6E+01		

Total Pathway: 0.0E+00

Chemical Hazard

Dermal Contact/Soil

Compound	nc'n (mg/k	ABS	Intake	RfD(derm)	Hazard
Arsenic	7.64	1.0E-03	3.1E-07	2.9E-04	1.1E-03
Beryllium	0.88	1.0E-02	3.6E-07	5.0E-05	7.2E-03
Chromium	19.90	1.0E-02	8.2E-06	2.3E-03	3.6E-03
U-TOTAL	297.00	1.0E-02	1.2E-04	1.5E-04	8.1E-01
Benzo(a)pyrene	7.00				
Aroclor-1254	0.04	3.0E-01	4.3E-07		

Total Pathway: 8.3E-01

Total Rad + Chem 8.3E-01

External Radiation/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard

Total Pathway: 0.0E+00

Total Rad + Chem 0.0E+00

Total

3.8E-03
7.3E-03
4.1E-03
8.3E-01

Total: 8.4E-01

TABLE C.4-17(a)
SOUTH FIELD
OFF-PROPERTY FARMER: SURFACE SOIL
Consolidation/Containment
Carcinogenic Risk

Radiation Risk					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
NP-237	1.48E-06	1.7E-01	2.9E-08	5.0E-09	5.0E-09
RA-226	4.69E-07	5.4E-02	3.0E-09	1.6E-10	1.6E-10
RA-228	3.98E-07	4.6E-02	6.6E-10	3.0E-11	3.0E-11
TH-228	3.22E-07	3.7E-02	7.8E-08	2.9E-09	2.9E-09
TH-230	6.78E-07	7.9E-02	2.9E-08	2.3E-09	2.3E-09
TH-232	3.00E-07	3.5E-02	2.8E-08	9.7E-10	9.7E-10
U-234	1.08E-06	1.3E-01	2.6E-08	3.3E-09	3.3E-09
U-235	6.26E-08	7.3E-03	2.5E-08	1.8E-10	1.8E-10
U-238	1.37E-06	1.6E-01	5.2E-08	8.3E-09	8.3E-09
			Total Pathway:	2.3E-08	

Chemical Risk					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	3.77E-06	2.4E-07	1.5E+00	3.7E-07	3.7E-07
Beryllium	1.56E-07	1.0E-08	8.4E+00	8.5E-08	8.5E-08
Chromium	6.60E-06	4.3E-07	4.1E+01	1.8E-05	1.8E-05
U-TOTAL	7.32E-06	4.7E-07			
Benzo(a)pyrene	1.82E-06	1.2E-07	6.1E+00	7.2E-07	7.2E-07
Aroclor-1254	1.04E-08	6.7E-10			
Aroclor-1260	1.04E-08	6.7E-10			
			Total Pathway:	1.9E-05	
			Total Rad + Chem	1.9E-05	*Total:* 1.9E-05

TABLEC.4-17(a) (continued)

Non-carcinogenic Hazard

Radiation Hazard					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	Hazard	
NP-237	1.48E-06				
RA-226	4.69E-07				
RA-228	3.98E-07				
TH-228	3.22E-07				
TH-230	6.78E-07				
TH-232	3.00E-07				
U-234	1.08E-06				
U-235	6.26E-08				
U-238	1.37E-06				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard	
Arsenic	3.77E-06	2.4E-07			
Beryllium	1.56E-07	1.0E-08			
Chromium	6.60E-06	4.3E-07	5.5E-07	7.8E-01	7.8E-01
U-TOTAL	7.32E-06	4.7E-07			
Benzo(a)pyrene	1.82E-06	1.2E-07			
Aroclor-1254	1.04E-08	6.7E-10			
Aroclor-1260	1.04E-08	6.7E-10			
			Total Pathway:	7.8E-01	7.8E-01
			Total Rad + Chem	7.8E-01	*Total:* 7.8E-01

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TABLE C.4-17(a)
SOUTH FIELD
OFF-PROPERTY FARMER: SURFACE SOIL
On-Site Disposal
Carcinogenic Risk

Radiation Risk					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
NP-237	1.56E-06	1.8E-01	2.9E-08	5.2E-09	5.2E-09
RA-226	2.78E-06	3.2E-01	3.0E-09	9.7E-10	9.7E-10
RA-228	8.11E-07	9.4E-02	6.6E-10	6.2E-11	6.2E-11
TH-228	7.05E-07	8.2E-02	7.8E-08	6.4E-09	6.4E-09
TH-230	4.09E-06	4.7E-01	2.9E-08	1.4E-08	1.4E-08
TH-232	3.65E-06	4.2E-01	2.8E-08	1.2E-08	1.2E-08
U-234	2.17E-05	2.5E+00	2.6E-08	6.5E-08	6.5E-08
U-235	1.13E-06	1.3E-01	2.5E-08	3.3E-09	3.3E-09
U-238	1.68E-05	1.9E+00	5.2E-08	1.0E-07	1.0E-07
			Total Pathway:	2.1E-07	

Chemical Risk					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	5.26E-06	3.4E-07	1.5E+00	5.1E-07	5.1E-07
Beryllium	2.96E-07	1.9E-08	8.4E+00	1.6E-07	1.6E-07
Chromium	1.05E-05	6.8E-07	4.1E+01	2.8E-05	2.8E-05
U-TOTAL	8.40E-05	5.4E-06			
Benzo(a)pyrene	2.20E-06	1.4E-07	6.1E+00	8.7E-07	8.7E-07
Aroclor-1254	1.97E-08	1.3E-09			
Aroclor-1260	1.01E-08	6.5E-10			
			Total Pathway:	2.9E-05	
			Total Rad + Chem	3.0E-05	*Total:* 3.0E-05

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TABLEC.4-17(a) (continued)

Non-carcinogenic Hazard

Radiation Hazard					
Inhalation of Particulates/Soil					Total
Compound	onc'n in Air (pCi/m3	Intake	RfD(i)	Hazard	
NP-237	1.56E-06				
RA-226	2.78E-06				
RA-228	8.11E-07				
TH-228	7.05E-07				
TH-230	4.09E-06				
TH-232	3.65E-06				
U-234	2.17E-05				
U-235	1.13E-06				
U-238	1.68E-05				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard	
Arsenic	3.77E-06	2.4E-07			
Beryllium	1.56E-07	1.0E-08			
Chromium	6.60E-06	4.3E-07	5.5E-07	7.8E-01	7.8E-01
U-TOTAL	7.32E-06	4.7E-07			
Benzo(a)pyrene	1.82E-06	1.2E-07			
Aroclor-1254	1.04E-08	6.7E-10			
Aroclor-1260	0.00E+00	0.0E+00			
			Total Pathway:	7.8E-01	7.8E-01
			Total Rad + Chem	7.8E-01	*Total:* 7.8E-01

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TABLE C.4-17(b)
SOUTH FIELD
OFF-PROPERTY FARMER: HOME GROWN PRODUCE (DUST AFFECTED)
Consolidation/Containment
Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
CS-137	0.00E+00	0.0E+00	2.8E-11	0.0E+00	0.0E+00
NP-237	5.72E-04	8.5E-01	2.2E-10	1.9E-10	1.9E-10
RA-226	1.72E-04	2.6E-01	1.2E-10	3.1E-11	3.1E-11
RA-228	1.47E-04	2.2E-01	1.0E-10	2.2E-11	2.2E-11
TH-228	1.19E-04	1.8E-01	5.5E-11	9.8E-12	9.8E-12
TH-230	2.47E-04	3.7E-01	1.3E-11	4.8E-12	4.8E-12
TH-232	1.10E-04	1.6E-01	1.2E-11	2.0E-12	2.0E-12
U-234	4.02E-04	6.0E-01	1.6E-11	9.6E-12	9.6E-12
U-235	2.33E-05	3.5E-02	1.6E-11	5.6E-13	5.6E-13
U-238	5.11E-04	7.6E-01	2.8E-11	2.1E-11	2.1E-11
			Total Pathway:	2.9E-10	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	1.40E-06	1.2E-09	1.8E+00	2.0E-09	2.0E-09
Beryllium	5.85E-08	4.9E-11	4.3E+00	2.1E-10	2.1E-10
Chromium	2.45E-06	2.1E-09			
Aroclor 1254	3.90E-09	3.3E-12	7.7E+00	2.5E-11	2.5E-11
Aroclor 1260	0.00E+00	0.0E+00	7.7E+00	0.0E+00	0.0E+00
			Total Pathway:	2.3E-09	
			Total Rad + Chem	2.6E-09	*Total:* 2.6E-09

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TABLE C.4-17(b) (continued)

Consolidation/Containment
Noncarcinogenic Hazard

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	0.0E+00	0.0E+00			
NP-237	5.7E-04	8.5E-01			
RA-226	1.7E-04	2.6E-01			
RA-228	1.5E-04	2.2E-01			
TH-228	1.2E-04	1.8E-01			
TH-230	2.5E-04	3.7E-01			
TH-232	1.1E-04	1.6E-01			
U-234	4.0E-04	6.0E-01			
U-235	2.3E-05	3.5E-02			
U-238	5.1E-04	7.6E-01			
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	1.4E-06	1.2E-09	3.0E-04	3.9E-06	3.9E-06
Beryllium	5.8E-08	4.9E-11	5.0E-03	9.8E-09	9.8E-09
Chromium	2.5E-06	2.1E-09	5.0E-03	4.1E-07	4.1E-07
Aroclor 1254	3.9E-09	3.3E-12			
Aroclor 1260	0.0E+00	0.0E+00			
			Total Pathway:	4.3E-06	
			Total Rad + Chem	4.3E-06	*Total:* 4.3E-06

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TABLE C.4-17(b)
SOUTH FIELD
OFF-PROPERTY FARMER: HOME GROWN PRODUCE (DUST AFFECTED)
On-Site Disposal
Carcinogenic Risk

Radiation Risk

Ingestion/Homegrown Produce

Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	Total
CS-137	6.77E-05	1.0E-01	2.8E-11	2.8E-12	2.8E-12
NP-237	6.02E-04	9.0E-01	2.2E-10	2.0E-10	2.0E-10
RA-226	1.00E-03	1.5E+00	1.2E-10	1.8E-10	1.8E-10
RA-228	3.02E-04	4.5E-01	1.0E-10	4.5E-11	4.5E-11
TH-228	2.58E-04	3.8E-01	5.5E-11	2.1E-11	2.1E-11
TH-230	1.47E-03	2.2E+00	1.3E-11	2.8E-11	2.8E-11
TH-232	1.31E-03	2.0E+00	1.2E-11	2.4E-11	2.4E-11
U-234	7.81E-03	1.2E+01	1.6E-11	1.9E-10	1.9E-10
U-235	4.06E-04	6.1E-01	1.6E-11	9.7E-12	9.7E-12
U-238	6.04E-03	9.0E+00	2.8E-11	2.5E-10	2.5E-10
			Total Pathway:	9.5E-10	

Chemical Risk

Ingestion/Homegrown Produce

Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	Total
Arsenic	1.97E-06	1.6E-09	1.8E+00	2.9E-09	2.9E-09
Beryllium	1.06E-07	8.8E-11	4.3E+00	3.8E-10	3.8E-10
Chromium	3.90E-06	3.3E-09			
Aroclor 1254	7.11E-09	5.9E-12	7.7E+00	4.6E-11	4.6E-11
Aroclor 1260	3.64E-09	3.0E-12	7.7E+00	2.3E-11	2.3E-11
			Total Pathway:	3.3E-09	
			Total Rad + Chem	4.3E-09	*Total:* 4.3E-09

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TABLE C.4-17(b) (continued)

On-Site Disposal

Noncarcinogenic Hazard

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	6.8E-05	1.0E-01			
NP-237	6.0E-04	9.0E-01			
RA-226	1.0E-03	1.5E+00			
RA-228	3.0E-04	4.5E-01			
TH-228	2.6E-04	3.8E-01			
TH-230	1.5E-03	2.2E+00			
TH-232	1.3E-03	2.0E+00			
U-234	7.8E-03	1.2E+01			
U-235	4.1E-04	6.1E-01			
U-238	6.0E-03	9.0E+00			
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	2.0E-06	1.6E-09	3.0E-04	5.5E-06	5.5E-06
Beryllium	1.1E-07	8.8E-11	5.0E-03	1.8E-08	1.8E-08
Chromium	3.9E-06	3.3E-09	5.0E-03	6.5E-07	6.5E-07
Aroclor 12	7.1E-09	5.9E-12			
Aroclor 12	3.6E-09	3.0E-12			
			Total Pathway:	6.1E-06	
			Total Rad + Chem	6.1E-06	*Total:* 6.1E-06

TABLE C.4-17(c)
SOUTH FIELD
OFF-PROPERTY FARMER: BEEF AND MILK (DUST AFFECTED)
Consolidation/Containment
CARCINOGENIC RISK

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
CS-137	0.00E+00	0.0E+00	2.8E-11	0.0E+00	CS-137	0.00E+00	0.0E+00	2.8E-11	0.0E+00	0.0E+00
NP-237	1.99E-06	3.7E-03	2.2E-10	8.0E-13	NP-237	1.81E-07	1.3E-03	2.2E-10	2.9E-13	1.1E-12
RA-226	2.79E-06	5.1E-03	1.2E-10	6.2E-13	RA-226	5.02E-06	3.7E-02	1.2E-10	4.4E-12	5.0E-12
RA-228	2.30E-06	4.2E-03	1.0E-10	4.2E-13	RA-228	4.15E-06	3.0E-02	1.0E-10	3.0E-12	3.5E-12
TH-228	4.21E-08	7.7E-05	5.5E-11	4.3E-15	TH-228	3.51E-08	2.6E-04	5.5E-11	1.4E-14	1.8E-14
TH-230	9.62E-08	1.8E-04	1.3E-11	2.3E-15	TH-230	8.02E-08	5.9E-04	1.3E-11	7.7E-15	1.0E-14
TH-232	4.31E-08	7.9E-05	1.2E-11	9.5E-16	TH-232	3.59E-08	2.6E-04	1.2E-11	3.2E-15	4.1E-15
U-234	5.23E-06	9.6E-03	1.6E-11	1.5E-13	U-234	1.57E-05	1.2E-01	1.6E-11	1.8E-12	2.0E-12
U-235	3.03E-07	5.6E-04	1.6E-11	8.9E-15	U-235	9.10E-07	6.7E-03	1.6E-11	1.1E-13	1.2E-13
U-238	6.64E-06	1.2E-02	2.8E-11	3.4E-13	U-238	1.99E-05	1.5E-01	2.8E-11	4.1E-12	4.4E-12
			Total Pathway:	2.4E-12				Total Pathway:	1.4E-11	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	1.80E-07	1.8E-10	1.8E+00	3.2E-10	Arsenic	5.40E-09	2.2E-11	1.8E+00	3.9E-11	3.6E-10
Beryllium	3.79E-09	3.9E-12	4.3E+00	1.7E-11	Beryllium	3.41E-12	1.4E-14	4.3E+00	6.0E-14	1.7E-11
Chromium	8.78E-07	9.0E-10			Chromium	2.39E-07	9.8E-10			
Aroclor 1254	6.85E-09	7.0E-12	7.7E+00	5.4E-11	Aroclor 1254	2.17E-09	8.9E-12	7.7E+00	6.9E-11	1.2E-10
Aroclor 1260	0.00E+00	0.0E+00	7.7E+00	0.0E+00	Aroclor 1260	0.00E+00	0.0E+00	7.7E+00	0.0E+00	0.0E+00
			Total Pathway:	3.9E-10				Total Pathway:	1.1E-10	
			Total Rad + Chem	4.0E-10				Total Rad + Chem	1.2E-10	*Total:* 5.2E-10

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TABLE C.4-17(c) (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Ingestion/Beef

Compound	Conc'n in Beef (pCi/kg)	Intake	RfD(o)	Hazard
CS-137	0.0E+00	0.0E+00		
NP-237	2.0E-06	3.7E-03		
RA-226	2.8E-06	5.1E-03		
RA-228	2.3E-06	4.2E-03		
TH-228	4.2E-08	7.7E-05		
TH-230	9.6E-08	1.8E-04		
TH-232	4.3E-08	7.9E-05		
U-234	5.2E-06	9.6E-03		
U-235	3.0E-07	5.6E-04		
U-238	6.6E-06	1.2E-02		

Total Pathway: 0.0E+00

Ingestion/Milk

Compound	Conc'n-Milk (pCi/L)	Intake	RfD(o)	Hazard
CS-137	0.00E+00			
NP-237	1.81E-07			
RA-226	5.02E-06			
RA-228	4.15E-06			
TH-228	3.51E-08			
TH-230	8.02E-08			
TH-232	3.59E-08			
U-234	1.57E-05			
U-235	9.10E-07			
U-238	1.99E-05			

Total Pathway: 0.0E+00

Chemical Hazard

Ingestion/Beef

Compound	Conc'n in Beef (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	1.8E-07	1.8E-10	3.0E-04	6.2E-07
Beryllium	3.8E-09	3.9E-12	5.0E-03	7.8E-10
Chromium	8.8E-07	9.0E-10	5.0E-03	1.8E-07
Aroclor 1254	6.8E-09	7.0E-12		
Aroclor 1260	0.0E+00	0.0E+00		

Total Pathway: 8.0E-07

Ingestion/Milk

Compound	Conc'n-Milk (mg/L)	Intake	RfD(o)	Hazard	Total
Arsenic	5.4E-09	2.2E-11	3.0E-04	7.4E-08	6.9E-07
Beryllium	3.4E-12	1.4E-14	5.0E-03	2.8E-12	7.8E-10
Chromium	2.4E-07	9.8E-10	6.1E-02	1.6E-08	3.8E-07
Aroclor 1254	2.2E-09	8.9E-12			

Total Pathway: 2.7E-07

Total Rad + Chem 8.0E-07

Total: 1.1E-06

TABLE C.4-17(c)
SOUTH FIELD
OFF-PROPERTY FARMER: BEEF AND MILK (DUST AFFECTED)

On-Site Disposal

CARCINOGENIC RISK

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	onc'n in Beef (pCi/kg	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
CS-137	8.68E-05	1.6E-01	2.8E-11	4.5E-12	CS-137	3.04E-05	2.2E-01	2.8E-11	6.3E-12	1.1E-11
NP-237	2.10E-06	3.9E-03	2.2E-10	8.5E-13	NP-237	1.91E-07	1.4E-03	2.2E-10	3.1E-13	1.2E-12
RA-226	1.63E-05	3.0E-02	1.2E-10	3.6E-12	RA-226	2.93E-05	2.2E-01	1.2E-10	2.6E-11	2.9E-11
RA-228	4.73E-06	8.7E-03	1.0E-10	8.7E-13	RA-228	8.52E-06	6.3E-02	1.0E-10	6.3E-12	7.1E-12
TH-228	9.12E-08	1.7E-04	5.5E-11	9.2E-15	TH-228	7.60E-08	5.6E-04	5.5E-11	3.1E-14	4.0E-14
TH-230	5.72E-07	1.1E-03	1.3E-11	1.4E-14	TH-230	4.77E-07	3.5E-03	1.3E-11	4.6E-14	5.9E-14
TH-232	5.11E-07	9.4E-04	1.2E-11	1.1E-14	TH-232	4.26E-07	3.1E-03	1.2E-11	3.8E-14	4.9E-14
U-234	1.01E-04	1.9E-01	1.6E-11	3.0E-12	U-234	3.04E-04	2.2E+00	1.6E-11	3.6E-11	3.9E-11
U-235	5.28E-06	9.7E-03	1.6E-11	1.6E-13	U-235	1.58E-05	1.2E-01	1.6E-11	1.9E-12	2.0E-12
U-238	7.86E-05	1.4E-01	2.8E-11	4.0E-12	U-238	2.36E-04	1.7E+00	2.8E-11	4.9E-11	5.3E-11
			Total Pathway:	1.7E-11				Total Pathway:	1.2E-10	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	onc'n in Beef (mg/kg	Intake	SF(o)	Risk	Compound	Conc'n-Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	2.53E-07	2.6E-10	1.8E+00	4.6E-10	Arsenic	7.60E-09	3.1E-11	1.8E+00	5.5E-11	5.1E-10
Beryllium	6.85E-09	7.0E-12	4.3E+00	3.0E-11	Beryllium	6.16E-12	2.5E-14	4.3E+00	1.1E-13	3.0E-11
Chromium	1.39E-06	1.4E-09			Chromium	3.80E-07	1.6E-09			
Aroclor 1254	1.25E-08	1.3E-11	7.7E+00	9.9E-11	Aroclor 12	3.95E-09	1.6E-11	7.7E+00	1.2E-10	2.2E-10
Aroclor 1260	7.70E-09	7.9E-12	7.7E+00	6.1E-11	Aroclor 12	2.43E-09	1.0E-11	7.7E+00	7.7E-11	1.4E-10
			Total Pathway:	6.5E-10				Total Pathway:	2.6E-10	
			Total Rad + Chem	6.6E-10				Total Rad + Chem	3.8E-10	*Total:* 1.0E-09

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TABLE C.4-17(c) (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Ingestion/Beef

Compound	Intake	RfD(o)	Hazard
CS-137	1.6E-01		
NP-237	3.9E-03		
RA-226	3.0E-02		
RA-228	8.7E-03		
TH-228	1.7E-04		
TH-230	1.1E-03		
TH-232	9.4E-04		
U-234	1.9E-01		
U-235	9.7E-03		
U-238	1.4E-01		
Total Pathway:	0.0E+00		

Ingestion/Milk

Compound	'n-Milk (p	Intake	RfD(o)	Hazard
CS-137	3.04E-05			
NP-237	1.91E-07			
RA-226	2.93E-05			
RA-228	8.52E-06			
TH-228	7.60E-08			
TH-230	4.77E-07			
TH-232	4.26E-07			
U-234	3.04E-04			
U-235	1.58E-05			
U-238	2.36E-04			
Total Pathway:	0.0E+00			

Chemical Hazard

Ingestion/Beef

Compound	Intake	RfD(o)	Hazard
Arsenic	2.6E-10	3.0E-04	8.7E-07
Beryllium	7.0E-12	5.0E-03	1.4E-09
Chromium	1.4E-09	5.0E-03	2.9E-07
Aroclor 12	1.3E-11		
Aroclor 12	7.9E-12		
Total Pathway:	1.2E-06		

Ingestion/Milk

Compound	c'n-Milk (m	Intake	RfD(o)	Hazard
Arsenic	7.6E-09	3.1E-11	3.0E-04	1.0E-07
Beryllium	6.2E-12	2.5E-14	5.0E-03	5.1E-12
Chromium	3.8E-07	1.6E-09	5.0E-03	3.1E-07
Aroclor 12	3.9E-09	1.6E-11		
Aroclor 12	2.4E-09	1.0E-11		
Total Pathway:	4.2E-07			

	Total
	9.7E-07
	1.4E-09
	6.0E-07
	0.0E+00
Total:	1.2E-06

Total Rad + Chem 1.2E-06

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TABLE C.4-18(a)
SOUTH FIELD
ON-PROPERTY FARMER: SURFACE SOIL
Consolidation/Containment

Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137		0.0E+00	1.9E-11	0.0E+00
NP-237	1.83E-04	2.1E+01	2.9E-08	6.2E-07
RA-226	4.21E-05	4.9E+00	3.0E-09	1.5E-08
RA-228	3.84E-05	4.5E+00	6.9E-10	3.1E-09
TH-228	3.21E-05	3.7E+00	7.8E-08	2.9E-07
TH-230	5.17E-05	6.0E+00	2.9E-08	1.7E-07
U-234	1.20E-04	1.4E+01	2.6E-08	3.6E-07
U-235/236	7.28E-06	8.4E-01	2.5E-08	2.1E-08
U-238	1.54E-04	1.8E+01	5.2E-08	9.3E-07
			Total Pathway:	2.4E-06

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137		0.0E+00	2.8E-11	0.0E+00
NP-237	5.00E+00	2.2E+04	2.2E-10	4.9E-06
RA-226	9.21E+00	4.1E+04	1.2E-10	4.9E-06
RA-228	1.94E+00	8.6E+03	1.0E-10	8.6E-07
TH-228	1.70E+00	7.5E+03	5.5E-11	4.1E-07
TH-230	1.38E+01	6.1E+04	1.3E-11	7.9E-07
U-234	7.83E+01	3.5E+05	1.6E-11	5.5E-06
U-235/236	4.05E+00	1.8E+04	1.6E-11	2.9E-07
U-238	5.70E+01	2.5E+05	2.8E-11	7.0E-06
			Total Pathway:	2.5E-05

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (mg/m3)	Intake	SF(i)	Risk
Arsenic	3.2E-04	2.1E-05	1.5E+00	3.1E-05
Beryllium	1.9E-05	1.3E-06	8.4E+00	1.1E-05
Chromium	7.0E-04	4.5E-05	4.1E+01	1.9E-03
Aroclor-1254	1.3E-06	8.4E-08		
			Total Pathway:	1.9E-03

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	7.64E+00	1.9E-05	1.8E+00	3.3E-05
Beryllium	8.80E-01	2.2E-06	4.3E+00	9.3E-06
Chromium	1.99E+01	4.9E-05		
Aroclor-1254	3.50E-02	8.6E-08	7.7E+00	6.6E-07
			Total Pathway:	4.3E-05

Total Rad + Chem 1.9E-03

Total Rad + Chem 6.8E-05

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TABLE C.4-18(a) (continued)

Consolidation/Containment

Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	0.0E+00	2.0E-06	0.0E+00	0.0E+00
	NP-237	2.1E+02	4.3E-07	8.9E-05	9.5E-05
	RA-226	3.8E+02	1.2E-08	4.6E-06	9.5E-06
	RA-228	8.1E+01	2.90E-06	2.3E-04	2.3E-04
	TH-228	7.1E+01	5.6E-06	4.0E-04	4.0E-04
	TH-230	5.7E+02	5.4E-11	3.1E-08	1.0E-06
	U-234	3.3E+03	3.0E-11	9.8E-08	6.0E-06
	U-235/236	1.7E+02	2.4E-07	4.0E-05	4.1E-05
	U-238	2.4E+03	3.6E-08	8.5E-05	9.3E-05
Total Pathway: 0.0E+00	Total Pathway:			8.5E-04	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	6.0E-07	1.8E+00	1.1E-06					6.5E-05
Beryllium	6.9E-07	4.30E+02	3.0E-04					3.2E-04
Chromium	1.6E-05			Not applicable				1.9E-03
Aroclor-1254	8.3E-07	1.03E+01	8.5E-06					9.2E-06
		Total Pathway:	3.1E-04			Total Pathway:	0.0E+00	
		Total Rad + Chem	3.1E-04				8.5E-04	
								0.0E+00
								Total: 3.1E-03

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TABLE C.4-18(a) (continued)

Consolidation/Containment

Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	0.0E+00	0.0E+00		
NP-237	1.8E-04	2.1E+01		
RA-226	4.2E-05	4.9E+00		
RA-228	3.8E-05	4.5E+00		
TH-228	3.2E-05	3.7E+00		
TH-230	5.2E-05	6.0E+00		
U-234	1.2E-04	1.4E+01		
U-235/236	7.3E-06	8.4E-01		
U-238	1.5E-04	1.8E+01		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.00	0.0E+00		
NP-237	5.00	2.2E+04		
RA-226	9.21	4.1E+04		
RA-228	1.94	8.6E+03		
TH-228	1.70	7.5E+03		
TH-230	13.80	6.1E+04		
U-234	78.30	3.5E+05		
U-235/236	4.05	1.8E+04		
U-238	57.00	2.5E+05		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	3.20E-04	2.1E-05		
Beryllium	1.93E-05	1.3E-06		
Chromium	7.00E-04	4.5E-05		
Aroclor-1254	1.29E-06	8.4E-08		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg	Intake	RfD(o)	Hazard
Arsenic	7.64	1.9E-05	3.0E-04	6.3E-02
Beryllium	0.88	2.2E-06	5.0E-03	4.3E-04
Chromium	19.90	4.9E-05	5.0E-03	9.8E-03
Aroclor-1254	0.04	8.6E-08		

Total Pathway: 0.1

Total Rad + Chem 0.0E+00

Total Rad + Chem 0.1

TABLE C.4-18(a) (continued)

Consolidation/Containment

Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil					Total
	Compound	onc'n (pCi/	Intake	RfD(e)	Hazard	
Not applicable	CS-137	0.00	0.0E+00			
	NP-237	5.00	2.1E+02			
	RA-226	9.21	3.8E+02			
	RA-228	1.94	8.1E+01			
	TH-228	1.70	7.1E+01			
	TH-230	13.80	5.7E+02			
	U-234	78.30	3.3E+03			
	U-235/236	4.05	1.7E+02			
	U-238	57.00	2.4E+03			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00					

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil					
Compound	Intake	RfD(derm)	Hazard	Compound	onc'n (mg/k	Intake	RfD(e)	Hazard	
Arsenic	6.0E-07	2.9E-04	2.1E-03						6.5E-02
Beryllium	6.9E-07	5.0E-05	1.4E-02						1.4E-02
Chromium	1.6E-05	2.3E-03	7.0E-03	Not applicable					1.7E-02
Aroclor-1254	8.3E-07								
Total Pathway:			2.3E-02	Total Pathway:				0.0E+00	
									0.0E+00
Total Rad + Chem			2.3E-02					0.0E+00	0.0E+00

Total: 9.6E-02

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TABLE C.4-18(a)
SOUTH FIELD
ON-PROPERTY FARMER: SURFACE SOIL
On-Site Disposal
Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	3.47E-05	4.0E+00	1.9E-11	7.6E-11
NP-237	1.07E-04	1.2E+01	2.9E-08	3.6E-07
RA-226	4.83E-04	5.6E+01	3.0E-09	1.7E-07
RA-228	1.16E-04	1.3E+01	6.9E-10	9.3E-09
TH-228	1.03E-04	1.2E+01	7.8E-08	9.3E-07
TH-230	7.18E-04	8.3E+01	2.9E-08	2.4E-06
U-234	3.98E-03	4.6E+02	2.6E-08	1.2E-05
U-235/236	2.07E-04	2.4E+01	2.5E-08	6.0E-07
U-238	3.03E-03	3.5E+02	5.2E-08	1.8E-05
			Total Pathway:	3.5E-05

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137		0.0E+00	2.8E-11	0.0E+00
NP-237	5.00E+00	2.2E+04	2.2E-10	4.9E-06
RA-226	9.21E+00	4.1E+04	1.2E-10	4.9E-06
RA-228	1.94E+00	8.6E+03	1.0E-10	8.6E-07
TH-228	1.70E+00	7.5E+03	5.5E-11	4.1E-07
TH-230	1.38E+01	6.1E+04	1.3E-11	7.9E-07
U-234	7.83E+01	3.5E+05	1.6E-11	5.5E-06
U-235/236	4.05E+00	1.8E+04	1.6E-11	2.9E-07
U-238	5.70E+01	2.5E+05	2.8E-11	7.0E-06
			Total Pathway:	2.5E-05

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (mg/m3)	Intake	SF(i)	Risk
Arsenic	5.1E-04	3.3E-05	1.5E+00	5.0E-05
Beryllium	3.9E-05	2.6E-06	8.4E+00	2.1E-05
Chromium	1.3E-03	8.1E-05	4.1E+01	3.3E-03
Aroclor-1254	2.6E-06	1.7E-07		
			Total Pathway:	3.4E-03

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	7.64E+00	1.9E-05	1.8E+00	3.3E-05
Beryllium	8.80E-01	2.2E-06	4.3E+00	9.3E-06
Chromium	1.99E+01	4.9E-05		
Aroclor-12	3.50E-02	8.6E-08	7.7E+00	6.6E-07
			Total Pathway:	4.3E-05

Total Rad + Chem 3.4E-03

Total Rad + Chem 6.8E-05

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TABLE C.4-18(a) (continued)

On-Site Disposal

Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil

Not applicable

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Conc'n (pCi/g)	Intake	SF(e)	Risk	Total
CS-137	0.00	0.0E+00	2.0E-06	0.0E+00	7.6E-11
NP-237	5.00	2.1E+02	4.3E-07	8.9E-05	9.5E-05
RA-226	9.21	3.8E+02	1.2E-08	4.6E-06	9.6E-06
RA-228	1.94	8.1E+01	2.90E-06	2.3E-04	2.3E-04
TH-228	1.70	7.1E+01	5.6E-06	4.0E-04	4.0E-04
TH-230	13.80	5.7E+02	5.4E-11	3.1E-08	3.2E-06
U-234	78.30	3.3E+03	3.0E-11	9.8E-08	1.8E-05
U-235/236	4.05	1.7E+02	2.4E-07	4.0E-05	4.1E-05
U-238	57.00	2.4E+03	3.6E-08	8.5E-05	1.1E-04

Total Pathway: 8.5E-04

Chemical Risk

Dermal Contact/Soil

Compound	onc'n (mg/k	ABS	Intake	SF(derm)	Risk	Total
Arsenic	7.64	1.0E-03	6.0E-07	1.8E+00	1.1E-06	8.4E-05
Beryllium	0.88	1.0E-02	6.9E-07	4.30E+02	3.0E-04	3.3E-04
Chromium	19.90	1.0E-02	1.6E-05			3.3E-03
Aroclor-12	0.04	3.0E-01	8.3E-07	1.03E+01	8.5E-06	9.2E-06

Total Pathway: 3.1E-04

External Radiation/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk

Not applicable

Total Pathway: 0.0E+00

Total Rad + Chem 3.1E-04 8.5E-04

0.0E+00

Total: 4.7E-03

TABLE C.4-18(a) (continued)

On-Site Disposal

Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	3.5E-05	4.0E+00		
NP-237	1.1E-04	1.2E+01		
RA-226	4.8E-04	5.6E+01		
RA-228	1.2E-04	1.3E+01		
TH-228	1.0E-04	1.2E+01		
TH-230	7.2E-04	8.3E+01		
U-234	4.0E-03	4.6E+02		
U-235/236	2.1E-04	2.4E+01		
U-238	3.0E-03	3.5E+02		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.00	0.0E+00		
NP-237	5.00	2.2E+04		
RA-226	9.21	4.1E+04		
RA-228	1.94	8.6E+03		
TH-228	1.70	7.5E+03		
TH-230	13.80	6.1E+04		
U-234	78.30	3.5E+05		
U-235/236	4.05	1.8E+04		
U-238	57.00	2.5E+05		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	5.12E-04	3.3E-05		
Beryllium	3.94E-05	2.6E-06		
Chromium	1.25E-03	8.1E-05		
Aroclor-12	2.63E-06	1.7E-07		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	7.64	1.9E-05	3.0E-04	6.3E-02
Beryllium	0.88	2.2E-06	5.0E-03	4.3E-04
Chromium	19.90	4.9E-05	5.0E-03	9.8E-03
Aroclor-12	0.04	8.6E-08		

Total Pathway: 0.1

Total Rad + Chem 0.0E+00

Total Rad + Chem 0.1

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TABLE C.4-18(a) (continued)

On-Site Disposal

Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil

Not applicable

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(c)	Hazard
CS-137	0.00	0.0E+00		
NP-237	5.00	2.1E+02		
RA-226	9.21	3.8E+02		
RA-228	1.94	8.1E+01		
TH-228	1.70	7.1E+01		
TH-230	13.80	5.7E+02		
U-234	78.30	3.3E+03		
U-235/236	4.05	1.7E+02		
U-238	57.00	2.4E+03		

Total Pathway: 0.0E+00

Chemical Hazard

Dermal Contact/Soil

Compound	onc'n (mg/k	ABS	Intake	RfD(derm)	Hazard
Arsenic	7.64	1.0E-03	6.0E-07	2.9E-04	2.1E-03
Beryllium	0.88	1.0E-02	6.9E-07	5.0E-05	1.4E-02
Chromium	19.90	1.0E-02	1.6E-05	2.3E-03	7.0E-03
Aroclor-12	0.04	3.0E-01	8.3E-07		

Total Pathway: 2.3E-02

External Radiation/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(c)	Hazard
Not applicable				

Total Pathway: 0.0E+00

Total Rad + Chem 2.3E-02

Total
6.5E-02
1.4E-02
1.7E-02
0.0E+00
0.0E+00

Total: 9.6E-02

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TABLE C.4-18(c)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: HOME GROWN PRODUCE (DUST AFFECTED)
Consolidation/Containment

Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
CS-137	0.00E+00	0.0E+00	2.8E-11	0.0E+00	0.0E+00
NP-237	9.08E-03	1.4E+01	2.2E-10	3.0E-09	3.0E-09
RA-226	2.06E-03	3.1E+00	1.2E-10	3.7E-10	3.7E-10
RA-228	1.87E-03	2.8E+00	1.0E-10	2.8E-10	2.8E-10
TH-228	1.55E-03	2.3E+00	5.5E-11	1.3E-10	1.3E-10
TH-230	2.79E-03	4.2E+00	1.3E-11	5.4E-11	5.4E-11
TH-232	1.42E-03	2.1E+00	1.2E-11	2.6E-11	2.6E-11
U-234	5.79E-03	8.7E+00	1.6E-11	1.4E-10	1.4E-10
U-235	3.51E-04	5.2E-01	1.6E-11	8.4E-12	8.4E-12
U-238	7.44E-03	1.1E+01	2.8E-11	3.1E-10	3.1E-10
			Total Pathway:	4.3E-09	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	1.58E-05	1.3E-08	1.8E+00	2.3E-08	2.3E-08
Beryllium	9.25E-07	7.7E-10	4.3E+00	3.3E-09	3.3E-09
U-TOTAL	3.24E-05	2.7E-08			
Benzo(a)pyrene	1.04E-05	8.7E-09	7.3E+00	6.4E-08	6.4E-08
Aroclor 1254	6.19E-08	5.2E-11	7.7E+00	4.0E-10	4.0E-10
			Total Pathway:	9.1E-08	
			Total Rad + Chem	9.5E-08	*Total:* 9.5E-08

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TABLE C.4-18(c) (continued)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: HOME GROWN PRODUCE (DUST AFFECTED)
Consolidation/Containment
Noncarcinogenic Hazard

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	0.0E+00				
NP-237	9.1E-03				
RA-226	2.1E-03				
RA-228	1.9E-03				
TH-228	1.6E-03				
TH-230	2.8E-03				
TH-232	1.4E-03				
U-234	5.8E-03				
U-235	3.5E-04				
U-238	7.4E-03				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	1.6E-05	1.3E-08	3.0E-04	4.4E-05	4.4E-05
Beryllium	9.3E-07	7.7E-10	5.0E-03	1.5E-07	1.5E-07
U-TOTAL	3.2E-05	2.7E-08	3.0E-03		0.0E+00
Benzo(a)pyrene	1.0E-05	8.7E-09			
Aroclor 1254	6.2E-08	5.2E-11			
			Total Pathway:	5.0E-05	
			Total Rad + Chem	5.0E-05	*Total:* 5.0E-05

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TABLE C.4-18(c)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: HOME GROWN PRODUCE (DUST AFFECTED)
On-Site Disposal

Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
CS-137	1.45E-03	2.2E+00	2.8E-11	6.1E-11	6.1E-11
NP-237	9.53E-03	1.4E+01	2.2E-10	3.1E-09	3.1E-09
RA-226	1.98E-02	3.0E+01	1.2E-10	3.5E-09	3.5E-09
RA-228	4.84E-03	7.2E+00	1.0E-10	7.2E-10	7.2E-10
TH-228	4.27E-03	6.4E+00	5.5E-11	3.5E-10	3.5E-10
TH-230	2.92E-02	4.4E+01	1.3E-11	5.7E-10	5.7E-10
TH-232	2.70E-02	4.0E+01	1.2E-11	4.8E-10	4.8E-10
U-234	1.63E-01	2.4E+02	1.6E-11	3.9E-09	3.9E-09
U-235	8.45E-03	1.3E+01	1.6E-11	2.0E-10	2.0E-10
U-238	1.24E-01	1.9E+02	2.8E-11	5.2E-09	5.2E-09
			Total Pathway:	1.8E-08	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	2.37E-05	2.0E-08	1.8E+00	3.5E-08	3.5E-08
Beryllium	1.68E-06	1.4E-09	4.3E+00	6.0E-09	6.0E-09
U-TOTAL	6.22E-04	5.2E-07			
Benzo(a)pyrene	1.24E-05	1.0E-08	7.3E+00	7.5E-08	7.5E-08
Aroclor 1254	1.12E-07	9.3E-11	7.7E+00	7.2E-10	7.2E-10
			Total Pathway:	1.2E-07	
			Total Rad + Chem	1.3E-07	*Total:* 1.3E-07

000510

TABLE C.4-18(c) (continued)
FUTURE ON-PROPERTY FARMER (RME VALUES)

On-Site Disposal

Noncarcinogenic Hazard

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	1.5E-03				
NP-237	9.5E-03				
RA-226	2.0E-02				
RA-228	4.8E-03				
TH-228	4.3E-03				
TH-230	2.9E-02				
TH-232	2.7E-02				
U-234	1.6E-01				
U-235	8.5E-03				
U-238	1.2E-01				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	2.4E-05	2.0E-08	3.0E-04	6.6E-05	6.6E-05
Beryllium	1.7E-06	1.4E-09	5.0E-03	2.8E-07	2.8E-07
U-TOTAL	6.2E-04	5.2E-07	3.0E-03		0.0E+00
Benzo(a)pyrene	1.2E-05	1.0E-08			
Aroclor 1254	1.1E-07	9.3E-11			
			Total Pathway:	7.5E-05	
			Total Rad + Chem	7.5E-05	*Total:* 7.5E-05

000311

TABLE C.4-18(d)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: BEEF AND MILK (DUST AFFECTED)
Consolidation/Containment

Carcinogenic Risk

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
CS-137	0.00E+00	0.0E+00	2.8E-11	0.0E+00	CS-137	0.00E+00	0.0E+00	2.8E-11	0.0E+00	0.0E+00
NP-237	2.08E-04	3.8E-01	2.2E-10	8.4E-11	NP-237	1.89E-05	1.4E-01	2.2E-10	3.1E-11	1.1E-10
RA-226	2.22E-04	4.1E-01	1.2E-10	4.9E-11	RA-226	3.99E-04	2.9E+00	1.2E-10	3.5E-10	4.0E-10
RA-228	1.94E-04	3.6E-01	1.0E-10	3.6E-11	RA-228	3.49E-04	2.6E+00	1.0E-10	2.6E-10	2.9E-10
TH-228	3.64E-06	6.7E-03	5.5E-11	3.7E-13	TH-228	3.03E-06	2.2E-02	5.5E-11	1.2E-12	1.6E-12
TH-230	6.59E-06	1.2E-02	1.3E-11	1.6E-13	TH-230	5.49E-06	4.0E-02	1.3E-11	5.3E-13	6.8E-13
TH-232	3.67E-06	6.7E-03	1.2E-11	8.1E-14	TH-232	3.06E-06	2.2E-02	1.2E-11	2.7E-13	3.5E-13
U-234	4.97E-04	9.1E-01	1.6E-11	1.5E-11	U-234	1.49E-03	1.1E+01	1.6E-11	1.8E-10	1.9E-10
U-235	3.01E-05	5.5E-02	1.6E-11	8.9E-13	U-235	9.04E-05	6.6E-01	1.6E-11	1.1E-11	1.2E-11
U-238	6.38E-04	1.2E+00	2.8E-11	3.3E-11	U-238	1.92E-03	1.4E+01	2.8E-11	3.9E-10	4.3E-10
			Total Pathway:	2.2E-10				Total Pathway:	1.2E-09	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	1.35E-05	1.4E-08	1.8E+00	2.4E-08	Arsenic	4.05E-07	1.7E-09	1.8E+00	2.9E-09	2.7E-08
Beryllium	3.96E-07	4.1E-10	4.3E+00	1.8E-09	Beryllium	3.57E-10	1.5E-12	4.3E+00	6.3E-12	1.8E-09
Chromium	8.01E-05	8.2E-08			Chromium	2.18E-05	9.0E-08			
U-TOTAL		0.0E+00			U-TOTAL		0.0E+00			
Aroclor 1254	7.15E-07	7.3E-10	7.7E+00	5.7E-09	Aroclor 1254	2.26E-07	9.3E-10	7.7E+00	7.2E-09	1.3E-08
			Total Pathway:	5.3E-07				Total Pathway:	6.4E-07	
			Total Rad + Chem	5.3E-07				Total Rad + Chem	6.4E-07	*Total:* 2.9E-08

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TABLE C.4-18(d) (continued)

Noncarcinogenic Hazard

Radiation Hazard

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n-Milk (pCi/L)	Intake	RfD(o)	Hazard	
CS-137	0.0E+00	0.0E+00			CS-137	0.00E+00				
NP-237	2.1E-04	3.8E-01			NP-237	1.89E-05				
RA-226	2.2E-04	4.1E-01			RA-226	3.99E-04				
RA-228	1.9E-04	3.6E-01			RA-228	3.49E-04				
TH-228	3.6E-06	6.7E-03			TH-228	3.03E-06				
TH-230	6.6E-06	1.2E-02			TH-230	5.49E-06				
TH-232	3.7E-06	6.7E-03			TH-232	3.06E-06				
U-234	5.0E-04	9.1E-01			U-234	1.49E-03				
U-235	3.0E-05	5.5E-02			U-235	9.04E-05				
U-238	6.4E-04	1.2E+00			U-238	1.92E-03				
			Total Pathway:	0.0E+00				Total Pathway:	0.0E+00	

Chemical Hazard

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (mg/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n-Milk (mg/L)	Intake	RfD(o)	Hazard	
Arsenic	1.4E-05	1.4E-08	3.0E-04	4.6E-05	Arsenic	4.1E-07	1.7E-09	3.0E-04	5.5E-06	5.2E-05
Beryllium	4.0E-07	4.1E-10	5.0E-03	8.1E-08	Beryllium	3.6E-10	1.5E-12	5.0E-03	2.9E-10	8.2E-08
Chromium	8.0E-05	8.2E-08	5.0E-03	1.6E-05	Chromium	2.2E-05	9.0E-08	5.0E-03	1.8E-05	3.4E-05
U-TOTAL	0.0E+00	0.0E+00			U-TOTAL	0.0E+00	0.0E+00	3.0E-03		
Aroclor 1254	7.2E-07	7.3E-10			Aroclor 1254	2.3E-07	9.3E-10			
			Total Pathway:	6.3E-05				Total Pathway:	2.4E-05	
			Total Rad + Chem	6.3E-05				Total Rad + Chem	2.4E-05	*Total:* 8.6E-05

000343

TABLE C.4-18(d)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: BEEF AND MILK (DUST AFFECTED)
On-Site Disposal
Carcinogenic Risk

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
CS-137	1.45E-02	2.7E+01	2.8E-11	7.5E-10	CS-137	5.08E-03	3.7E+01	2.8E-11	1.0E-09	1.8E-09
NP-237	1.28E-04	2.4E-01	2.2E-10	5.2E-11	NP-237	1.16E-05	8.6E-02	2.2E-10	1.9E-11	7.1E-11
RA-226	2.51E-03	4.6E+00	1.2E-10	5.5E-10	RA-226	4.52E-03	3.3E+01	1.2E-10	4.0E-09	4.5E-09
RA-228	5.88E-04	1.1E+00	1.0E-10	1.1E-10	RA-228	1.06E-03	7.8E+00	1.0E-10	7.8E-10	8.9E-10
TH-228	1.18E-05	2.2E-02	5.5E-11	1.2E-12	TH-228	9.81E-06	7.2E-02	5.5E-11	4.0E-12	5.2E-12
TH-230	8.95E-05	1.6E-01	1.3E-11	2.1E-12	TH-230	7.46E-05	5.5E-01	1.3E-11	7.1E-12	9.3E-12
TH-232	8.21E-05	1.5E-01	1.2E-11	1.8E-12	TH-232	6.84E-05	5.0E-01	1.2E-11	6.0E-12	7.8E-12
U-234	1.65E-02	3.0E+01	1.6E-11	4.9E-10	U-234	4.96E-02	3.6E+02	1.6E-11	5.8E-09	6.3E-09
U-235	8.58E-04	1.6E+00	1.6E-11	2.5E-11	U-235	2.57E-03	1.9E+01	1.6E-11	3.0E-10	3.3E-10
U-238	1.26E-02	2.3E+01	2.8E-11	6.5E-10	U-238	3.78E-02	2.8E+02	2.8E-11	7.8E-09	8.4E-09
			Total Pathway:	2.6E-09				Total Pathway:	2.0E-08	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	2.18E-05	2.2E-08	1.8E+00	3.9E-08	Arsenic	6.55E-07	2.7E-09	1.8E+00	4.7E-09	4.4E-08
Beryllium	8.25E-07	8.5E-10	4.3E+00	3.6E-09	Beryllium	7.42E-10	3.1E-12	4.3E+00	1.3E-11	3.7E-09
Chromium	1.45E-04	1.5E-07			Chromium	3.95E-05	1.6E-07			
U-TOTAL	6.32E-05	6.5E-08			U-TOTAL	1.90E-04	7.8E-07			
Aroclor 1254	1.49E-06	1.5E-09	7.7E+00	1.2E-08	Aroclor 1254	4.71E-07	1.9E-09	7.7E+00	1.5E-08	2.7E-08
			Total Pathway:	5.5E-08				Total Pathway:	2.0E-08	
			Total Rad + Chem	5.7E-08				Total Rad + Chem	3.9E-08	*Total:* 6.6E-08

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TABLE C.4-18(d) (continued)

On-Site Disposal

Noncarcinogenic Hazard

Radiation Hazard

Ingestion/Beef

Compound	Conc'n in Beef (pCi/kg)	Intake	RfD(o)	Hazard
CS-137	1.5E-02	2.7E+01		
NP-237	1.3E-04	2.4E-01		
RA-226	2.5E-03	4.6E+00		
RA-228	5.9E-04	1.1E+00		
TH-228	1.2E-05	2.2E-02		
TH-230	8.9E-05	1.6E-01		
TH-232	8.2E-05	1.5E-01		
U-234	1.7E-02	3.0E+01		
U-235	8.6E-04	1.6E+00		
U-238	1.3E-02	2.3E+01		

Total Pathway: 0.0E+00

Ingestion/Milk

Compound	Conc'n-Milk (pCi/L)	Intake	RfD(o)	Hazard
CS-137	5.08E-03			
NP-237	1.16E-05			
RA-226	4.52E-03			
RA-228	1.06E-03			
TH-228	9.81E-06			
TH-230	7.46E-05			
TH-232	6.84E-05			
U-234	4.96E-02			
U-235	2.57E-03			
U-238	3.78E-02			

Total Pathway: 0.0E+00

Chemical Hazard

Ingestion/Beef

Compound	Conc'n in Beef (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	2.2E-05	2.2E-08	3.0E-04	7.5E-05
Beryllium	8.2E-07	8.5E-10	5.0E-03	1.7E-07
Chromium	1.4E-04	1.5E-07	5.0E-03	3.0E-05
U-TOTAL	6.3E-05	6.5E-08		
Aroclor 1254	1.5E-06	1.5E-09		

Total Pathway: 1.0E-04

Total Rad + Chem 1.0E-04

Ingestion/Milk

Compound	Conc'n-Milk (mg/L)	Intake	RfD(o)	Hazard
Arsenic	6.5E-07	2.7E-09	3.0E-04	9.0E-06
Beryllium	7.4E-10	3.1E-12	5.0E-03	6.1E-10
Chromium	3.9E-05	1.6E-07	5.0E-03	3.2E-05
U-TOTAL	1.9E-04	7.8E-07	3.0E-03	
Aroclor 125	4.7E-07	1.9E-09		

Total Pathway: 4.1E-05

Total Rad + Chem 4.1E-05

Total	
	8.4E-05
	1.7E-07
	6.2E-05
Total:	1.5E-04

000545

TABLE C.4-19(a)
FUTURE, ON-PROPERTY (SOUTH FIELD) FARMER
SOUTH FIELD: GROUNDWATER

Alternative 7

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Groundwater					Inhalation/Groundwater
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk	
U234	9.35E-01	4.6E+04	1.6E-11	7.3E-07	Not Applicable
U235/236	4.90E-02	2.4E+03	1.6E-11	3.8E-08	
U238	1.03E+00	5.0E+04	2.8E-11	1.4E-06	
			Total Pathway:	2.2E-06	Total Pathway: 0.0E+00

Alternative 3/4/5/6

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Groundwater					Inhalation/Groundwater
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk	
U234	8.71E-01	4.3E+04	1.6E-11	6.8E-07	Not Applicable
U235/236	4.60E-02	2.3E+03	1.6E-11	3.6E-08	
U238	9.57E-01	4.7E+04	2.8E-11	1.3E-06	
			Total Pathway:	2.0E-06	Total Pathway: 0.0E+00

000226

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TABLE C.4-19(a) (continued)

Alternative 3/4/5/6/7

CARCINOGENIC RISK

Radiation Risk	Total
Dermal Contact/Groundwater	
Not Applicable	7.3E-07
	3.8E-08
	1.4E-06
Total Pathway: 0.0E+00	
	Total: 2.2E-06

CARCINOGENIC RISK

Radiation Risk	Total
Dermal Contact/Groundwater	
Not Applicable	6.8E-07
	3.6E-08
	1.3E-06
Total Pathway: 0.0E+00	
	Total: 2.0E-06

000317

TABLE C.4-19(b)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: HOME GROWN PRODUCE (GROUNDWATER AFFECTED)
Alternative 7
Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
U-234	9.18E-01	1.4E+03	1.6E-11	2.2E-08	2.2E-08
U-235/236	8.30E-02	1.2E+02	1.6E-11	2.0E-09	2.0E-09
U-238	1.18E+00	1.8E+03	2.8E-11	4.9E-08	4.9E-08
			Total Pathway:	7.3E-08	
					Total: 7.3E-08

Alternative 3/4/5/6
Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
U-234	9.18E-01	1.4E+03	1.6E-11	2.2E-08	2.2E-08
U-235/236	8.30E-02	1.2E+02	1.6E-11	2.0E-09	2.0E-09
U-238	1.18E+00	1.8E+03	2.8E-11	4.9E-08	4.9E-08
			Total Pathway:	7.3E-08	
					Total: 7.3E-08

000349

TABLE C.4-19(c)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: BEEF AND MILK (GROUNDWATER AFFECTED)

Alternative 7
Carcinogenic Risk

Radiation Risk										Total
Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n-Beef (pCi/L)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
U-234	3.35E-02	6.1E+01	1.6E-11	9.8E-10	U-234	1.00E-01	7.4E+02	1.6E-11	1.2E-08	1.3E-08
U-235	1.42E-03	2.6E+00	1.6E-11	4.2E-11	U-235	4.25E-03	3.1E+01	1.6E-11	5.0E-10	5.4E-10
U-238	2.78E-02	5.1E+01	2.8E-11	1.4E-09	U-238	8.34E-02	6.1E+02	2.8E-11	1.7E-08	1.9E-08
			Total Pathway:	2.5E-09				Total Pathway:	2.9E-08	
										Total: 3.2E-08

Alternative 3/4/5/6
Carcinogenic Risk

Radiation Risk										Total
Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n-Beef (pCi/L)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
U-234	3.12E-02	5.7E+01	1.6E-11	9.2E-10	U-234	9.35E-02	6.9E+02	1.6E-11	1.1E-08	1.2E-08
U-235	1.39E-03	2.6E+00	1.6E-11	4.1E-11	U-235	4.16E-03	3.1E+01	1.6E-11	4.9E-10	5.3E-10
U-238	2.71E-02	5.0E+01	2.8E-11	1.4E-09	U-238	8.13E-02	6.0E+02	2.8E-11	1.7E-08	1.8E-08
			Total Pathway:	2.4E-09				Total Pathway:	2.8E-08	
										Total: 3.1E-08

TABLE C.4-20(a)
FUTURE, OFF-PROPERTY FARMER
SOUTH FIELD: GROUNDWATER

Alternative 7
CARCINOGENIC RISK

Radiation Risk					
Ingestion/Groundwater					Inhalation/Groundwater
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk	
U234	1.7E-01	8.1E+03	1.6E-11	1.3E-07	
U235/236	9.0E-03	4.4E+02	1.6E-11	7.1E-09	
U238	1.8E-01	8.9E+03	2.8E-11	2.5E-07	
			Total Pathway:	3.8E-07	Total Pathway: 0.0E+00

Alternative 3/4/5/6
CARCINOGENIC RISK

Radiation Risk					
Ingestion/Groundwater					Inhalation/Groundwater
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk	
U234	1.4E-01	6.8E+03	1.6E-11	1.1E-07	
U235/236	7.0E-03	3.4E+02	1.6E-11	5.5E-09	
U238	1.5E-01	7.5E+03	2.8E-11	2.1E-07	
			Total Pathway:	3.2E-07	Total Pathway: 0.0E+00

000300

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TABLE C.4-20(a) (continued)

CARCINOGENIC RISK

Radiation Risk	
Dermal Contact/Groundwater	**Total**
	1.3E-07
	7.1E-09
	2.5E-07
Total Pathway: 0.0E+00	
	Total: 3.8E-07

CARCINOGENIC RISK

Radiation Risk	
Dermal Contact/Groundwater	**Total**
	1.1E-07
	5.5E-09
	2.1E-07
Total Pathway: 0.0E+00	
	Total: 3.2E-07

TABLE C.4-20(b)
FUTURE OFF-PROPERTY FARMER
SOUTH FIELD: HOME GROWN PRODUCE (GROUNDWATER AFFECTED)

Alternative 7
Carcinogenic Risk

Radiation Risk						Total
Ingestion/Homegrown Produce						
	Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
	U-234	8.10E-01	1.2E+03	1.6E-11	1.9E-08	1.9E-08
	U-235	4.42E-02	6.6E+01	1.6E-11	1.1E-09	1.1E-09
	U-238	8.89E-01	1.3E+03	2.8E-11	3.7E-08	3.7E-08
				Total Pathway:	5.8E-08	
					Total:	5.8E-08

Alternative 3/4/5/6
Carcinogenic Risk

Radiation Risk						Total
Ingestion/Homegrown Produce						
	Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
	U-234	6.82E-01	1.0E+03	1.6E-11	1.6E-08	1.6E-08
	U-235	3.44E-02	5.1E+01	1.6E-11	8.2E-10	8.2E-10
	U-238	7.51E-01	1.1E+03	2.8E-11	3.1E-08	3.1E-08
				Total Pathway:	1.1E-07	
					Total:	4.9E-08

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TABLE C.4-20(c)
FUTURE, OFF-PROPERTY FARMER
SOUTH FIELD: BEEF AND MILK (GROUNDWATER AFFECTED)

Alternative 7
CARCINOGENIC RISK

Radiation Risk										Total
Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L	Intake	SF(o)	Risk	
U-234	5.90E-03	1.1E+01	1.6E-11	1.7E-10	U-234	1.77E-02	1.3E+02	1.6E-11	2.1E-09	2.3E-09
U-235	3.22E-04	5.9E-01	1.6E-11	9.5E-12	U-235	9.66E-04	7.1E+00	1.6E-11	1.1E-10	1.2E-10
U-238	6.48E-03	1.2E+01	2.8E-11	3.3E-10	U-238	1.94E-02	1.4E+02	2.8E-11	4.0E-09	4.3E-09
			Total Pathway:	5.2E-10				Total Pathway:	6.2E-09	
									Total:	6.7E-09

Alternative 3/4/5/6
CARCINOGENIC RISK

Radiation Risk										Total
Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L	Intake	SF(o)	Risk	
U-234	4.97E-03	9.1E+00	1.6E-11	1.5E-10	U-234	1.49E-02	1.1E+02	1.6E-11	1.8E-09	1.9E-09
U-235	2.50E-04	4.6E-01	1.6E-11	7.4E-12	U-235	7.51E-04	5.5E+00	1.6E-11	8.8E-11	9.6E-11
U-238	5.47E-03	1.0E+01	2.8E-11	2.8E-10	U-238	1.64E-02	1.2E+02	2.8E-11	3.4E-09	3.7E-09
			Total Pathway:	4.4E-10				Total Pathway:	5.2E-09	
									Total:	5.7E-09

TABLE C.~~4-20~~ 21(a)
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
Consolidation/Containment

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Soil	CS-137	1.7E-06		0.0E+00		0.0E+00		3.7E-05		N/A
(Alternative 7)	NP-237	9.9E-07		5.0E-09		9.5E-05		N/A		N/A
	RA-226	7.7E-08		1.6E-10		9.5E-06		1.4E-06		N/A
	RA-228	2.5E-06		3.0E-11		2.3E-04		1.4E-04		N/A
	TH-228	4.3E-06		2.9E-09		4.0E-04		2.6E-04		N/A
	TH-230	5.6E-09		2.3E-09		1.0E-06		2.1E-06		N/A
	TH-232	4.4E-09		9.7E-10		N/A		1.5E-06		N/A
	U-234	3.4E-08		3.3E-09		6.0E-06		1.4E-06		N/A
	U-235/236	4.4E-07		1.8E-10		4.1E-05		9.9E-07		N/A
	U-238	9.6E-07		8.3E-09		9.3E-05		4.4E-06		N/A
	Arsenic	6.2E-07	3.8E-03	3.7E-07		6.5E-05	6.5E-02	2.6E-05	4.9E-02	N/A
	Chromium	1.3E-05	4.1E-03	1.8E-05	7.8E-01	1.9E-03	1.7E-02	1.3E-05	9.8E-03	N/A
	Benzo(a)anthracene	0.0E+00						N/A		N/A
	Benzo(a)pyrene	1.6E-06						N/A		N/A
	Aroclor-1254	1.1E-06				9.2E-06		N/A		N/A
Groundwater	U234	N/A		1.3E-07		1.5E-07		1.5E-07		
(Alternative	U235/236	N/A		7.1E-09		1.3E-08		1.3E-08		
#7)	U238	N/A		2.5E-07		3.3E-07		3.3E-07		
Homegrown	CS-137	N/A		0.0E+00		0.0E+00		1.4E-09		N/A
Produce	NP-237	N/A		1.9E-10		3.0E-09				N/A
(Dust	RA-226	N/A		3.1E-11		3.7E-10		1.7E-09		N/A
Affected)	RA-228	N/A		2.2E-11		2.8E-10		1.3E-08		N/A
(Alternative 7)	TH-228	N/A		9.8E-12		1.3E-10		7.0E-09		N/A
	TH-230	N/A		4.8E-12		5.4E-11		2.2E-09		N/A
	U-234	N/A		9.6E-12		1.4E-10		1.9E-09		N/A
	U-235	N/A		5.6E-13		8.4E-12		1.6E-10		N/A
	U-238	N/A		2.1E-11		3.1E-10		3.4E-09		N/A
	Arsenic	N/A		2.0E-09	3.9E-06	2.3E-08	4.4E-05	6.5E-10	1.2E-06	N/A
	Chromium	N/A			4.1E-07		5.7E-06		1.5E-07	N/A
	Aroclor 1254	N/A		2.5E-11		4.0E-10				N/A

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TABLE C.4-20
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
Consolidation/Containment

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Homegrown Produce (Groundwater Affected) (Alternative 7)	U-234	N/A		1.3E-07		2.2E-08		2.2E-08		2.2E-08
	U-235/236	N/A		7.1E-09		2.0E-09		2.0E-09		2.0E-09
	U-238	N/A		2.5E-07		4.9E-08		4.9E-08		4.9E-08
Beef/Milk (Dust Affected) (Alternative 7)	CS-137	N/A		*0.0E+00*		0.0E+00		5.4E-09		N/A
	NP-237	N/A		*1.1E-12*		1.1E-10				N/A
	RA-226	N/A		*5.0E-12*		4.0E-10		2.7E-10		N/A
	RA-228	N/A		*3.5E-12*		2.9E-10		2.0E-09		N/A
	TH-228	N/A		*1.8E-14*		1.6E-12		1.3E-11		N/A
	TH-230	N/A		*1.0E-14*		6.8E-13		4.6E-12		N/A
	TH-232	N/A		*4.1E-15*		3.5E-13		3.1E-12		N/A
	U-234	N/A		*2.0E-12*		1.9E-10		3.9E-10		N/A
	U-235	N/A		*1.2E-13*		1.2E-11		3.3E-11		N/A
	U-238	N/A		*4.4E-12*		4.3E-10		7.1E-10		N/A
Beef/Milk Affected) (Alternative 7)	Arsenic	N/A		*3.6E-10*	*6.9E-07*	2.7E-08	5.2E-05	1.2E-10	2.2E-07	N/A
	Chromium	N/A			*3.8E-07*		3.4E-05		1.4E-07	N/A
	Aroclor 1254	N/A		*1.2E-10*		1.3E-08				N/A
Beef/Milk (Groundwater Affected) (Alt #7)**	U-234	N/A		*2.3E-09*		5.5E-09		2.6E-09		1.3E-08
	U-235	N/A		*1.2E-10*		3.4E-10		2.3E-10		5.4E-10
	U-238	N/A		*4.3E-09*		1.0E-08		5.7E-09		1.9E-08
TOTAL (Alternative #2)		**9.5E-06**	**1.5E-02**	**4.1E-07**	**7.8E-01**	**2.8E-03**	**8.2E-02**	**4.9E-04**	**5.9E-02**	**1.1E-07**

*Long-term protectiveness represents Alternative 7 for this subunit.

**For background summaries risk calculations are independent of the alternative used for remedial action.

Numbers in italics represent summary calculations for contaminants that are not classified as COCs.

TABLE C.4-~~20~~ 21(b)
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
On-Site Disposal

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Soil	CS-137	6.2E-07		0.0E+00		0.0E+00		3.7E-05		N/A
(Alternative 3/4/5/6)	NP-237	9.9E-07		5.2E-09		9.5E-05		N/A		N/A
	RA-226	5.3E-08		9.7E-10		9.5E-06		1.4E-06		N/A
	RA-228	2.5E-06		6.2E-11		2.3E-04		1.4E-04		N/A
	TH-228	4.3E-06		6.4E-09		4.0E-04		2.6E-04		N/A
	TH-230	2.9E-08		1.4E-08		1.0E-06		2.1E-06		N/A
	TH-232	2.8E-08		1.2E-08		N/A		1.5E-06		N/A
	U-234	2.7E-08		6.5E-08		6.0E-06		1.4E-06		N/A
	U-235/236	4.6E-07		3.3E-09		4.1E-05		9.9E-07		N/A
	U-238	9.7E-07		1.0E-07		9.3E-05		4.4E-06		N/A
	Arsenic	4.7E-07	3.8E-03	5.1E-07		6.5E-05	6.5E-02	2.6E-05	4.9E-02	N/A
	Chromium	1.3E-05	4.1E-03	2.8E-05	7.8E-01	1.9E-03	1.7E-02	1.3E-05	9.8E-03	N/A
	Benzo(a)anthracene	0.0E+00						N/A		N/A
	Benzo(a)pyrene	1.6E-06						N/A		N/A
	Aroclor-1254	5.3E-09				9.2E-06		N/A		N/A
Groundwater										
(Alternatives 3/4/5/6)	U234	N/A		1.1E-07		6.8E-07				7.3E-07
	U235/236	N/A		5.5E-09		3.6E-08				3.8E-08
	U238	N/A		2.1E-07		1.3E-06				1.4E-06
Homegrown	CS-137	N/A		2.8E-12		0.0E+00		1.4E-09		N/A
Produce	NP-237	N/A		2.0E-10		3.0E-09				N/A
(Dust Affected)	RA-226	N/A		1.8E-10		3.7E-10		1.7E-09		N/A
(Alternative 3/4/5/6)	RA-228	N/A		4.5E-11		2.8E-10		1.3E-08		N/A
	TH-228	N/A		2.1E-11		1.3E-10		7.0E-09		N/A
	TH-230	N/A		2.8E-11		5.4E-11		2.2E-09		N/A
	U-234	N/A		1.9E-10		1.4E-10		1.9E-09		N/A
	U-235	N/A		9.7E-12		8.4E-12		1.6E-10		N/A
	U-238	N/A		2.5E-10		3.1E-10		3.4E-09		N/A
	Arsenic	N/A		2.9E-09	5.5E-06	2.3E-08	4.4E-05	6.5E-10	1.2E-06	N/A
	Chromium	N/A			6.5E-07		5.7E-06		1.5E-07	N/A
	Aroclor 1254	N/A		4.6E-11		4.0E-10				N/A

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TABLE C.4-20
SOUTH FIELD
SUMMARY OF LONG-TERM RISKS AND HAZARDS
On-Site Disposal

Medium	Parameter	Expanded Trespasser Carcinogen	Expanded Trespasser Non-Carcinogen	Off-Property Farmer Carcinogen	Off-Property Farmer Non-Carcinogen	On-Property Farmer Carcinogen	On-Property Farmer Non-Carcinogen	Risks Due to Background On-Property Farmer Carcinogen	Risks Due to Background On-Property Farmer Non-Carcinogen	On-Property Farmer Long-Term Protectiveness*
Homegrown Produce										
(Groundwater Affected)										
(Alternatives3/4/5/6)	U-234	N/A		1.1E-07		1.0E-07				
	U-235/236	N/A		5.5E-09		5.4E-09				
	U-238	N/A		2.1E-07		2.0E-07				
Beef/Milk	CS-137	N/A		*1.1E-11*		0.0E+00		5.4E-09		N/A
(Dust Affected)	NP-237	N/A		*1.2E-12*		1.1E-10				N/A
(Alternative 3/4/5/6)	RA-226	N/A		*2.9E-11*		4.0E-10		2.7E-10		N/A
	RA-228	N/A		*7.1E-12*		2.9E-10		2.0E-09		N/A
	TH-228	N/A		*4.0E-14*		1.6E-12		1.3E-11		N/A
	TH-230	N/A		*5.9E-14*		6.8E-13		4.6E-12		N/A
	TH-232	N/A		*4.9E-14*		3.5E-13		3.1E-12		N/A
	U-234	N/A		*3.9E-11*		1.9E-10		3.9E-10		N/A
	U-235	N/A		*2.0E-12*		1.2E-11		3.3E-11		N/A
	U-238	N/A		*5.3E-11*		4.3E-10		7.1E-10		N/A
Beef/Milk	Arsenic	N/A		*5.1E-10*	*1.4E-09*	2.7E-08	5.2E-05	1.2E-10	2.2E-07	N/A
(Dust Affected)	Beryllium	N/A		*3.0E-11*	*6.0E-07*	1.8E-09	8.2E-08	1.3E-11	6.1E-10	N/A
	Aroclor 1254	N/A		*2.2E-10*		1.3E-08				N/A
	Aroclor 1260	N/A		*1.4E-10*		0.0E+00				N/A
(Groundwater Affected)										
(Alternatives 3/4/5/6)	U-234	N/A		*1.9E-09*		1.3E-08				
	U-235	N/A		*9.6E-11*		7.9E-10				
	U-238	N/A		*3.7E-09*		2.4E-08				
TOTAL (Alternatives #3/4/5/6)		**4.2E-06**	**7.9E-03**	**2.9E-05**	**7.8E-01**	**2.8E-03**	**8.2E-02**	**4.9E-04**	**9.7E-03**	**2.1E-06**

*Long-term protectiveness represents Alternative 7 for this subunit.

**For background summaries risk calculations are independent of the alternative used for remedial action.

Numbers in italics represent summary calculations for contaminants that are not classified as COCs.

N/A = Not Applicable.

TABLE C.5-15
INACTIVE FLYASH PILE: SOIL
EXPANDED TRESPASSER
Alternative 3/4/5/6/7/8
CARCINOGENIC RISK

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137		0.0E+00	1.9E-11	0.0E+00
NP-237	9.18E-07	3.0E-03	2.9E-08	8.7E-11
RA-226	4.74E-06	1.5E-02	3.0E-09	4.6E-11
RA-228	3.18E-06	1.0E-02	6.9E-10	7.1E-12
TH-228	3.12E-06	1.0E-02	7.8E-08	7.9E-10
TH-230	1.01E-05	3.3E-02	2.9E-08	9.5E-10
TH-232	2.74E-06	8.9E-03	2.8E-08	2.5E-10
U-234	5.28E-06	1.7E-02	2.6E-08	4.5E-10
U-235/236	3.83E-07	1.2E-03	2.5E-08	3.1E-11
U-238	6.79E-06	2.2E-02	5.2E-08	1.1E-09
			Total Pathway:	3.8E-09

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137		0.0E+00	2.8E-11	0.0E+00
NP-237	1.80E-01	4.4E+00	2.2E-10	9.7E-10
RA-226	1.01E+00	2.5E+01	1.2E-10	3.0E-09
RA-228	7.30E-01	1.8E+01	1.0E-10	1.8E-09
TH-228	8.33E-01	2.0E+01	5.5E-11	1.1E-09
TH-230	2.03E+00	5.0E+01	1.3E-11	6.5E-10
TH-232	7.32E-01	1.8E+01	1.2E-11	2.2E-10
U-234	1.09E+00	2.7E+01	1.6E-11	4.3E-10
U-235/236	8.00E-02	2.0E+00	1.6E-11	3.1E-11
U-238	1.44E+00	3.5E+01	2.8E-11	9.9E-10
			Total Pathway:	9.2E-09

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	SF(i)	Risk
Arsenic	3.02E-05	7.8E-08	1.5E+01	1.2E-06
Beryllium	4.45E-06	1.2E-08	8.4E+00	9.7E-08
U-TOTAL	2.88E-05	7.5E-08		
			Total Pathway:	1.3E-06

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	6.9E+00	1.7E-07	1.8E+00	2.9E-07
Beryllium	1.4E+00	3.4E-08	4.3E+00	1.4E-07
U-TOTAL	5.9E+00	1.4E-07		
			Total Pathway:	4.3E-07

Total Rad + Chem 1.3E-06

Total Rad + Chem 4.4E-07

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TABLE C.5-15 (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	0.0E+00	2.0E-06	0.0E+00	0.0E+00
	NP-237	8.1E-02	4.3E-07	3.5E-08	3.6E-08
	RA-226	4.5E-01	1.2E-08	5.4E-09	8.4E-09
	RA-228	3.3E-01	2.9E-06	9.5E-07	9.5E-07
	TH-228	3.7E-01	5.6E-06	2.1E-06	2.1E-06
	TH-230	9.1E-01	5.4E-11	4.9E-11	1.6E-09
	TH-232	3.3E-01	2.6E-11	8.5E-12	4.7E-10
	U-234	4.9E-01	3.0E-11	1.5E-11	8.9E-10
	U-235/236	3.6E-02	2.4E-07	8.6E-09	8.7E-09
	U-238	6.4E-01	3.6E-08	2.3E-08	2.5E-08
Total Pathway: 0.0E+00	Total Pathway: 3.1E-06				

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	6.3E-08	1.8E+00	1.2E-07					1.6E-06
Beryllium	1.3E-07	4.3E+02	5.5E-05					5.5E-05
U-TOTAL	5.4E-07							
		Total Pathway:	5.5E-05			Total Pathway:	0.0E+00	

Total Rad + Chem 5.5E-05 Total Rad + Chem: 3.1E-06 *Total:* 6.0E-05

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TABLE C.5-15 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3	Intake	RfD(i)	Hazard
CS-137	0.00E+00	0.0E+00		
NP-237	9.18E-07	3.0E-03		
RA-226	4.74E-06	1.5E-02		
RA-228	3.18E-06	1.0E-02		
TH-228	3.12E-06	1.0E-02		
TH-230	1.01E-05	3.3E-02		
TH-232	2.74E-06	8.9E-03		
U-234	5.28E-06	1.7E-02		
U-235/236	3.83E-07	1.2E-03		
U-238	6.79E-06	2.2E-02		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.00E+00	0.0E+00		
NP-237	1.80E-01	4.4E+00		
RA-226	1.01E+00	2.5E+01		
RA-228	7.30E-01	1.8E+01		
TH-228	8.33E-01	2.0E+01		
TH-230	2.03E+00	5.0E+01		
TH-232	7.32E-01	1.8E+01		
U-234	1.09E+00	2.7E+01		
U-235/236	8.00E-02	2.0E+00		
U-238	1.44E+00	3.5E+01		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(i)	Hazard
Arsenic	3.02E-05	3.9E-07		
Beryllium	4.45E-06	5.8E-08		
U-TOTAL	2.88E-05	3.7E-07		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	6.90	7.4E-07	3.0E-04	2.5E-03
Beryllium	1.40	1.5E-07	5.0E-03	3.0E-05
U-TOTAL	5.86	6.3E-07	3.0E-03	

Total Pathway: 2.5E-03

Total Rad + Chem 0.0E+00

Total Rad + Chem 2.5E-03

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TABLE C.5-15 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	0.0E+00			
	NP-237	8.1E-02			
	RA-226	4.5E-01			
	RA-228	3.3E-01			
	TH-228	3.7E-01			
	TH-230	9.1E-01			
	TH-232	3.3E-01			
	U-234	4.9E-01			
	U-235/236	3.6E-02			
	U-238	6.4E-01			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				Total
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	2.7E-07	2.9E-04	9.3E-04					3.4E-03
Beryllium	5.4E-07	5.0E-05	1.1E-02					1.1E-02
U-TOTAL	2.3E-06	1.5E-04						
Total Pathway:			1.2E-02	Total Pathway:			0.0E+00	
Total Rad + Chem			1.2E-02	Total Rad + Chem:			0.0E+00	*otal:* 1.4E-02

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TABLE C.5-16(a)
INACTIVE FLYASH PILE: SOIL
OFF-PROPERTY FARMER
Alternative 3/4/5/6/7/8

Carcinogenic Risk

Radiation Risk					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
NP-237	8.14E-08	9.4E-03	2.9E-08	2.7E-10	2.7E-10
RA-226	4.32E-07	5.0E-02	3.0E-09	1.5E-10	1.5E-10
RA-228	2.82E-07	3.3E-02	6.9E-10	2.3E-11	2.3E-11
TH-228	2.63E-07	3.0E-02	7.8E-08	2.4E-09	2.4E-09
TH-230	8.87E-07	1.0E-01	2.9E-08	3.0E-09	3.0E-09
TH-232	2.31E-07	2.7E-02	2.8E-08	7.5E-10	7.5E-10
U-234	4.58E-07	5.3E-02	2.6E-08	1.4E-09	1.4E-09
U-235	3.30E-08	3.8E-03	2.5E-08	9.6E-11	9.6E-11
U-238	5.80E-07	6.7E-02	5.2E-08	3.5E-09	3.5E-09
			Total Pathway:	1.2E-08	

Chemical Risk					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	2.70E-06	1.7E-07	1.5E+01	2.6E-06	2.6E-06
Beryllium	3.83E-07	2.5E-08	8.4E+00	2.1E-07	2.1E-07
U-TOTAL	2.51E-06	1.6E-07			
			Total Pathway:	2.9E-06	

Total Rad + Chem 2.9E-06 *Total:* 2.9E-06

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TABLE C.5-16(a) (continued)

Non-carcinogenic Hazard

Radiation Hazard				
Inhalation of Particulates/Soil				
Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	Hazard
NP-237	8.14E-08			
RA-226	4.32E-07			
RA-228	2.82E-07			
TH-228	2.63E-07			
TH-230	8.87E-07			
TH-232	2.31E-07			
U-234	4.58E-07			
U-235	3.30E-08			
U-238	5.80E-07			
			Total Pathway:	0.0E+00

Chemical Hazard				
Inhalation of Particulates/Soil				
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	2.70E-06	1.7E-07		
Beryllium	3.83E-07	2.5E-08		
U-TOTAL	2.51E-06	1.6E-07		
			Total Pathway:	0.0E+00

			Total
			0.0E+00
Total Rad + Chem	0.0E+00	*Total:*	0.0E+00

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TABLE C.5-16(b)
INACTIVE FLYASH PILE
OFF-PROPERTY FARMER: HOMEGROWN PRODUCE (DUST AFFECTED)
Alternative 3/4/5/6/7/8

Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
CS-137		0.0E+00	2.8E-11	0.0E+00	0.0E+00
NP-237	2.92E-08	4.4E-05	2.2E-10	9.6E-15	9.6E-15
RA-226	1.51E-07	2.3E-04	1.2E-10	2.7E-14	2.7E-14
RA-228	9.87E-08	1.5E-04	1.0E-10	1.5E-14	1.5E-14
TH-228	9.13E-08	1.4E-04	5.5E-11	7.5E-15	7.5E-15
TH-230	3.08E-07	4.6E-04	1.3E-11	6.0E-15	6.0E-15
TH-232	8.05E-08	1.2E-04	1.2E-11	1.4E-15	1.4E-15
U-234	1.59E-07	2.4E-04	1.6E-11	3.8E-15	3.8E-15
U-235	1.15E-08	1.7E-05	1.6E-11	2.7E-16	2.7E-16
U-238	2.01E-07	3.0E-04	2.8E-11	8.4E-15	8.4E-15
			Total Pathway:	4.4E-14	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	9.52E-07	8.0E-10	1.8E+00	1.4E-09	1.4E-09
Beryllium	1.33E-07	1.1E-10	4.3E+00	4.8E-10	4.8E-10
U-TOTAL	8.73E-07	7.3E-10			
			Total Pathway:	1.9E-09	

Total Rad + Chem 1.9E-09 *Total:* 1.9E-09

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TABLE C.5-16(b) (continued)

Noncarcinogenic Hazard

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	0.0E+00				
NP-237	2.9E-08				
RA-226	1.5E-07				
RA-228	9.9E-08				
TH-228	9.1E-08				
TH-230	3.1E-07				
TH-232	8.1E-08				
U-234	1.6E-07				
U-235	1.1E-08				
U-238	2.0E-07				
				Total Pathway:	0.0E+00

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	9.5E-07	8.0E-10	3.0E-04	2.7E-06	2.7E-06
Beryllium	1.3E-07	1.1E-10	5.0E-03	2.2E-08	2.2E-08
U-TOTAL	8.7E-07	7.3E-10	3.0E-03		
				Total Pathway:	2.7E-06

Total Rad + Chem 2.7E-06 *Total:* 2.7E-06

TABLEC.5-16(c)

INACTIVE FLYASH PILE: BEEF AND MILK (DUST AFFECTED)

OFF-PROPERTY FARMER

Alternative 3/4/5/6/7/8

CARCINOGENIC RISK

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
NP-237	1.02E-10	1.9E-07	2.2E-10	4.1E-17	NP-237	9.25E-12	6.8E-08	2.2E-10	1.5E-17	5.6E-17
RA-226	2.44E-09	4.5E-06	1.2E-10	5.4E-16	RA-226	4.39E-09	3.2E-05	1.2E-10	3.9E-15	4.4E-15
RA-228	1.55E-09	2.8E-06	1.0E-10	2.8E-16	RA-228	2.78E-09	2.0E-05	1.0E-10	2.0E-15	2.3E-15
TH-228	3.23E-11	5.9E-08	5.5E-11	3.3E-18	TH-228	2.70E-11	2.0E-07	5.5E-11	1.1E-17	1.4E-17
TH-230	1.20E-10	2.2E-07	1.3E-11	2.9E-18	TH-230	1.00E-10	7.4E-07	1.3E-11	9.6E-18	1.2E-17
TH-232	3.14E-11	5.8E-08	1.2E-11	6.9E-19	TH-232	2.62E-11	1.9E-07	1.2E-11	2.3E-18	3.0E-18
U-234	2.07E-09	3.8E-06	1.6E-11	6.1E-17	U-234	6.20E-09	4.6E-05	1.6E-11	7.3E-16	7.9E-16
U-235	1.49E-10	2.7E-07	1.6E-11	4.4E-18	U-235	4.48E-10	3.3E-06	1.6E-11	5.3E-17	5.7E-17
U-238	2.62E-09	4.8E-06	2.8E-11	1.3E-16	U-238	7.86E-09	5.8E-05	2.8E-11	1.6E-15	1.8E-15
			Total Pathway:	5.3E-16				Total Pathway:	4.5E-15	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	1.23E-07	1.3E-10	1.8E+00	2.2E-10	Arsenic	3.68E-09	1.5E-11	1.8E+00	2.6E-11	2.5E-10
Beryllium	8.64E-09	8.9E-12	4.3E+00	3.8E-11	Beryllium	7.78E-12	3.2E-14	4.3E+00	1.4E-13	3.8E-11
U-TOTAL	1.14E-08	1.2E-11			U-TOTAL	3.41E-08	1.4E-10			
			Total Pathway:	2.6E-10				Total Pathway:	2.7E-11	
			Total Rad + Chem	2.6E-10				Total Rad + Chem	2.7E-11	*Total:* 2.9E-10

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TABLE C.5-16(c) (continued)

OFF-PROPERTY FARMER

NONCARCINOGENIC HAZARD

Radiation Hazard

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n in Milk (pCi/L)	Intake	RfD(o)	Risk	
NP-237	1.0E-10	1.9E-07			NP-237	9.25E-12	6.8E-08			
RA-226	2.4E-09	4.5E-06			RA-226	4.39E-09	3.2E-05			
RA-228	1.5E-09	2.8E-06			RA-228	2.78E-09	2.0E-05			
TH-228	3.2E-11	5.9E-08			TH-228	2.70E-11	2.0E-07			
TH-230	1.2E-10	2.2E-07			TH-230	1.00E-10	7.4E-07			
TH-232	3.1E-11	5.8E-08			TH-232	2.62E-11	1.9E-07			
U-234	2.1E-09	3.8E-06			U-234	6.20E-09	4.6E-05			
U-235	1.5E-10	2.7E-07			U-235	4.48E-10	3.3E-06			
U-238	2.6E-09	4.8E-06			U-238	7.86E-09	5.8E-05			
		Total Pathway:		0.0E+00			Total Pathway:		0.0E+00	

Chemical Hazard

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n in Milk (mg/L)	Intake	RfD(o)	Risk	
Arsenic	1.2E-07	1.3E-10	3.0E-04	4.2E-07	Arsenic	3.68E-09	1.5E-11	3.0E-04	5.0E-08	4.7E-07
Beryllium	8.6E-09	8.9E-12	5.0E-03	1.8E-09	Beryllium	7.78E-12	3.2E-14	5.0E-03	6.4E-12	1.8E-09
U-TOTAL	1.1E-08	1.2E-11	3.0E-03	3.9E-09	U-TOTAL	3.41E-08	1.4E-10	3.0E-03	4.7E-08	5.1E-08
		Total Pathway:		4.2E-07			Total Pathway:		5.0E-08	
		Total Rad + Chem		4.2E-07			Total Rad + Chem		5.0E-08	*Total:* 4.7E-07

TABLE C.5-17(a)

FUTURE, ON-PROPERTY (SOUTH FIELD) FARMER

INACTIVE FLYASH PILE: GROUNDWATER

Alternative 7

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Groundwater					Inhalation/Groundwater
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk	
U234	9.35E-01	4.6E+04	1.6E-11	7.3E-07	
U235/236	4.90E-02	2.4E+03	1.6E-11	3.8E-08	
U238	1.03E+00	5.0E+04	2.8E-11	1.4E-06	
			Total Pathway:	2.2E-06	Total Pathway: 0.0E+00

Alternative 3/4/5/6

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Groundwater					Inhalation/Groundwater
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk	
U234	8.71E-01	4.3E+04	1.6E-11	6.8E-07	
U235/236	4.60E-02	2.3E+03	1.6E-11	3.6E-08	
U238	9.57E-01	4.7E+04	2.8E-11	1.3E-06	
			Total Pathway:	2.0E-06	Total Pathway: 0.0E+00

TABLEC.5-17(a) (continued)

CARCINOGENIC RISK

Radiation Risk
Dermal Contact/Groundwater
7.3E-07
3.8E-08
1.4E-06
Total Pathway: 0.0E+00
Total: 2.2E-06

CARCINOGENIC RISK

Radiation Risk
Dermal Contact/Groundwater
6.8E-07
3.6E-08
1.3E-06
Total Pathway: 0.0E+00
Total: 2.0E-06

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TABLE C.5-17(b)

INACTIVE FLYASH PILE: HOMEGROWN PRODUCE (GROUNDWATER AFFECTED)

ON-PROPERTY FARMER

Alternative 7

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
U-234	4.59E+00	6.9E+03	1.6E-11	1.1E-07	1.1E-07
U-235/236	2.41E-01	3.6E+02	1.6E-11	5.8E-09	5.8E-09
U-238	5.04E+00	7.5E+03	2.8E-11	2.1E-07	2.1E-07
			Total Pathway:	3.3E-07	

Total: 3.3E-07

Alternative 3/4/5/6

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
U-234	4.28E+00	6.4E+03	1.6E-11	1.0E-07	1.0E-07
U-235/236	2.26E-01	3.4E+02	1.6E-11	5.4E-09	5.4E-09
U-238	4.70E+00	7.0E+03	2.8E-11	2.0E-07	2.0E-07
			Total Pathway:	3.0E-07	

Total: 3.0E-07

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TABLE C. 5-17(c)

INACTIVE FLYASH PILE: BEEF AND MILK (GROUNDWATER AFFECTED)

ON-PROPERTY FARMER

Alternative 7

CARCINOGENIC RISK

Radiation Risk										
Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
U-234	4.29E-02	7.9E+01	1.6E-11	1.3E-09	U-234	1.00E-01	7.4E+02	1.6E-11	1.2E-08	1.3E-08
U-235/236	2.01E-02	3.7E+01	1.6E-11	5.9E-10	U-235/236	5.26E-03	3.9E+01	1.6E-11	6.2E-10	1.2E-09
U-238	4.53E-02	8.3E+01	2.8E-11	2.3E-09	U-238	1.10E-01	8.1E+02	2.8E-11	2.3E-08	2.5E-08
			Total Pathway:	4.2E-09				Total Pathway:	3.5E-08	

Total: 3.9E-08

Alternative 3/4/5/6

CARCINOGENIC RISK

Radiation Risk										
Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
U-234	4.13E-02	7.6E+01	1.6E-11	1.2E-09	U-234	9.35E-02	6.9E+02	1.6E-11	1.1E-08	1.2E-08
U-235/236	2.00E-02	3.7E+01	1.6E-11	5.9E-10	U-235/236	4.94E-03	3.6E+01	1.6E-11	5.8E-10	1.2E-09
U-238	4.35E-02	8.0E+01	2.8E-11	2.2E-09	U-238	1.03E-01	7.6E+02	2.8E-11	2.1E-08	2.3E-08
			Total Pathway:	4.0E-09				Total Pathway:	3.3E-08	

Total: 3.7E-08

TABLE C.5-18(a)
FUTURE, OFF-PROPERTY FARMER
INACTIVE FLYASH PILE: GROUNDWATER

Alternative 7
CARCINOGENIC RISK

Radiation Risk						
Ingestion/Groundwater					Inhalation/Groundwater	
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk		
U234	4.59E-01	2.2E+04	1.6E-11	3.6E-07		
U235/236	1.65E-01	8.1E+03	1.6E-11	1.3E-07		
U238	9.00E-03	4.4E+02	2.8E-11	1.2E-08		
			Total Pathway:	5.0E-07	Total Pathway:	0.0E+00

Alternative 3/4/5/6
CARCINOGENIC RISK

Radiation Risk						
Ingestion/Groundwater					Inhalation/Groundwater	
Compound	Conc'n (pCi/L)	Intake	SF(o)	Risk		
U234	1.39E-01	6.8E+03	1.6E-11	1.1E-07		
U235/236	7.00E-03	3.4E+02	1.6E-11	5.5E-09		
U238	1.53E-01	7.5E+03	2.8E-11	2.1E-07		
			Total Pathway:	3.2E-07	Total Pathway:	0.0E+00

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TABLE C.5-18(a) (continued)

CARCINOGENIC RISK

Radiation Risk	
Dermal Contact/Groundwater	**Total**
	3.6E-07
	1.3E-07
	1.2E-08
Total Pathway: 0.0E+00	
	Total: 5.0E-07

CARCINOGENIC RISK

Radiation Risk	
Dermal Contact/Groundwater	**Total**
	1.1E-07
	5.5E-09
	2.1E-07
Total Pathway: 0.0E+00	
	Total: 3.2E-07

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TABLE C.5-18(b)
FUTURE, OFF-PROPERTY FARMER
INACTIVE FLYASH PILE: HOME GROWN PRODUCE (GROUNDWATER AFFECTED)

Alternative 7
CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
U-234	2.25E+00	3.4E+03	1.6E-11	5.4E-08	5.4E-08
U-235/236	8.10E-01	1.2E+03	1.6E-11	1.9E-08	1.9E-08
U-238	4.42E-02	6.6E+01	2.8E-11	1.8E-09	1.8E-09
			Total Pathway:	7.5E-08	
				Total:	7.5E-08

Alternative 3/4/5/6
CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
U-234	6.82E-01	1.0E+03	1.6E-11	1.6E-08	1.6E-08
U-235/236	3.44E-02	5.1E+01	1.6E-11	8.2E-10	8.2E-10
U-238	7.51E-01	1.1E+03	2.8E-11	3.1E-08	3.1E-08
			Total Pathway:	1.2E-07	
				Total:	4.9E-08

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TABLE C.5-18(c)
FUTURE, OFF-PROPERTY FARMER
INACTIVE FLYASH PILE: BEEF AND MILK (GROUNDWATER AFFECTED)

Alternative 7
CARCINOGENIC RISK

Radiation Risk										Total
Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
U-234	1.64E-02	3.0E+01	1.6E-11	4.8E-10	U-234	4.93E-02	3.6E+02	1.6E-11	5.8E-09	6.3E-09
U-235/236	5.90E-03	1.1E+01	1.6E-11	1.7E-10	U-235/236	1.77E-02	1.3E+02	1.6E-11	2.1E-09	2.3E-09
U-238	3.22E-04	5.9E-01	2.8E-11	1.7E-11	U-238	9.66E-04	7.1E+00	2.8E-11	2.0E-10	2.2E-10
								Total Pathway:	8.1E-09	
									Total:	8.7E-09

Alternative 3/4/5/6
CARCINOGENIC RISK

Radiation Risk										Total
Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
U-234	4.97E-03	9.1E+00	1.6E-11	1.5E-10	U-234	1.49E-02	1.1E+02	1.6E-11	1.8E-09	1.9E-09
U-235/236	2.50E-04	4.6E-01	1.6E-11	7.4E-12	U-235/236	7.51E-04	5.5E+00	1.6E-11	8.8E-11	9.6E-11
U-238	5.47E-03	1.0E+01	2.8E-11	2.8E-10	U-238	1.64E-02	1.2E+02	2.8E-11	3.4E-09	3.7E-09
			Total Pathway:	4.4E-10				Total Pathway:	1.3E-08	
									Total:	5.7E-09

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ATTACHMENT III

DERIVATION OF PRELIMINARY REMEDIATION GOALS

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A.III PRELIMINARY REMEDIAL GOAL METHODOLOGY

A.III-1.1 Background /Current Risk Basis of PRGs

Preliminary Remediation Goals (PRGs) are calculated in accordance with Fernald Risk Assessment Policy No. 94-15: "Preliminary Remediation Goal/Proposed Remedial Levels Development" (February 10, 1994) and the "Draft Policy Paper on Development of Remedial Goals" (January 11, 1994). PRGs calculated prior to March 24, 1994 are not valid and should not be used in developing remedial actions for Operable Unit 2 (OU2).

Based on human health risks and hazards established in the Baseline Risk Assessment (BLRA) for OU2 (February 18, 1994), contaminants of concern (COCs) were identified for receptors contacting contaminated soils or surface materials for each subunit at OU2. COCs are those contaminants which pose a carcinogenic risk of 1.0×10^{-6} or greater; *or* result in a non-carcinogenic hazard equal to or greater than 0.2 and therefore may warrant remedial action. COCs are subunit-, medium- and receptor-specific, *i.e.* COC selection is dependent on the specific source medium to which the receptor is exposed, the route of exposure, and the location at which exposure occurs. For the Feasibility Study, PRGs were calculated for a future expanded trespasser receptor, and future on-property and off-property farmer receptors since these were the receptors most often associated with potentially unacceptable levels of risk in the BLRA.

The method stipulated by Fernald Risk Assessment Policy No. 94-15 to derive PRGs depends on the observed relationship between risk resulting from all pathways of exposure involving soil and soil COC concentrations. Thus, the relationship between total risk from soil pathways and soil concentrations is a key determinant in the calculation of PRGs. Because of this, any changes in parameters or source terms which impact the quantitation of intake and thus risk, will also impact PRG derivations.

In order to derive PRGs for the Feasibility Study, risks to the expanded trespasser and on- and off-property farmer receptors were recalculated. This was done for three reasons. First, stipulated exposure parameter values for estimating intake for the expanded trespasser receptor has changed since the February 18, 1994 OU2 BLRA submittal. Second, surface soil/waste material concentrations for some subunits within OU2 were refined for the Feasibility Study report. Third, refinements of assumptions used to estimate air concentrations and dust deposition rates for the identified receptors have occurred. For all of these reasons estimates of intake, and thus risk, upon which current FS PRGs are based differ slightly from the risk reported in the February 18, 1994 OU2 BLRA.

For each subunit risk was recalculated for each receptor of concern based on direct and indirect exposure pathways using surface soil concentrations for COCs defined in the FS report. FS surface soil concentrations are also used to estimate air concentrations and dust deposition rates. Soil and air concentrations are reflected in the concentrations columns of the attached risk tables. FS soil exposure pathways are identical to the OU2 BLRA pathways used to estimate risk. They are:

Expanded Trespasser	- inhalation of particulates, gases and VOCs - ingestion of soil/surface material - dermal contact with soil/surface material - external radiation from soil/surface material
Off-Property Farmer	- inhalation of particulates, gases and VOCs
On-Property Farmer	- inhalation of particulates, gases and VOCs - ingestion of soil/surface material - dermal contact with soil/surface material - external radiation from soil/surface material - ingestion of dust affected homegrown produce and contaminated beef and milk products

Exposure parameter values used to recalculate intake and risk for the expanded trespasser, off-property farmer and on-property farmer are as listed in the most recent specifications from the Regulatory Programs Group (Fernald Risk Assessment Policy 94-11, Revision I, March 1994). These values are as reported in the FS report Section C.2.0.

Parameter values and equations used to estimate COC concentrations in produce, beef and milk are as reported in the February 18, 1994 OU2 BLRA. Exposure point concentrations used in the estimation of intake from inhalation and from ingestion of contaminated produce, beef and milk impacted by dust deposition for the off-property farmer were based on air modeling results supplied by John Pehrson of Fluor-Daniel (modeling results dated 3/2/94 and 3/4/94) and are listed in Tables A.III-1, A.III-2, A.III-3, A.III-4, A.III-5. Intakes and risks are summarized in the tables accompanying the text of this attachment.

For the current estimates of risk upon which PRGs are based, air concentrations and deposition rates determined by John Pehrson of Fluor-Daniel, reflect the following assumptions:

Off-Property Farmer/Expanded Trespasser:	Limited Erosion Potential 85% Vegetative Cover
On-Property Farmer:	Unlimited Erosion Potential 50% Vegetative Cover

Air concentrations and deposition rates for the off-property farmer and expanded trespasser under these conditions were made available to Jacobs Engineering Group (JEG) March 2, 1994. As of 3/24/94 results were not yet available for the specified on-property farmer assumption. Therefore using the air modeling results from March 2, 1994 for the unlimited erosion potential, 85% vegetative cover assumption, the following relationship was made to determine on-property air concentrations for the on-property farmer assumption listed above.

$$[Air_{fs50\%}] = (X)([Air_{fs85\%}] \qquad \text{eq.1}$$

where: $[Air_{fs50\%}]$ = Air concentration of COC assuming 50% vegetative cover and unlimited erosion potential

X = Ratio of 50% vegetative cover to 85% vegetative cover (3.33) (unitless)

$[Air_{fs85\%}]$ = Air concentration of COC assuming 85% vegetative cover and limited erosion potential

Deposition rates were calculated using the relationship:

$$dd_{fs50\%} = (dd_{fs85\%})(X)(Y) \qquad \text{eq.2}$$

where: $dd_{fs50\%}$ = Deposition rate on-property for unlimited erosion potential and 50% vegetative cover

$dd_{fs85\%}$ = Deposition rate off-property for limited erosion potential and 85% vegetative cover

X = Ratio of 50% vegetative cover to 85% vegetative cover (3.33) (unitless)

Y = Ratio of unlimited to limited erosion potential (3.95)(unitless)

This ratio approach was taken under the direction of John Pehrson of Fluor-Daniel based on a March 24, 1994 phone conversation.

A.III.1-2. Quantitative Derivation of PRGs

By summing risk or hazard across all applicable direct and indirect soil pathways, and using the receptors mentioned above, COCs are identified for contaminants which pose a risk equal to or above 1×10^{-6} or have a hazard index of 0.2 or more. This was done on a subunit- and receptor-specific basis. Hence, total risk (**TR**) for contaminant "i" due to direct and indirect soil exposures pathways is calculated in the following manner:

Expanded Trespasser

TR = Ingestion Risk + Inhalation Risk + External Radiation Risk + Dermal Contact Risk

Off-Property Farmer

TR = Inhalation Risk	+	Ingestion Risk Dust Affected Produce	+	Ingestion Risk Dust Affected Animal Products	+	Soil Ingestion Risk

On-Property Farmer

TR = Inhalation Risk	+	Ingestion Risk Dust Affected Produce	+	Ingestion Risk Dust Affected Animal Products	+	Soil Ingestion Risk

By incorporating the above total risk number for each COC for the receptor of interest, the following equation was then used to calculate the PRG:

$$PRG_i = \frac{TRL}{} \qquad \text{eq. 3}$$

$$\Sigma risk_i / C_{si}$$

where: PRG_i = Preliminary remediation goal for each COC in soil;

TRL = Target risk level; or 10^{-4}, 10^{-5} or 10^{-6}; or HQ ≤ 0.2.

$\Sigma risk_i$ = Sum of risk from all direct and indirect exposure pathways; and

C_{si} = Concentration of each COC in **source** medium, *i.e.* contaminant concentration in soil (or the source term concentration).

To derive the current PRGs, JEG solved for the concentration term using the specified level of risk of 1 x 10^{-6}. The resultant PRGs are listed in Tables A.III- 6, A.III-7, A.III-8, A.III-9 and A.III-10.

In addition, PRGs were calculated for contaminants which did not pose an unacceptable risk to the off-property farmer and expanded trespasser receptors. Current soil studies, which demonstrate COC concentrations at varying depths, suggest subsurface soil may have higher COC concentrations than surface soil. Hence, PRG calculations for contaminants serve as alert values to determine which soil concentrations will exert an unacceptable risk or hazard to the off-property farmer and expanded trespasser.

It is emphasized that these risk-based PRGs are directly related to the ratio of the estimated COC source medium concentrations, *i.e.* soil concentration. In addition, resultant estimates of risk are based on conservative air dispersion modeling results, as well as many other conservative assumptions, *e.g.* slope factors derived from limited human epidemiological studies. Thus they are as inherently "conservative" as the assumptions driving the risk estimates.

Also note that in the determination of PRGs only direct (*i.e.* ingestion, dermal contact, external radiation) and indirect (*i.e.* inhalation, ingestion of contaminated food products) soil exposure pathways were considered. Therefore the procedure discussed in this memorandum is intended to allow derivation of PRGs that are protective of receptors contacting soil via the aforementioned pathways. These soil PRGs are not intended to be equivalent to soil PRGs that are protective of groundwater and should not be interchanged.

TABLE A.III-1
ACTIVE FLYASH PILE: DUST AFFECTED CONCENTRATIONS & DEPOSITION RATES

	Milk Conc'n (mg/L; pCi/L)		Beef Conc'n (mg/kg; pCi/kg)		Vegetable Conc'n (mg/kg; pCi/kg)		Conc'n in air (mg/m³; pCi/m³)			Deposition Rate (mg/m2/hr)	
Contaminant	On site	Off site	On site	Off site	On site	Off site	On-Subunit*	On-Site*	Off-Site**	On-Site	Off-Site
Arsenic	5.69E-06	4.66E-08	1.90E-04	1.55E-06	1.47E-03	1.21E-05	5.91E-07	7.50E-06	3.79E-08	1.92E-05	1.58E-07
Beryllium	4.39E-09	3.60E-11	4.88E-06	4.00E-08	7.52E-05	6.16E-07	3.04E-08	3.87E-07	1.95E-09	9.92E-07	8.13E-09
U-TOTAL	7.77E-06	6.37E-08	2.59E-06	2.12E-08	1.99E-04	1.63E-06	8.06E-08	1.02E-06	5.18E-09	2.63E-06	2.16E-08
Neptunium-237	1.52E-06	1.24E-08	1.67E-05	1.37E-07	4.80E-03	3.93E-05	7.43E-06	2.39E-05	1.21E-07	6.15E-05	5.03E-07
Radium-226+D	2.09E-03	1.71E-05	1.16E-03	9.51E-06	7.17E-02	5.87E-04	1.14E-04	3.67E-04	1.86E-06	9.46E-04	7.74E-06
Radium-228+D	1.39E-03	1.14E-05	7.71E-04	6.32E-06	4.92E-02	4.03E-04	7.85E-05	2.53E-04	1.28E-06	6.49E-04	5.32E-06
Thorium-228+D	1.74E-05	1.42E-07	2.09E-05	1.71E-07	5.90E-02	4.82E-04	9.44E-05	3.04E-04	1.53E-06	7.82E-04	6.39E-06
Thorium-232	1.32E-05	1.08E-07	1.58E-05	1.30E-07	4.05E-02	3.32E-04	6.49E-05	2.09E-04	1.06E-06	5.37E-04	4.39E-06
Uranium-234	2.18E-03	1.78E-05	7.27E-04	5.95E-06	5.59E-02	4.57E-04	8.92E-05	2.87E-04	1.45E-06	7.38E-04	6.04E-06
Uranium-235	1.04E-04	8.53E-07	3.46E-05	2.84E-07	2.66E-03	2.19E-05	4.26E-06	1.37E-05	6.92E-08	3.52E-05	2.89E-07
Uranium-238+D	2.21E-03	1.81E-05	7.36E-04	6.02E-06	5.66E-02	4.63E-04	9.04E-05	2.91E-04	1.47E-06	7.47E-04	6.12E-06

*On-site concentrations and deposition rates assume 50% vegetative cover, unlimited erosion.

**On-subunit and off-site concentrations and deposition rates assume 85% vegetative cover, limited erosion potential.

TABLE A.III-2

SOUTH FIELD: DUST AFFECTED CONCENTRATIONS AND DEPOSITION RATES

Contaminant	Vegetable Conc'n (mg/kg; pCi/kg)		Milk Conc'n (mg/L; pCi/L)		Beef Conc'n (mg/kg; pCi/kg)		Deposition Rates (mg/m2/hr)		Conc'n in Air (pCi/m3; mg/m3)		
	On-Site	Off-Site	On-Site	Off-Site	On-Site	Off-Site	On-Site*	Off-Site**	On-Subunit**	On-Site*	Off-Site**
Arsenic	1.17E-04	1.66E-06	4.53E-07	6.41E-09	1.51E-05	2.14E-07	1.53E-06	2.17E-08	4.50E-08	5.73E-07	5.43E-09
Beryllium	1.51E-05	2.13E-07	8.85E-10	1.24E-11	9.83E-07	1.38E-08	2.00E-07	2.81E-09	5.84E-09	7.43E-08	7.05E-10
Chromium	2.26E-04	3.21E-06	2.21E-05	3.13E-07	8.10E-05	1.15E-06	2.99E-06	4.24E-08	8.79E-08	1.12E-06	1.06E-08
U-TOTAL	4.89E-04	6.91E-06	1.91E-05	2.69E-07	6.36E-06	8.98E-08	6.46E-06	9.12E-08	1.89E-07	2.41E-06	2.29E-08
Benzo(a)anthracene	3.90E-05	5.51E-07	4.89E-06	6.90E-08	1.55E-05	2.18E-07	5.29E-07	7.47E-09	1.55E-08	1.97E-07	1.87E-09
Benzo(a)pyrene	7.27E-05	1.03E-06	2.19E-05	3.09E-07	6.92E-05	9.78E-07	9.94E-07	1.40E-08	2.91E-08	3.70E-07	3.51E-09
Benzo(b)fluoranthene	6.06E-05	8.56E-07	7.08E-05	9.99E-07	2.24E-04	3.16E-06	8.25E-07	1.16E-08	2.42E-08	3.08E-07	2.92E-09
Benzo(k)fluoranthene	5.23E-05	7.38E-07	1.22E-04	1.72E-06	3.85E-04	5.43E-06	6.97E-07	9.85E-09	2.05E-08	2.60E-07	2.47E-09
Chrysene	5.03E-05	7.10E-07	0.00E+00	0.00E+00	1.99E-05	2.82E-07	6.76E-07	9.55E-09	1.98E-08	2.52E-07	2.39E-09
Dibenzo(a,h)anthracene	1.73E-05	2.44E-07	5.05E-06	7.13E-08	1.60E-05	2.25E-07	2.33E-07	3.29E-09	6.82E-09	8.67E-08	8.23E-10
Indeno(1,2,3-cd)pyrene	4.68E-05	6.61E-07	6.69E-04	9.45E-06	2.12E-03	2.99E-05	6.34E-07	8.96E-09	1.86E-08	2.37E-07	2.24E-09
Aroclor 1254	1.42E-06	2.02E-08	7.90E-07	1.12E-08	2.50E-06	3.54E-08	1.88E-08	2.66E-10	5.52E-10	7.03E-09	6.65E-11
Aroclor 1260	6.10E-07	8.60E-09	4.07E-07	5.75E-09	1.29E-06	1.82E-08	8.04E-09	1.13E-10	2.36E-10	3.00E-09	2.84E-11
Dieldrin	1.59E-07	2.25E-09	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.04E-09	2.90E-11	6.01E-11	7.67E-10	7.25E-12
CS-137	8.50E-03	1.20E-04	3.81E-03	5.40E-05	1.09E-02	1.54E-04	1.10E-04	1.55E-06	3.22E-06	4.10E-05	3.88E-07
NP-237	3.96E-03	5.59E-05	1.26E-06	1.77E-08	1.38E-05	1.95E-07	5.08E-05	7.17E-07	1.49E-06	1.89E-05	1.80E-07
RA-226	3.47E-01	4.89E-03	1.01E-02	1.43E-04	5.62E-03	7.93E-05	4.57E-03	6.45E-05	1.34E-04	1.70E-03	1.62E-05
RA-228	3.08E-02	4.35E-04	8.68E-04	1.23E-05	4.82E-04	6.81E-06	4.06E-04	5.73E-06	1.19E-05	1.51E-04	1.44E-06
TC-99	3.87E+00	5.46E-02	1.77E+00	2.49E-02	1.50E+00	2.11E-02	3.01E-02	4.24E-04	8.80E-04	1.12E-02	1.06E-04
TH-228	7.04E-02	9.91E-04	2.08E-05	2.92E-07	2.50E-05	3.51E-07	9.33E-04	1.31E-05	2.73E-05	3.47E-04	3.30E-06
TH-230	2.20E-01	3.11E-03	7.16E-05	1.01E-06	8.59E-05	1.21E-06	2.92E-03	4.12E-05	8.55E-05	1.09E-03	1.03E-05
TH-232	6.37E-02	8.97E-04	2.07E-05	2.92E-07	2.49E-05	3.50E-07	8.43E-04	1.19E-05	2.47E-05	3.15E-04	2.98E-06
U-234	1.39E-01	1.95E-03	5.42E-03	7.62E-05	1.81E-03	2.54E-05	1.83E-03	2.58E-05	5.37E-05	6.83E-04	6.47E-06
U-235	6.70E-03	9.51E-05	2.62E-04	3.71E-06	8.72E-05	1.24E-06	8.85E-05	1.26E-06	2.60E-06	3.30E-05	3.13E-07
U-238	1.49E-01	2.11E-03	5.82E-03	8.23E-05	1.94E-03	2.74E-05	1.97E-03	2.79E-05	5.77E-05	7.33E-04	6.96E-06

*On-site concentrations and deposition rates assume 50% vegetative cover and unlimited erosion potential.

**On-subunit and off-site concentraitons and deposition rates assume 85% vegetative cover and limited erosion potential.

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TABLE A.III-3
INACTIVE FLYASH PILE: DUST AFFECTED CONCENTRATIONS AND DEPOSITION RATES

Contaminant	Milk Conc'n (mg/L; pCi/L)		Beef Conc'n (mg/kg; pCi/kg)		Vegetable Conc'n (mg/kg; pCi/kg)		(Conc'n in air mg/m³; pCi/m³)			Deposition Rate (mg/m2/hr)	
	On site	Off site	On site	Off site	On site	Off site	On-Subunit*	On-Site**	Off-Site*	On-Site**	Off-Site*
Arsenic	1.27E-03	1.20E-08	4.24E-02	3.98E-07	3.29E-01	3.09E-06	6.55E-08	1.68E-06	1.08E-08	4.30E-03	3.54E-04
Beryllium	1.20E-06	1.13E-11	1.34E-03	1.26E-08	2.06E-02	1.94E-07	4.14E-09	1.06E-07	6.81E-10	2.72E-04	2.24E-05
U-TOTAL	1.09E-02	1.03E-07	3.64E-03	3.42E-08	2.80E-01	2.63E-06	5.62E-08	1.44E-06	9.24E-09	3.70E-03	3.04E-04
Dibenzo(a,h)anthracene	6.19E-03	5.81E-08	1.96E-02	1.84E-07	2.12E-02	1.99E-07	4.34E-09	1.12E-07	7.13E-10	2.86E-04	2.35E-05
CS-137	2.88E-03	2.71E-05	8.24E-03	7.75E-05	6.43E-03	6.05E-05	1.26E-06	3.25E-05	2.08E-07	8.30E-05	6.84E-03
NP-237	4.38E-07	4.12E-09	4.82E-06	4.53E-08	1.38E-03	1.30E-05	2.70E-07	6.93E-06	4.44E-08	1.77E-05	1.46E-03
RA-226	5.65E-04	5.33E-06	3.14E-04	2.96E-06	1.94E-02	1.83E-04	3.90E-06	1.00E-04	6.40E-07	2.56E-04	2.11E-02
RA-228	6.20E-04	5.83E-06	3.45E-04	3.24E-06	2.20E-02	2.07E-04	4.42E-06	1.14E-04	7.27E-07	2.90E-04	2.39E-02
TH-228	7.84E-06	7.35E-08	9.40E-06	8.82E-08	2.65E-02	2.49E-04	5.35E-06	1.37E-04	8.78E-07	3.52E-04	2.89E-02
TH-230	8.82E-06	8.30E-08	1.06E-05	9.96E-08	2.71E-02	2.55E-04	5.47E-06	1.40E-04	8.98E-07	3.59E-04	2.96E-02
TH-232	7.42E-06	6.98E-08	8.90E-06	8.38E-08	2.28E-02	2.15E-04	4.60E-06	1.18E-04	7.55E-07	3.02E-04	2.49E-02
U-234	3.61E-03	3.41E-05	1.20E-03	1.14E-05	9.25E-02	8.73E-04	1.86E-05	4.77E-04	3.06E-06	1.22E-03	1.01E-01
U-235	1.76E-04	1.65E-06	5.86E-05	5.51E-07	4.51E-03	4.24E-05	9.06E-07	2.33E-05	1.49E-07	5.95E-05	4.90E-03
U-238	3.70E-03	3.47E-05	1.23E-03	1.16E-05	9.49E-02	8.90E-04	1.91E-05	4.90E-04	3.14E-06	1.25E-03	1.03E-01

*On-subunit and off-site concentrations and deposition rates assume 85% vegetative cover and limited erosion potential.

**On-site concentrations and deposition rates assume 50% vegetative cover and unlimited erosion potential.

000556

TABLE A.III-4

SOLID WASTE LANDFILL: DUST AFFECTED CONCENTRATIONS AND ON-DEPOSITION RATES

	Milk Conc'n (mg/L; pCi/L)		Beef Conc'n (mg/kg;pCi/kg)		Vegetable Conc'n (mg/kg; pCi/L		Deposition Rate (mg/m2/hr)		Conc'n in air (pCi/m3; mg/m3)		
Contaminant	On-Site	Off-Site	On-Site	Off-Site	On-Site	Off-Site	On-Site*	Off-Site**	On-Subunit**	On-Site*	Off-Site**
Arsenic	1.50E-07	6.04E-10	5.01E-06	2.01E-08	3.89E-05	1.56E-07	5.08E-07	2.04E-09	1.63E-08	1.79E-07	4.43E-10
Beryllium	2.31E-10	9.34E-13	2.56E-07	1.04E-09	3.95E-06	1.60E-08	5.22E-08	2.11E-10	1.67E-09	1.84E-08	4.56E-11
Chromium	8.54E-06	3.45E-08	3.13E-05	1.26E-07	8.75E-05	3.53E-07	1.16E-06	4.67E-09	3.71E-08	4.07E-07	1.01E-09
U-TOTAL	4.97E-05	2.01E-07	1.66E-05	6.69E-08	1.27E-03	5.14E-06	1.68E-05	6.79E-08	5.40E-07	5.93E-06	1.47E-08
4,4'-DDE	5.43E-08	2.19E-10	1.72E-13	6.93E-16	6.78E-08	2.74E-10	8.97E-10	3.62E-12	2.88E-11	3.17E-10	7.83E-13
Benzo(a)pyrene	1.25E-06	5.05E-09	3.96E-06	1.60E-08	4.16E-06	1.68E-08	5.68E-08	2.29E-10	1.82E-09	2.01E-08	4.96E-11
Benzo(b)fluoranthene	4.55E-06	1.84E-08	1.44E-05	5.82E-08	3.90E-06	1.58E-08	5.31E-08	2.15E-10	1.70E-09	1.87E-08	4.63E-11
Carbazole	9.23E-08	3.73E-10	2.90E-07	1.17E-09	4.42E-07	1.79E-09	5.76E-09	2.33E-11	1.85E-10	2.03E-09	5.03E-12
Dibenzo(a,h)anthracene	3.24E-07	1.31E-09	1.03E-06	4.14E-09	1.11E-06	4.48E-09	1.50E-08	6.04E-11	4.80E-10	5.27E-09	1.31E-11
Indeno(1,2,3-cd)pyrene	3.79E-05	1.53E-07	1.20E-04	4.84E-07	2.65E-06	1.07E-08	3.59E-08	1.45E-10	1.15E-09	1.27E-08	3.13E-11
CS-137	6.69E-04	2.69E-06	1.91E-03	7.70E-06	1.49E-03	6.01E-06	1.92E-05	7.75E-08	6.17E-07	6.80E-06	1.68E-08
NP-237	6.27E-06	2.54E-08	6.90E-05	2.79E-07	1.98E-02	8.01E-05	2.54E-04	1.03E-06	8.17E-06	9.00E-05	2.22E-07
PU-238	2.83E-08	1.14E-10	1.41E-07	5.71E-10	4.36E-03	1.76E-05	5.77E-05	2.33E-07	1.85E-06	2.04E-05	5.04E-08
RA-226	3.72E-04	1.51E-06	2.07E-04	8.37E-07	1.28E-02	5.17E-05	1.68E-04	6.82E-07	5.42E-06	5.97E-05	1.48E-07
RA-228	2.69E-04	1.08E-06	1.49E-04	6.02E-07	9.53E-03	3.84E-05	1.26E-04	5.07E-07	4.03E-06	4.43E-05	1.10E-07
TH-228	2.70E-06	1.09E-08	3.24E-06	1.31E-08	9.15E-03	3.69E-05	1.21E-04	4.90E-07	3.89E-06	4.27E-05	1.06E-07
TH-230	1.18E-05	4.77E-08	1.41E-05	5.72E-08	3.62E-02	1.47E-04	4.80E-04	1.94E-06	1.54E-05	1.69E-04	4.19E-07
TH-232	2.77E-06	1.12E-08	3.32E-06	1.34E-08	8.52E-03	3.43E-05	1.13E-04	4.54E-07	3.62E-06	3.97E-05	9.83E-08
U-234	9.32E-03	3.74E-05	3.11E-03	1.25E-05	2.39E-01	9.59E-04	3.16E-03	1.27E-05	1.01E-04	1.11E-03	2.75E-06
U-235	6.26E-04	2.53E-06	2.09E-04	8.43E-07	1.60E-02	6.48E-05	2.12E-04	8.56E-07	6.81E-06	7.50E-05	1.85E-07
U-238	1.70E-02	6.88E-05	5.68E-03	2.29E-05	4.37E-01	1.76E-03	5.77E-03	2.33E-05	1.85E-04	2.04E-03	5.04E-06

*On-site concentrations and deposition rates assume 50% vegetative cover and unlimited erosion potential.

**On-subunit and off-site concentrations and deposition rates assume 85% vegetative cover and limited deposition rates.

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TABLE A.III-5

LIME SLUDGE PONDS: DUST AFFECTED CONCENTRATIONS AND DEPOSITION RATES

Contaminant	Milk Conc'n (mg/L; pCi/L)		Beef Conc'n (mg/kg; pCi/kg)		Vegetable Conc'n (mg/kg; pCi/kg		Conc'n in Air mg/m³; pCi/m³			Deposition Rate (mg/m2/hr)	
	On site	Off site	On site	Off site	On site	Off site	On-Subunit*	On-Site**	Off-Site*	On-Site	Off-Site
Arsenic	1.94E-07	4.63E-10	6.46E-06	1.54E-08	5.01E-05	1.20E-07	1.93E-08	2.60E-07	3.52E-10	6.55E-07	1.37E-05
Beryllium	6.24E-10	1.49E-12	6.93E-07	1.66E-09	1.07E-05	2.55E-08	4.15E-09	5.60E-08	7.57E-11	1.41E-07	2.95E-06
Chromium	1.14E-05	2.72E-08	4.19E-05	9.96E-08	1.17E-04	2.78E-07	4.54E-08	6.10E-07	8.27E-10	1.55E-06	3.22E-05
U-Total	5.64E-05	1.34E-07	1.88E-05	4.47E-08	1.45E-03	3.44E-06	5.60E-07	7.53E-06	1.02E-08	1.91E-05	3.98E-04
Aroclor 1254	2.21E-06	5.28E-09	6.98E-06	1.67E-08	3.98E-06	9.52E-09	1.54E-09	2.08E-08	2.81E-11	5.25E-08	1.10E-06
Benzo(a)pyrene	2.15E-06	5.13E-09	6.80E-06	1.62E-08	7.15E-06	1.70E-08	2.88E-09	3.87E-08	5.25E-11	9.77E-08	2.04E-06
Benzo(b)fluoranthene	7.62E-06	1.82E-08	2.41E-05	5.76E-08	6.53E-06	1.56E-08	2.62E-09	3.53E-08	4.77E-11	8.88E-08	1.86E-06
Dibenzo(a,h)anthracene	6.16E-07	1.47E-09	1.95E-06	4.65E-09	2.11E-06	5.03E-09	8.37E-10	1.13E-08	1.53E-11	2.84E-08	5.94E-07
Indeno(1,2,3-cd)pyrene	6.76E-05	1.61E-07	2.14E-04	5.10E-07	4.73E-06	1.13E-08	1.88E-09	2.54E-08	3.43E-11	6.40E-08	1.34E-06
CS-137	2.17E-03	5.16E-06	6.19E-03	1.47E-05	4.83E-03	1.15E-05	1.84E-06	2.47E-05	3.35E-08	6.24E-05	1.30E-03
NP-237	1.70E-06	4.06E-09	1.87E-05	4.47E-08	5.36E-03	1.28E-05	2.02E-06	2.72E-05	3.69E-08	6.87E-05	1.44E-03
RA-226	4.02E-04	9.62E-07	2.24E-04	5.34E-07	1.38E-02	3.30E-05	5.37E-06	7.23E-05	9.80E-08	1.82E-04	3.81E-03
RA-228	3.31E-04	7.93E-07	1.84E-04	4.41E-07	1.17E-02	2.81E-05	4.58E-06	6.17E-05	8.35E-08	1.55E-04	3.25E-03
TH-228	5.76E-06	1.37E-08	6.91E-06	1.65E-08	1.95E-02	4.65E-05	7.61E-06	1.02E-04	1.39E-07	2.59E-04	5.40E-03
TH-230	9.78E-05	2.33E-07	1.17E-04	2.80E-07	3.01E-01	7.17E-04	1.17E-04	1.58E-03	2.14E-06	3.98E-03	8.32E-02
TH-232	3.08E-06	7.35E-09	3.69E-06	8.81E-09	9.47E-03	2.26E-05	3.69E-06	4.97E-05	6.73E-08	1.25E-04	2.62E-03
U-234	5.51E-03	1.32E-05	1.84E-03	4.38E-06	1.41E-01	3.37E-04	5.49E-05	7.40E-04	1.00E-06	1.86E-03	3.90E-02
U-235	4.57E-04	1.09E-06	1.52E-04	3.64E-07	1.17E-02	2.80E-05	4.56E-06	6.13E-05	8.31E-08	1.55E-04	3.24E-03
U-238	1.87E-02	4.48E-05	6.25E-03	1.49E-05	4.80E-01	1.15E-03	1.87E-04	2.51E-03	3.41E-06	6.34E-03	1.33E-01

*On-subunit and off-site concentrations and deposition rates assume 85% vegetative cover and limited erosion potential.

**On-site concentrations and deposition rates assume 50% vegetative cover and unlimited erosion potential.

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TABLE A.III-6

ACTIVE FLYASH PILE
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	NP-237	5.2E-02	Not a COC	5.00E+00
		RA-226	9.4E-01	Not a COC	3.72E-01
		RA-228	8.3E-03	Not a COC	7.69E-01
		TH-228	4.3E-03	Not a COC	3.98E-01
		U-235/236	9.7E-02	Not a COC	Not a COC
		U-238	4.8E-01	Not a COC	Not a COC
		Arsenic	2.2E-01	8.55E+02	1.95E+01
		Beryllium	9.6E+00	Not a COC	2.53E-02
NON-CARCINOGENS	Soil	Arsenic	2.3E+01	Not a COC	Not a COC

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration.

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TABLE A.III-7

SOUTH FIELD
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expandèd Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	CS-137	1.2E-02	Not a COC	Not a COC
		NP-237	5.2E-02	Not a COC	Not a COC
		RA-226	9.4E-01	Not a COC	Not a COC
		RA-228	8.3E-03	Not a COC	7.69E-01
		TH-228	4.3E-03	Not a COC	3.99E-01
		TH-230	3.1E+00	Not a COC	Not a COC
		TH-232	3.2E+00	Not a COC	Not a COC
		U-234	3.2E+00	Not a COC	Not a COC
		U-235/236	9.7E-02	Not a COC	Not a COC
		U-238	4.8E-01	Not a COC	Not a COC
		Arsenic	2.2E-01	Not a COC	Not a COC
		Beryllium	2.9E-03	Not a COC	2.53E-02
		Chromium	4.8E+00	Not a COC	Not a COC
		Benzo(a)anthracene	3.6E-01	Not a COC	Not a COC
		Benzo(a)pyrene	5.4E-02	5.09E+01	7.02E+00
		Benzo(b)fluoranthene	4.3E-01	Not a COC	Not a COC
		Benzo(k)fluoranthene	9.6E-01	Not a COC	Not a COC
		Dibenzo(a,h)anthracene	3.4E-02	Not a COC	Not a COC
		Indeno(1,2,3-cd)pyrene	2.0E-01	1.22E+04	Not a COC
		Aroclor-1254	3.8E-03	Not a COC	3.53E-02
		Aroclor-1260	3.8E-03	Not a COC	3.53E-02
		Dieldrin	2.1E-03	Not a COC	Not a COC
NON-CARCINOGENS	Soil	Arsenic	2.3E+01	6.7E+04	4.1E+02
		U-TOTAL	3.7E+04	6.2E+05	7.7E+01
	Groundwater	U-TOTAL	1.7E-02	1.7E-02	N/A

* Contaminants associated with greater than 1.0 x 10E-6 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration.

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TABLE A.III-8

INACTIVE FLYASH PILE
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	CS-137	1.20E-02	Not a COC	Not a COC
		NP-237	5.26E-02	Not a COC	Not a COC
		RA-226	9.55E-01	Not a COC	Not a COC
		RA-228	8.27E-03	Not a COC	7.69E-01
		TH-228	4.29E-03	Not a COC	3.99E-01
		U-235/236	9.82E-02	Not a COC	Not a COC
		U-238	4.76E-01	Not a COC	Not a COC
		Arsenic	4.64E-02	Not a COC	1.96E+01
		Beryllium	2.58E-03	Not a COC	2.53E-02
		Dibenzo(a,h)anthracene	5.33E-03	Not a COC	Not a COC
			PRG (mg/L)		
NON-CARCINOGENS	Groundwater	U-Total	1.7E-02	3.2E-01	N/A

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration.

TABLE C.A.III-9

SOLID WASTE LANDFILL
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Surface Soil	CS-137	1.20E-02	*5.34E+04*	*1.1E+00*
		NP-237	5.29E-02	*4.00E+03*	*5.0E+00*
		PU-238	9.15E-01	*3.08E+03*	*1.8E+02*
		RA-226	9.63E-01	*2.31E+04*	*1.2E+02*
		RA-228	8.27E-03	*4.76E+04*	7.7E-01
		TH-228	4.30E-03	*1.68E+03*	4.0E-01
		TH-230	6.80E+00	*4.56E+03*	*1.8E+03*
		U-234	6.59E+00	*5.01E+03*	*1.6E+03*
		U-235/236	9.89E-02	*5.22E+03*	*9.3E+00*
		U-238	5.62E-01	*2.51E+03*	5.8E+01
		Arsenic	2.19E-01	*8.03E+02*	*2.0E+01*
		Beryllium	2.86E-03	*1.43E+03*	2.5E-02
		Chromium	1.43E+01	*5.76E+03*	*3.9E+03*
		Benzo(a)pyrene	5.52E-02	*5.29E+02*	*7.0E+00*
		Benzo(b)fluoranthene	4.41E-01	*1.35E+03*	*5.7E+01*
		Dibenzo(a,h)anthracene	4.97E-02	*4.80E+02*	*6.3E+00*
		Indeno(1,2,3-cd)pyrene	1.64E-01	*5.34E+01*	*2.6E+01*
NON-CARCINOGENS	Surface Soil	Arsenic	2.35E+01	*6.65E+05*	*4.1E+02*
		U-Total	3.29E+01	*6.56E+06*	7.7E+01

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration. Numbers in italics represent PRG calculations for contaminants that do not pose a risk greater than 1.0E-06 or an HI > 0.2.

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TABLE A.III-10

LIME SLUDGE PONDS
CONTAMINANTS OF CONCERN*
AND RISK-BASED PRELIMINARY REMEDIATION GOALS (PRGs) **

	Medium	Parameter	On-Property Farmer (RME) PRG (pCi/g or mg/kg)	Off-Property Farmer PRG (pCi/g or mg/kg)	Expanded Trespasser PRG (pCi/g or mg/kg)
CARCINOGENS	Soil	CS-137	1.20E-02	Not a COC	Not a COC
		NP-237	5.28E-02	Not a COC	Not a COC
		RA-226	9.60E-01	Not a COC	Not a COC
		RA-228	8.27E-03	Not a COC	7.69E-01
		TH-228	4.29E-03	Not a COC	3.99E-01
		TH-230	5.62E+00	Not a COC	Not a COC
		U-234	5.61E+00	Not a COC	Not a COC
		U-235/236	9.86E-02	Not a COC	Not a COC
		U-238	5.46E-01	Not a COC	5.80E+01
		Arsenic	2.22E-01	Not a COC	Not a COC
		Beryllium	2.86E-03	Not a COC	2.53E-02
		Aroclor-1254	3.82E-03	Not a COC	3.53E-02
		Benzo(a)anthracene	3.68E-01	Not a COC	Not a COC
		Benzo(a)pyrene	5.51E-02	Not a COC	Not a COC
		Benzo(b)fluoranthene	4.39E-01	Not a COC	Not a COC
		Dibenzo(a,h)anthracene	4.96E-02	Not a COC	Not a COC
		Indeno(1,2,3-cd)pyrene	2.03E-01	Not a COC	Not a COC
NON-CARCINOGENS	Soil	U-TOTAL	2.43E+02	Not a COC	7.70E+01

* Contaminants associated with greater than 1.0 x 10E-06 risk or an HI of > 0.2.

** PRGs include all pathways impacted by contaminants present in soil. PRGs calculated as described in Section C.2.1.2 assuming a linear relationship between total risk via all relevant soil pathways (i.e., air, ingestion, dermal contact, homegrown produce [dust affected], etc.) and surface soil concentration.

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TABLE A.III-11
FUTURE, EXPANDED TRESPASSER
ACTIVE FLYASH PILE: SOIL
CARCINOGENIC RISK

Radiation Risk

Inhalation/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
NP-237	1.88E-06	6.1E-03	2.9E-08	1.8E-10
PU-238		0.0E+00	3.9E-08	0.0E+00
PU-239/240		0.0E+00	3.8E-08	0.0E+00
RA-226	2.89E-05	9.4E-02	3.0E-09	2.8E-10
RA-228	1.99E-05	6.5E-02	6.9E-10	4.5E-11
SR-90		0.0E+00	6.2E-11	0.0E+00
TH-228	2.39E-05	7.8E-02	7.8E-08	6.1E-09
TH-230		0.0E+00	2.9E-08	0.0E+00
TH-232	1.64E-05	5.3E-02	2.8E-08	1.5E-09
U-234	2.26E-05	7.4E-02	2.6E-08	1.9E-09
U-235/236	1.08E-06	3.5E-03	2.5E-08	8.8E-11
U-238	2.29E-05	7.5E-02	5.2E-08	3.9E-09
			Total Pathway:	1.4E-08

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
NP-237	0.30	7.4E+00	2.2E-10	1.6E-09
PU-238		0.0E+00	2.2E-10	0.0E+00
PU-239/240		0.0E+00	2.3E-10	0.0E+00
RA-226	4.61	1.1E+02	1.2E-10	1.4E-08
RA-228	3.17	7.8E+01	1.0E-10	7.8E-09
SR-90		0.0E+00	3.6E-11	0.0E+00
TH-228	3.81	9.3E+01	5.5E-11	5.1E-09
TH-230		0.0E+00	1.3E-11	0.0E+00
TH-232	2.62	6.4E+01	1.2E-11	7.7E-10
U-234	3.599	8.8E+01	1.6E-11	1.4E-09
U-235/236	0.17	4.2E+00	1.6E-11	6.5E-11
U-238	3.65	8.9E+01	2.8E-11	2.5E-09
			Total Pathway:	3.3E-08

Chemical Risk

Inhalation/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	5.91E-07	1.5E-09	1.5E+01	2.3E-08
Barium		0.0E+00		
Beryllium	3.04E-08	7.9E-11	8.4E+00	6.6E-10
Chromium		0.0E+00	4.1E+01	0.0E+00
Cobalt		0.0E+00		
Copper		0.0E+00		
Cyanide		0.0E+00		
Lead		0.0E+00		
Molybdenum		0.0E+00		
Nickel		0.0E+00		
Selenium		0.0E+00		
Thallium		0.0E+00		
Toluene		0.0E+00		
Vanadium		0.0E+00		
Zinc		0.0E+00		
TH-Total		0.0E+00		
U-Total	8.1E-08	2.1E-10		
			Total Pathway:	2.4E-08

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	94.16	1.8E-06	1.8E+00	3.2E-06
Barium		0.0E+00		
Beryllium	4.84	9.4E-08	4.3E+00	4.1E-07
Chromium		0.0E+00		
Cobalt		0.0E+00		
Copper		0.0E+00		
Cyanide		0.0E+00		
Lead		0.0E+00		
Molybdenum		0.0E+00		
Nickel		0.0E+00		
Selenium		0.0E+00		
Thallium		0.0E+00		
Toluene		0.0E+00		
Vanadium		0.0E+00		
Zinc		0.0E+00		
TH-Total		0.0E+00		
U-Total	12.8	2.5E-07		
			Total Pathway:	3.6E-06

Total Rad + Chem 3.8E-08

Total Rad + Chem 3.7E-06

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TABLE A.III-11 (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil

Not applicable (1)

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Intake	SF(e)	Risk	Total
NP-237	1.3E-01	4.3E-07	5.8E-08	6.0E-08
PU-238	0.0E+00	2.8E-11	0.0E+00	0.0E+00
PU-239/240	0.0E+00	2.2E-11	0.0E+00	0.0E+00
RA-226	2.1E+00	6.0E-06	1.2E-05	1.2E-05
RA-228	1.4E+00	2.9E-06	4.1E-06	4.1E-06
SR-90	0.0E+00	0.0E+00	0.0E+00	0.0E+00
TH-228	1.7E+00	5.6E-06	9.5E-06	9.6E-06
TH-230	0.0E+00	5.4E-11	0.0E+00	0.0E+00
TH-232	1.2E+00	2.6E-11	3.0E-11	2.3E-09
U-234	1.6E+00	3.0E-11	4.8E-11	3.4E-09
U-235/236	7.7E-02	2.4E-07	1.8E-08	1.9E-08
U-238	1.6E+00	3.6E-08	5.9E-08	6.5E-08

Total Pathway: 2.6E-05

Chemical Risk

Dermal Contact/Soil

Compound	Intake	SF(derm)	Risk	Total
Arsenic	8.6E-07	1.8E+00	1.6E-06	4.8E-06
Barium	0.0E+00			
Beryllium	4.4E-07	4.3E+02	1.9E-04	1.9E-04
Chromium	0.0E+00			
Cobalt	0.0E+00			
Copper	0.0E+00			
Cyanide	0.0E+00			
Lead	0.0E+00			
Molybdenum	0.0E+00			
Nickel	0.0E+00			
Selenium	0.0E+00			
Thallium	0.0E+00			
Toluene	0.0E+00			
Vanadium	0.0E+00			
Zinc	0.0E+00			
TH-Total	0.0E+00			
U-Total	1.2E-06			

Total Pathway: 1.9E-04

External Radiation/Soil

Compound	Intake	SF(o)	Risk

Not applicable (2)

Total Pathway: 0.0E+00

Total Rad + Chem 1.9E-04

2.6E-05 | *Total:* 2.21E-04

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TABLE A.III-11 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil

Not applicable

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Intake	RfD(e)	HQ
NP-237	1.3E-01		
PU-238	0.0E+00		
PU-239/240	0.0E+00		
RA-226	2.1E+00		
RA-228	1.4E+00		
SR-90	0.0E+00		
TH-228	1.7E+00		
TH-230	0.0E+00		
TH-232	1.2E+00		
U-234	1.6E+00		
U-235/236	7.7E-02		
U-238	1.6E+00		

Total Pathway: 0.0E+00

Chemical Hazard

Dermal Contact/Soil

Compound	Intake	RfD(derm)	HQ
Arsenic	3.6E-05	2.9E-04	1.3E-01
Barium	0.0E+00	6.4E-02	0.0E+00
Beryllium	1.9E-06	5.0E-05	3.7E-02
Chromium	0.0E+00	2.3E-03	0.0E+00
Cobalt	0.0E+00		
Copper	0.0E+00	2.4E-02	0.0E+00
Cyanide	0.0E+00	1.4E-02	0.0E+00
Lead	0.0E+00		
Molybdenum	0.0E+00	1.9E-03	0.0E+00
Nickel	0.0E+00	1.0E-03	0.0E+00
Selenium	0.0E+00	4.0E-03	0.0E+00
Thallium	0.0E+00	7.0E-05	0.0E+00
Toluene	0.0E+00	2.0E-03	0.0E+00
Vanadium	0.0E+00	3.5E-04	0.0E+00
Zinc	0.0E+00	7.5E-02	0.0E+00
TH-Total	0.0E+00		
U-Total	4.9E-06	1.5E-04	3.3E-02

Total Pathway: 2.0E-01

External Radiation/Soil

Compound	Intake	RfD(o)	HQ

Not applicable

Total Pathway: 0.0E+00

Total Rad + Chem 2.0E-01

Total Rad + Chem 0.0E+00

Total
1.6E-01
3.7E-02
3.3E-02

Total: 0.23

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TABLE A.III-11 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Inhalation/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	HQ
NP-237	1.88E-06	6.1E-03		
PU-238	0.00E+00	0.0E+00		
PU-239/240	0.00E+00	0.0E+00		
RA-226	2.89E-05	9.4E-02		
RA-228	1.99E-05	6.5E-02		
SR-90	0.00E+00	0.0E+00		
TH-228	2.39E-05	7.8E-02		
TH-230	0.00E+00	0.0E+00		
TH-232	1.64E-05	5.3E-02		
U-234	2.26E-05	7.4E-02		
U-235/236	1.08E-06	3.5E-03		
U-238	2.29E-05	7.5E-02		
		Total Pathway:		0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	HQ
NP-237	0.30	7.4E+00		
PU-238	0.00	0.0E+00		
PU-239/240	0.00	0.0E+00		
RA-226	4.61	1.1E+02		
RA-228	3.17	7.8E+01		
SR-90	0.00	0.0E+00		
TH-228	3.81	9.3E+01		
TH-230	0.00	0.0E+00		
TH-232	2.62	6.4E+01		
U-234	3.60	8.8E+01		
U-235/236	0.17	4.2E+00		
U-238	3.65	8.9E+01		
		Total Pathway:		0.0E+00

Chemical Hazard

Inhalation/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	HQ
Arsenic	5.91E-07	7.6E-09		
Barium	0.00E+00	0.0E+00	1.4E-04	0.0E+00
Beryllium	3.04E-08	3.9E-10		
Chromium	0.00E+00	0.0E+00		
Cobalt	0.00E+00	0.0E+00	5.5E-07	0.0E+00
Copper	0.00E+00	0.0E+00		
Cyanide	0.00E+00	0.0E+00		
Lead	0.00E+00	0.0E+00		
Molybdenum	0.00E+00	0.0E+00		
Nickel	0.00E+00	0.0E+00		
Selenium	0.00E+00	0.0E+00		
Thallium	0.00E+00	0.0E+00		
Toluene	0.00E+00	0.0E+00		
Vanadium	0.00E+00	0.0E+00		
Zinc	0.00E+00	0.0E+00		
TH-Total		0.0E+00		
U-Total		0.0E+00		
		Total Pathway:		0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	HQ
Arsenic	94.16	1.0E-05	3.0E-04	3.4E-02
Barium	0.00	0.0E+00	7.0E-02	0.0E+00
Beryllium	4.84	5.2E-07	5.0E-03	1.0E-04
Chromium	0.00	0.0E+00	5.0E-03	0.0E+00
Cobalt	0.00	0.0E+00		
Copper	0.00	0.0E+00	4.0E-02	0.0E+00
Cyanide	0.00	0.0E+00	2.0E-02	0.0E+00
Lead	0.00	0.0E+00		
Molybdenum	0.00	0.0E+00	5.0E-03	0.0E+00
Nickel	0.00	0.0E+00	2.0E-02	0.0E+00
Selenium	0.00	0.0E+00	5.0E-03	0.0E+00
Thallium	0.00	0.0E+00	7.0E-05	0.0E+00
Toluene	0.00	0.0E+00	2.0E-01	0.0E+00
Vanadium	0.00	0.0E+00	7.0E-03	0.0E+00
Zinc	0.00	0.0E+00	3.0E-01	0.0E+00
TH-Total	0.00	0.0E+00		
U-Total	12.85	1.4E-06	3.0E-03	4.6E-04
		Total Pathway:		3.4E-02

Total Rad + Chem 0.0E+00

Total Rad + Chem 3.4E-02

TABLE A.III-12

FUTURE OFF-PROPERTY FARMER [85% vegetative cover; limited erosion]

ACTIVE FLYASH PILE: SURFACE SOIL/AIR

CARCINOGENIC RISK

Radiation Risk					
Inhalation/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
NP-237	1.21E-07	1.4E-02	2.9E-08	4.1E-10	4.1E-10
RA-226	1.86E-06	2.2E-01	3.0E-09	6.5E-10	6.5E-10
RA-228	1.28E-06	1.5E-01	6.9E-10	1.0E-10	1.0E-10
TH-228	1.53E-06	1.8E-01	7.8E-08	1.4E-08	1.4E-08
TH-232	1.06E-06	1.2E-01	2.8E-08	3.4E-09	3.4E-09
U-234	1.45E-06	1.7E-01	2.6E-08	4.4E-09	4.4E-09
U-235/236	6.92E-08	8.0E-03	2.5E-08	2.0E-10	2.0E-10
U-238	1.47E-06	1.7E-01	5.2E-08	8.9E-09	8.9E-09
			Total Pathway:	3.2E-08	

Chemical Risk					
Inhalation/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	3.79E-08	2.5E-09	1.5E+01	3.7E-08	3.7E-08
Beryllium	1.95E-09	1.3E-10	8.4E+00	1.1E-09	1.1E-09
U-Total	5.18E-09	3.4E-10			
			Total Pathway:	3.8E-08	
			Total Rad + Chem	7.0E-08	*Total:* 7.0E-08

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TABLE A.III-12 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard				
Inhalation/Soil				
Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	Hazard
NP-237	1.21E-07			
RA-226	1.86E-06			
RA-228	1.28E-06			
TH-228	1.53E-06			
TH-232	1.06E-06			
U-234	1.45E-06			
U-235/236	6.92E-08			
U-238	1.47E-06			
			Total Pathway:	0.0E+00

Chemical Hazard				
Inhalation/Soil				
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	3.79E-08	2.5E-09		
Beryllium	1.95E-09	1.3E-10		
U-Total	5.18E-09	3.4E-10		
			Total Pathway:	0.0E+00

Total Rad + Chem	0.0E+00	*Total:*	0.0E+00

Total

000369

TABLE A.III-13

FUTURE, ON-PROPERTY (SOUTH FIELD) FARMER

ACTIVE FLYASH PILE: SURFACE MATERIAL (RME VALUES) [50% vegetative cover; unlimited erosion]

CARCINOGENIC RISK

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
NP-237	2.39E-05	2.8E+00	2.9E-08	8.0E-08
RA-226	3.67E-04	4.3E+01	3.0E-09	1.3E-07
RA-228	2.53E-04	2.9E+01	6.9E-10	2.0E-08
TH-228	3.04E-04	3.5E+01	7.8E-08	2.7E-06
TH-232	2.09E-04	2.4E+01	2.8E-08	6.8E-07
U-234	2.87E-04	3.3E+01	2.6E-08	8.6E-07
U-235/236	1.37E-05	1.6E+00	2.5E-08	4.0E-08
U-238	2.91E-04	3.4E+01	5.2E-08	1.8E-06

Total Pathway: 6.3E-06

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
NP-237	0.30	1.3E+03	2.2E-10	2.9E-07
RA-226	4.61	2.0E+04	1.2E-10	2.4E-06
RA-228	3.17	1.4E+04	1.0E-10	1.4E-06
TH-228	3.81	1.7E+04	5.5E-11	9.2E-07
TH-232	2.62	1.2E+04	1.2E-11	1.4E-07
U-234	3.60	1.6E+04	1.6E-11	2.5E-07
U-235/236	0.17	7.6E+02	1.6E-11	1.2E-08
U-238	3.65	1.6E+04	2.8E-11	4.5E-07

Total Pathway: 5.9E-06

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	7.50E-06	4.9E-07	1.5E+01	7.3E-06
Beryllium	3.87E-07	2.5E-08	8.4E+00	2.1E-07
U-Total	1.02E-06	6.6E-08		

Total Pathway: 7.5E-06

Total Rad + Chem 1.4E-05

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	94.164	2.3E-04	1.8E+00	4.1E-04
Beryllium	4.842	1.2E-05		
U-Total	12.849	3.2E-05		

Total Pathway: 4.1E-04

Total Rad + Chem 4.1E-04

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TABLE A.III-13 (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Conc'n (pCi/g)	Intake	SF(e)	Risk	Total
NP-237	3.0E-01	1.2E+01	4.3E-07	5.4E-06	5.7E-06
RA-226	4.6E+00	1.9E+02	1.2E-08	2.3E-06	4.9E-06
RA-228	3.2E+00	1.3E+02	2.9E-06	3.8E-04	3.8E-04
TH-228	3.8E+00	1.6E+02	5.6E-06	8.9E-04	8.9E-04
TH-232	2.6E+00	1.1E+02	2.6E-11	2.8E-09	8.2E-07
U-234	3.6E+00	1.5E+02	3.0E-11	4.5E-09	1.1E-06
U-235/236	1.7E-01	7.1E+00	2.4E-07	1.7E-06	1.8E-06
U-238	3.6E+00	1.5E+02	3.6E-08	5.5E-06	7.7E-06

Total Pathway: 1.3E-03

Chemical Risk

Dermal Contact/Soil

Compound	Intake	SF(derm)	Risk	Total
Arsenic	7.4E-06	1.8E+00	1.4E-05	4.3E-04
Beryllium	3.8E-06			2.1E-07
U-Total	1.0E-05			

Total Pathway: 1.4E-05

External Radiation/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk

Total Pathway: 0.0E+00

Total Rad + Chem 1.4E-05

Total Rad + Chem 1.3E-03 *Total:* 1.7E-03

TABLE A.III-13 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
NP-237	2.39E-05	2.8E+00		
RA-226	3.67E-04	4.3E+01		
RA-228	2.53E-04	2.9E+01		
TH-228	3.04E-04	3.5E+01		
TH-232	2.09E-04	2.4E+01		
U-234	2.87E-04	3.3E+01		
U-235/236	1.37E-05	1.6E+00		
U-238	2.91E-04	3.4E+01		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
NP-237	3.0E-01	1.3E+03		
RA-226	4.6E+00	2.0E+04		
RA-228	3.2E+00	1.4E+04		
TH-228	3.8E+00	1.7E+04		
TH-232	2.6E+00	1.2E+04		
U-234	3.6E+00	1.6E+04		
U-235/236	1.7E-01	7.6E+02		
U-238	3.6E+00	1.6E+04		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	7.50E-06	4.9E-07		
Beryllium	3.87E-07	2.5E-08		
U-Total	1.02E-06	6.6E-08		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	94.2	2.3E-04	3.0E-04	7.7E-01
Beryllium	4.8	1.2E-05	5.0E-03	2.4E-03
U-Total	12.8	3.2E-05	3.0E-03	1.1E-02

Total Pathway: 0.8

Total Rad + Chem 0.0E+00

Total Rad + Chem 0.8

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TABLE A.III-13 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil				External Radiation/Soil				Total
				Compound	Intake	RfD(e)	Hazard	
				NP-237	1.2E+01			
				RA-226	1.9E+02			
				RA-228	1.3E+02			
				TH-228	1.6E+02			
				TH-232	1.1E+02			
				U-234	1.5E+02			
				U-235/236	7.1E+00			
				U-238	1.5E+02			
Total Pathway:			0.0E+00	Total Pathway:			0.0E+00	

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	7.4E-06	2.9E-04	2.6E-02					0.8
Beryllium	3.8E-06	5.0E-05	7.6E-02					7.9E-02
U-Total	1.0E-05	1.5E-04	6.7E-02					7.8E-02
Total Pathway:			1.0E-01	Total Pathway:			0.0E+00	
Total Rad + Chem			1.0E-01	Total Rad + Chem			0.0E+00	*Total:* 0.9

TABLE A.III-14

FUTURE ON-PROPERTY (SOUTH FIELD) FARMER (RME VALUES) [50% vegetative cover; unlimited erosion]

ACTIVE FLYASH PILE: HOME GROWN PRODUCE (DUST AFFECTED)

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
NP-237	4.80E-03	7.2E+00	2.2E-10	1.6E-09	1.6E-09
RA-226	7.17E-02	1.1E+02	1.2E-10	1.3E-08	1.3E-08
RA-228	4.92E-02	7.4E+01	1.0E-10	7.4E-09	7.4E-09
TH-228	5.90E-02	8.8E+01	5.5E-11	4.8E-09	4.8E-09
TH-232	4.05E-02	6.1E+01	1.2E-11	7.3E-10	7.3E-10
U-234	5.59E-02	8.4E+01	1.6E-11	1.3E-09	1.3E-09
U-235/236	2.66E-03	4.0E+00	1.6E-11	6.2E-11	6.2E-11
U-238	5.66E-02	8.5E+01	2.8E-11	2.4E-09	2.4E-09
			Total Pathway:	3.1E-08	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	1.47E-03	1.2E-06	1.8E+00	2.2E-06	2.2E-06
Beryllium	7.52E-05	6.3E-08	4.3E+00	2.7E-07	2.7E-07
U-Total	1.99E-04	1.7E-07			
			Total Pathway:	2.4E-06	
			Total Rad + Chem	2.5E-06	*Total:* 2.5E-06

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TABLE A.III-14 (continued)

ACTIVE FLYASH PILE: HOME GROWN PRODUCE (DUST AFFECTED)

NONCARCINOGENIC HAZARD

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
NP-237	4.8E-03				
RA-226	7.2E-02				
RA-228	4.9E-02				
TH-228	5.9E-02				
TH-232	4.1E-02				
U-234	5.6E-02				
U-235/236	2.7E-03				
U-238	5.7E-02				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	1.5E-03	1.2E-06	3.0E-04	4.1E-03	4.1E-03
Beryllium	7.5E-05	6.3E-08	5.0E-03	1.3E-05	1.3E-05
U-Total	2.0E-04	1.7E-07	3.0E-03	5.5E-05	5.5E-05
			Total Pathway:	4.2E-03	
			Total Rad + Chem	4.2E-03	*Total:* 4.2E-03

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TABLE A.III-15

FUTURE ON-PROPERTY (SOUTH FIELD) FARMER (RME VALUES)

ACTIVE FLYASH PILE: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]

CARCINOGENIC RISK

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
NP-237	1.67E-05	3.1E-02	2.2E-10	6.8E-12	NP-237	1.52E-06	1.1E-02	2.2E-10	2.5E-12	9.2E-12
RA-226	1.16E-03	2.1E+00	1.2E-10	2.6E-10	RA-226	2.09E-03	1.5E+01	1.2E-10	1.8E-09	2.1E-09
RA-228	7.71E-04	1.4E+00	1.0E-10	1.4E-10	RA-228	1.39E-03	1.0E+01	1.0E-10	1.0E-09	1.2E-09
TH-228	2.09E-05	3.8E-02	5.5E-11	2.1E-12	TH-228	1.74E-05	1.3E-01	5.5E-11	7.0E-12	9.2E-12
TH-232	1.58E-05	2.9E-02	1.2E-11	3.5E-13	TH-232	1.32E-05	9.7E-02	1.2E-11	1.2E-12	1.5E-12
U-234	7.27E-04	1.3E+00	1.6E-11	2.1E-11	U-234	2.18E-03	1.6E+01	1.6E-11	2.6E-10	2.8E-10
U-235/236	3.46E-05	6.4E-02	1.6E-11	9.9E-13	U-235/236	1.04E-04	7.6E-01	1.6E-11	1.2E-11	1.3E-11
U-238	7.36E-04	1.4E+00	2.8E-11	3.8E-11	U-238	2.21E-03	1.6E+01	2.8E-11	4.5E-10	4.9E-10
			Total Pathway:	4.7E-10				Total Pathway:	3.6E-09	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	1.90E-04	1.9E-07	1.8E+00	3.4E-07	Arsenic	5.69E-06	2.3E-08	1.8E+00	4.1E-08	3.8E-07
Beryllium	4.88E-06	5.0E-09	4.3E+00	2.2E-08	Beryllium	4.39E-09	1.8E-11	4.3E+00	7.8E-11	2.2E-08
U-Total	2.59E-06	2.7E-09			U-Total	7.77E-06	3.2E-08			
			Total Pathway:	3.6E-07				Total Pathway:	4.1E-08	
			Total Rad + Chem	3.6E-07				Total Rad + Chem	4.5E-08	*Total:* 4.1E-07

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TABLE A.III-15 (continued)

ACTIVE FLYASH PILE: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]

NONCARCINOGENIC HAZARD

Radiation Hazard

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n in Milk (pCi/L)	Intake	RfD(o)	Risk	
NP-237	1.7E-05				NP-237	1.52E-06				
RA-226	1.2E-03				RA-226	2.09E-03				
RA-228	7.7E-04				RA-228	1.39E-03				
TH-228	2.1E-05				TH-228	1.74E-05				
TH-232	1.6E-05				TH-232	1.32E-05				
U-234	7.3E-04				U-234	2.18E-03				
U-235/236	3.5E-05				U-235/236	1.04E-04				
U-238	7.4E-04				U-238	2.21E-03				
			Total Pathway:	0.0E+00				Total Pathway:	0.0E+00	

Chemical Hazard

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n in Milk (mg/L)	Intake	RfD(o)	Risk	
Arsenic	1.9E-04	1.9E-07	3.0E-04	6.5E-04	Arsenic	5.69E-06	2.3E-08	3.0E-04	7.8E-05	7.3E-04
Beryllium	4.9E-06	5.0E-09	5.0E-03	1.0E-06	Beryllium	4.39E-09	1.8E-11	5.0E-03	3.6E-09	1.0E-06
U-Total	2.6E-06	2.7E-09	3.0E-03	8.9E-07	U-Total	7.77E-06	3.2E-08	3.0E-03	1.1E-05	1.2E-05
			Total Pathway:	6.5E-04				Total Pathway:	8.9E-05	
			Total Rad + Chem	6.5E-04				Total Rad + Chem	8.9E-05	*Total:* 7.4E-04

TABLE A.III-16
FUTURE, EXPANDED TRESPASSER
SOUTH FIELD: SURFACE SOIL [85% vegetative cover; limited erosion]
Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil					Ingestion/Soil				
Compound	onc'n in Air (pCi/m	Intake	SF(i)	Risk	Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	3.2E-06	1.0E-02	1.9E-11	2.0E-13	CS-137	0.519	1.3E+01	2.8E-11	3.6E-10
NP-237	1.5E-06	4.8E-03	2.9E-08	1.4E-10	NP-237	0.240	5.9E+00	2.2E-10	1.3E-09
RA-226	1.3E-04	4.4E-01	3.0E-09	1.3E-09	RA-226	21.600	5.3E+02	1.2E-10	6.4E-08
RA-228	1.2E-05	3.9E-02	6.9E-10	2.7E-11	RA-228	1.920	4.7E+01	1.0E-10	4.7E-09
TC-99	8.8E-04	2.9E+00	8.3E-12	2.4E-11	TC-99	142.000	3.5E+03	1.3E-12	4.5E-09
TH-228	2.7E-05	8.9E-02	7.8E-08	6.9E-09	TH-228	4.410	1.1E+02	5.5E-11	5.9E-09
TH-230	8.6E-05	2.8E-01	2.9E-08	8.1E-09	TH-230	13.800	3.4E+02	1.3E-11	4.4E-09
TH-232	2.5E-05	8.0E-02	2.8E-08	2.3E-09	TH-232	3.990	9.8E+01	1.2E-11	1.2E-09
U-234	5.4E-05	1.7E-01	2.6E-08	4.5E-09	U-234	8.658	2.1E+02	1.6E-11	3.4E-09
U-235/236	2.6E-06	8.5E-03	2.5E-08	2.1E-10	U-235/236	0.419	1.0E+01	1.6E-11	1.6E-10
U-238	5.8E-05	1.9E-01	5.2E-08	9.8E-09	U-238	9.311	2.3E+02	2.8E-11	6.4E-09
			Total Pathway:	3.3E-08				Total Pathway:	9.6E-08

Chemical Risk

Inhalation of Particulates/Soil					Ingestion/Soil				
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	4.5E-08	1.2E-10	1.5E+00	1.8E-10	Arsenic	7.268	1.4E-07	1.8E+00	2.5E-07
Beryllium	5.8E-09	1.5E-11	8.4E+00	1.3E-10	Beryllium	0.942	1.8E-08	4.3E+00	7.9E-08
Chromium	8.8E-08	2.3E-10	4.1E+01	9.3E-09	Chromium	14.176	2.8E-07		
U-TOTAL	1.9E-07	4.9E-10			U-TOTAL	30.562	6.0E-07		
Benzo(a)anthracene	1.6E-08	4.0E-11	8.9E-01	3.6E-11	Benzo(a)anthracene	2.500	4.9E-08	1.1E+00	5.4E-08
Benzo(a)pyrene	2.9E-08	7.5E-11	6.1E+00	4.6E-10	Benzo(a)pyrene	4.700	9.2E-08	7.3E+00	6.7E-07
Benzo(b)fluoranthene	2.4E-08	6.3E-11	7.5E-01	4.7E-11	Benzo(b)fluoranthene	3.900	7.6E-08	9.0E-01	6.8E-08
Benzo(k)fluoranthene	2.1E-08	5.3E-11	3.2E-01	1.7E-11	Benzo(k)fluoranthene	3.300	6.4E-08	3.8E-01	2.4E-08
Chrysene	2.0E-08	5.1E-11	2.7E-02	1.4E-12	Chrysene	3.200	6.2E-08	3.2E-02	2.0E-09
Dibenzo(a,h)anthracene	6.8E-09	1.8E-11	6.8E+00	1.2E-10	Dibenzo(a,h)anthracene	1.100	2.1E-08	8.1E+00	1.7E-07
Indeno(1,2,3-cd)pyrene	1.9E-08	4.8E-11	1.7E+00	8.2E-11	Indeno(1,2,3-cd)pyrene	3.000	5.8E-08	2.0E+00	1.2E-07
Aroclor-1254	5.5E-10	1.4E-12			Aroclor-1254	0.089	1.7E-09	7.7E+00	1.3E-08
Aroclor-1260	2.4E-10	6.1E-13			Aroclor-1260	0.038	7.4E-10	7.7E+00	5.7E-09
Dieldrin	6.0E-11	1.6E-13	1.6E+01	2.5E-12	Dieldrin	0.010	1.9E-10	1.6E+01	3.1E-09
			Total Pathway:	1.0E-08				Total Pathway:	1.5E-06
			Total Rad + Chem	4.4E-08				Total Rad + Chem	1.6E-06

TABLE A.III-16 (continued)
FUTURE, EXPANDED TRESPASSER
SOUTH FIELD: SURFACE SOIL [85% vegetative cover; limited erosion]
Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil					Total
	Compound	Conc'n (pCi/g)	Intake	SF(e)	Risk	
Not applicable	CS-137	0.52	2.3E-01	2.0E-06	4.6E-07	4.6E-07
	NP-237	0.24	1.1E-01	4.3E-07	4.6E-08	4.8E-08
	RA-226	21.60	9.7E+00	1.2E-08	1.2E-07	1.8E-07
	RA-228	1.92	8.6E-01	2.90E-06	2.5E-06	2.5E-06
	TC-99	142.00	6.4E+01	6.0E-13	3.8E-11	4.6E-09
	TH-228	4.41	2.0E+00	5.6E-06	1.1E-05	1.1E-05
	TH-230	13.80	6.2E+00	5.4E-11	3.3E-10	1.3E-08
	TH-232	3.99	1.8E+00	2.6E-11	4.6E-11	3.5E-09
	U-234	8.66	3.9E+00	3.0E-11	1.2E-10	8.1E-09
	U-235/236	0.42	1.9E-01	2.4E-07	4.5E-08	4.5E-08
	U-238	9.31	4.2E+00	3.6E-08	1.5E-07	1.7E-07
Total Pathway: 0.0E+00					Total Pathway: 1.4E-05	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil					
Compound	Intake	SF(derm)	Risk	Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk	
Arsenic	6.7E-08	1.8E+00	1.2E-07						3.7E-07
Beryllium	8.6E-08	4.30E+02	3.7E-05						3.7E-05
Chromium	1.3E-06								9.3E-09
U-TOTAL	2.8E-06								
Benzo(a)anthracene	0.0E+00	2.56E+00	0.0E+00						5.4E-08
Benzo(a)pyrene	0.0E+00	1.70E+01	0.0E+00						6.7E-07
Benzo(b)fluoranthene	0.0E+00	2.09E+00	0.0E+00						6.8E-08
Benzo(k)fluoranthene	0.0E+00	8.84E-01	0.0E+00						2.4E-08
Chrysene	0.0E+00	7.44E-02	0.0E+00						2.0E-09
Dibenzo(a,h)anthracene	0.0E+00	1.88E+01	0.0E+00						1.7E-07
Indeno(1,2,3-cd)pyrene	0.0E+00	4.65E+00	0.0E+00						1.2E-07
Aroclor-1254	2.4E-07	1.03E+01	2.5E-06						2.5E-06
Aroclor-1260	1.0E-07	1.03E+01	1.1E-06						1.1E-06
Dieldrin	2.7E-08	1.78E+01	4.9E-07						4.9E-07
Total Pathway:			4.1E-05	Total Pathway:				0.0E+00	
Total Rad + Chem			4.1E-05	Total Rad + Chem				1.4E-05	*Total:* 5.7E-05

TABLE A.III-16 (continued)
FUTURE, EXPANDED TRESPASSER
SOUTH FIELD: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	3.2E-06	1.0E-02		
NP-237	1.5E-06	4.8E-03		
RA-226	1.3E-04	4.4E-01		
RA-228	1.2E-05	3.9E-02		
TC-99	8.8E-04	2.9E+00		
TH-228	2.7E-05	8.9E-02		
TH-230	8.6E-05	2.8E-01		
TH-232	2.5E-05	8.0E-02		
U-234	5.4E-05	1.7E-01		
U-235/236	2.6E-06	8.5E-03		
U-238	5.8E-05	1.9E-01		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.52	1.3E+01		
NP-237	0.24	5.9E+00		
RA-226	21.60	5.3E+02		
RA-228	1.92	4.7E+01		
TC-99	142.00	3.5E+03		
TH-228	4.41	1.1E+02		
TH-230	13.80	3.4E+02		
TH-232	3.99	9.8E+01		
U-234	8.66	2.1E+02		
U-235/236	0.42	1.0E+01		
U-238	9.31	########		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	4.50E-08	5.8E-10		
Beryllium	5.84E-09	7.6E-11		
Chromium	8.79E-08	1.1E-09		
U-TOTAL	1.89E-07	2.4E-09		
Benzo(a)anthracene	1.55E-08	2.0E-10		
Benzo(a)pyrene	2.91E-08	3.8E-10		
Benzo(b)fluoranthene	2.42E-08	3.1E-10		
Benzo(k)fluoranthene	2.05E-08	2.7E-10		
Chrysene	1.98E-08	2.6E-10		
Dibenzo(a,h)anthracene	6.82E-09	8.8E-11		
Indeno(1,2,3-cd)pyrene	1.86E-08	2.4E-10		
Aroclor-1254	5.52E-10	7.1E-12		
Aroclor-1260	2.36E-10	3.1E-12		
Dieldrin	6.01E-11	7.8E-13		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	7.27	7.8E-07	3.0E-04	2.6E-03
Beryllium	0.94	1.0E-07	5.0E-03	2.0E-05
Chromium	14.18	1.5E-06	5.0E-03	3.0E-04
U-TOTAL	30.56	3.3E-06	3.0E-03	1.1E-03
Benzo(a)anthracene	2.50	2.7E-07		
Benzo(a)pyrene	4.70	5.0E-07		
Benzo(b)fluoranthene	3.90	4.2E-07		
Benzo(k)fluoranthene	3.30	3.5E-07		
Chrysene	3.20	3.4E-07		
Dibenzo(a,h)anthracene	1.10	1.2E-07		
Indeno(1,2,3-cd)pyrene	3.00	3.2E-07		
Aroclor-1254	0.09	9.5E-09		
Aroclor-1260	0.04	4.1E-09		
Dieldrin	0.01	1.1E-09	5.0E-05	2.1E-05

Total Pathway: 4.0E-03
Total Rad + Chem 4.0E-03

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TABLE A.III-16 (continued)
FUTURE, EXPANDED TRESPASSER
SOUTH FIELD: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	2.3E-01			
	NP-237	1.1E-01			
	RA-226	9.7E+00			
	RA-228	8.6E-01			
	TC-99	6.4E+01			
	TH-228	2.0E+00			
	TH-230	6.2E+00			
	TH-232	1.8E+00			
	U-234	3.9E+00			
	U-235/236	1.9E-01			
	U-238	4.2E+00			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	2.8E-07	2.9E-04	9.8E-04					3.6E-03
Beryllium	3.6E-07	5.0E-05	7.2E-03					7.3E-03
Chromium	5.4E-06	2.3E-03	2.4E-03					2.7E-03
U-TOTAL	1.2E-05	1.5E-04	7.8E-02					7.9E-02
Benzo(a)anthracene	0.0E+00							
Benzo(a)pyrene	0.0E+00							
Benzo(b)fluoranthene	0.0E+00							
Benzo(k)fluoranthene	0.0E+00							
Chrysene	0.0E+00							
Dibenzo(a,h)anthracene	0.0E+00							
Indeno(1,2,3-cd)pyrene	0.0E+00							
Aroclor-1254	1.0E-06							
Aroclor-1260	4.4E-07							
Dieldrin	1.2E-07	4.5E-05	2.6E-03					2.6E-03
Total Pathway:			9.2E-02	Total Pathway:			0.0E+00	
Total Rad + Chem			9.2E-02	Total Rad + Chem			0.0E+00	*Total:* 9.6E-02

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TABLE A.III-17
FUTURE, OFF-PROPERTY RESIDENT FARMER
SOUTH FIELD: SURFACE SOIL [85% vegetative cover; limited erosion]

Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	Total
CS-137	3.88E-07	4.5E-02	1.9E-11	8.5E-13	8.5E-13
NP-237	1.80E-07	2.1E-02	2.9E-08	6.1E-10	6.1E-10
RA-226	1.62E-05	1.9E+00	3.0E-09	5.6E-09	5.6E-09
RA-228	1.44E-06	1.7E-01	6.6E-10	1.1E-10	1.1E-10
TC-99	1.06E-04	1.2E+01	8.3E-12	1.0E-10	1.0E-10
TH-228	3.30E-06	3.8E-01	7.8E-08	3.0E-08	3.0E-08
TH-230	1.03E-05	1.2E+00	2.9E-08	3.5E-08	3.5E-08
TH-232	2.98E-06	3.5E-01	2.8E-08	9.7E-09	9.7E-09
U-234	6.47E-06	7.5E-01	2.6E-08	1.9E-08	1.9E-08
U-235/236	3.13E-07	3.6E-02	2.5E-08	9.1E-10	9.1E-10
U-238	6.96E-06	8.1E-01	5.2E-08	4.2E-08	4.2E-08
			Total Pathway:	1.4E-07	

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	Total
Arsenic	5.43E-09	3.5E-10	1.5E+00	5.3E-10	5.3E-10
Beryllium	7.05E-10	4.6E-11	8.4E+00	3.8E-10	3.8E-10
Chromium	1.06E-08	6.9E-10	4.1E+01	2.8E-08	2.8E-08
U-TOTAL	2.29E-08	1.5E-09			
Benzo(a)anthracene	1.87E-09	1.2E-10	8.9E-01	1.1E-10	1.1E-10
Benzo(a)pyrene	3.51E-09	2.3E-10	6.1E+00	1.4E-09	1.4E-09
Benzo(b)fluoranthene	2.92E-09	1.9E-10	7.5E-01	1.4E-10	1.4E-10
Benzo(k)fluoranthene	2.47E-09	1.6E-10	3.2E-01	5.1E-11	5.1E-11
Chrysene	2.39E-09	1.5E-10	2.7E-02	4.2E-12	4.2E-12
Dibenzo(a,h)anthracene	8.23E-10	5.3E-11	6.8E+00	3.6E-10	3.6E-10
Indeno(1,2,3-cd)pyrene	2.24E-09	1.5E-10	1.7E+00	2.5E-10	2.5E-10
Aroclor-1254	6.65E-11	4.3E-12			
Aroclor-1260	2.84E-11	1.8E-12			
Dieldrin	7.25E-12	4.7E-13	1.6E+01	7.5E-12	7.5E-12
			Total Pathway:	3.1E-08	
			Total Rad + Chem	1.7E-07	*Total:* 1.7E-07

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TABLE A.III-17 (continued)
FUTURE, OFF-PROPERTY RESIDENT FARMER
SOUTH FIELD: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	Hazard	
CS-137	3.88E-07				
NP-237	1.80E-07				
RA-226	1.62E-05				
RA-228	1.44E-06				
TC-99	1.06E-04				
TH-228	3.30E-06				
TH-230	1.03E-05				
TH-232	2.98E-06				
U-234	6.47E-06				
U-235/236	3.13E-07				
U-238	6.96E-06				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard	
Arsenic	5.43E-09	3.5E-10			
Beryllium	7.05E-10	4.6E-11			
Chromium	1.06E-08	6.9E-10	5.5E-07	1.3E-03	1.3E-03
U-TOTAL	2.29E-08	1.5E-09			
Benzo(a)anthracene	1.87E-09	1.2E-10			
Benzo(a)pyrene	3.51E-09	2.3E-10			
Benzo(b)fluoranthene	2.92E-09	1.9E-10			
Benzo(k)fluoranthene	2.47E-09	1.6E-10			
Chrysene	2.39E-09	1.5E-10			
Dibenzo(a,h)anthracene	8.23E-10	5.3E-11			
Indeno(1,2,3-cd)pyrene	2.24E-09	1.5E-10			
Aroclor-1254	6.65E-11	4.3E-12			
Aroclor-1260	2.84E-11	1.8E-12			
Dieldrin	7.25E-12	4.7E-13			
			Total Pathway:	1.3E-03	1.3E-03
			Total Rad + Chem	1.3E-03	*Total:* 1.3E-03

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TABLE A.III-18
FUTURE, ON-PROPERTY RESIDENT FARMER (RME VALUES)
SOUTH FIELD: SURFACE SOIL [50% vegetative cover; unlimited erosion]

Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	4.1E-05	4.8E+00	1.9E-11	9.0E-11
NP-237	1.9E-05	2.2E+00	2.9E-08	6.4E-08
RA-226	1.7E-03	2.0E+02	3.0E-09	5.9E-07
RA-228	1.5E-04	1.8E+01	6.9E-10	1.2E-08
TC-99	1.1E-02	1.3E+03	8.3E-12	1.1E-08
TH-228	3.5E-04	4.0E+01	7.8E-08	3.1E-06
TH-230	1.1E-03	1.3E+02	2.9E-08	3.7E-06
TH-232	3.1E-04	3.6E+01	2.8E-08	1.0E-06
U-234	6.8E-04	7.9E+01	2.6E-08	2.1E-06
U-235/236	3.3E-05	3.8E+00	2.5E-08	9.6E-08
U-238	7.3E-04	8.5E+01	5.2E-08	4.4E-06
			Total Pathway:	1.5E-05

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	0.52	2.3E+03	2.8E-11	6.4E-08
NP-237	0.24	1.1E+03	2.2E-10	2.3E-07
RA-226	21.60	9.5E+04	1.2E-10	1.1E-05
RA-228	1.92	8.5E+03	1.0E-10	8.5E-07
TC-99	142.00	6.3E+05	1.3E-12	8.1E-07
TH-228	4.41	1.9E+04	5.5E-11	1.1E-06
TH-230	13.80	6.1E+04	1.3E-11	7.9E-07
TH-232	3.99	1.8E+04	1.2E-11	2.1E-07
U-234	8.66	3.8E+04	1.6E-11	6.1E-07
U-235/236	0.42	1.8E+03	1.6E-11	3.0E-08
U-238	9.31	4.1E+04	2.8E-11	1.1E-06
			Total Pathway:	1.7E-05

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	5.7E-07	3.7E-08	1.5E+00	5.6E-08
Beryllium	7.4E-08	4.8E-09	8.4E+00	4.0E-08
Chromium	1.1E-06	7.2E-08	4.1E+01	3.0E-06
U-TOTAL	0.0E+00	0.0E+00		
Benzo(a)anthracene	0.0E+00	0.0E+00	8.9E-01	0.0E+00
Benzo(a)pyrene	2.0E-07	1.3E-08	6.1E+00	7.8E-08
Benzo(b)fluoranthene	3.7E-07	2.4E-08	7.5E-01	1.8E-08
Benzo(k)fluoranthene	0.0E+00	0.0E+00	3.2E-01	0.0E+00
Chrysene	0.0E+00	0.0E+00	2.7E-02	0.0E+00
Dibenzo(a,h)anthracene	2.5E-07	1.6E-08	6.8E+00	1.1E-07
Indeno(1,2,3-cd)pyrene	0.0E+00	0.0E+00	1.7E+00	0.0E+00
Aroclor-1254	0.0E+00	0.0E+00		
Aroclor-1260	7.0E-09	4.6E-10		
Dieldrin	9.0E-08	1.0E-10	1.6E+01	3.1E-09
Endrin ketone	7.7E-10	3.0E-11		
			Total Pathway:	3.3E-06
			Total Rad + Chem	1.8E-05

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	7.268	1.8E-05	1.8E+00	3.1E-05
Beryllium	0.942	2.3E-06	4.3E+00	1.0E-05
Chromium	14.176	3.5E-05		
U-TOTAL	30.562	7.5E-05		
Benzo(a)anthracene	2.500	6.2E-06	1.1E+00	6.8E-06
Benzo(a)pyrene	4.700	1.2E-05	7.3E+00	8.5E-05
Benzo(b)fluoranthene	3.900	9.6E-06	9.0E-01	8.7E-06
Benzo(k)fluoranthene	3.300	8.1E-06	3.8E-01	3.1E-06
Chrysene	3.200	7.9E-06	3.2E-02	2.5E-07
Dibenzo(a,h)anthracene	1.100	2.7E-06	8.1E+00	2.2E-05
Indeno(1,2,3-cd)pyrene	3.000	7.4E-06	2.0E+00	1.5E-05
Aroclor-1254	0.089	2.2E-07	7.7E+00	1.7E-06
Aroclor-1260	0.038	9.4E-08	7.7E+00	7.2E-07
Dieldrin	0.040	2.5E-08	1.6E+01	3.9E-07
Endrin ketone	0.000	0.0E+00		
			Total Pathway:	1.8E-04
			Total Rad + Chem	2.0E-04

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TABLE A.III-18 (continued)
FUTURE, ON-PROPERTY RESIDENT FARMER (RME VALUES)
SOUTH FIELD: SURFACE SOIL [50% vegetative cover; unlimited erosion]
Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	2.2E+01	2.0E-06	4.3E-05	4.3E-05
	NP-237	1.0E+01	4.3E-07	4.3E-06	4.6E-06
	RA-226	9.0E+02	1.2E-08	1.1E-05	2.3E-05
	RA-228	8.0E+01	2.90E-06	2.3E-04	2.3E-04
	TC-99	5.9E+03	6.0E-13	3.5E-09	8.3E-07
	TH-228	1.8E+02	5.6E-06	1.0E-03	1.0E-03
	TH-230	5.7E+02	5.4E-11	3.1E-08	4.5E-06
	TH-232	1.7E+02	2.6E-11	4.3E-09	1.2E-06
	U-234	3.6E+02	3.0E-11	1.1E-08	2.7E-06
	U-235/236	1.7E+01	2.4E-07	4.2E-06	4.3E-06
	U-238	3.9E+02	3.6E-08	1.4E-05	1.9E-05
Total Pathway: 0.0E+00			Total Pathway:	1.3E-03	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	5.7E-07	1.8E+00	1.1E-06					3.2E-05
Beryllium	7.4E-07	4.30E+02	3.2E-04					3.3E-04
Chromium	1.1E-05			Not applicable				3.0E-06
U-TOTAL	2.4E-05							
Benzo(a)anthracene	0.0E+00	2.56E+00	0.0E+00					6.8E-06
Benzo(a)pyrene	0.0E+00	1.70E+01	0.0E+00					8.5E-05
Benzo(b)fluoranthene	0.0E+00	2.09E+00	0.0E+00					8.7E-06
Benzo(k)fluoranthene	0.0E+00	8.84E-01	0.0E+00					3.1E-06
Chrysene	0.0E+00	3.56E-02	0.0E+00					2.5E-07
Dibenzo(a,h)anthracene	0.0E+00	9.00E+00	0.0E+00					2.2E-05
Indeno(1,2,3-cd)pyrene	0.0E+00	2.22E+00	0.0E+00					1.5E-05
Aroclor-1254	2.1E-06	1.03E+01	2.2E-05					2.3E-05
Aroclor-1260	9.0E-07	1.03E+01	9.2E-06					9.9E-06
Dieldrin	2.4E-07	1.78E+01	4.2E-06					4.6E-06
Endrin ketone	0.0E+00							
Total Pathway:			3.6E-04	Total Pathway:			0.0E+00	1.9E-03
Total Rad + Chem			3.6E-04				1.3E-03	*Total:* 1.9E-03

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TABLE A.III-18 (continued)
FUTURE, ON-PROPERTY RESIDENT FARMER (RME VALUES)
SOUTH FIELD: SURFACE SOIL [50% vegetative cover; unlimited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil					Ingestion/Soil				
Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard	Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	4.1E-05	4.8E+00			CS-137	0.52	2.3E+03		
NP-237	1.9E-05	2.2E+00			NP-237	0.24	1.1E+03		
RA-226	1.7E-03	2.0E+02			RA-226	21.60	9.5E+04		
RA-228	1.5E-04	1.8E+01			RA-228	1.92	8.5E+03		
TC-99	1.1E-02	1.3E+03			TC-99	142.00	6.3E+05		
TH-228	3.5E-04	4.0E+01			TH-228	4.41	1.9E+04		
TH-230	1.1E-03	1.3E+02			TH-230	13.80	6.1E+04		
TH-232	3.1E-04	3.6E+01			TH-232	3.99	1.8E+04		
U-234	6.8E-04	7.9E+01			U-234	8.66	3.8E+04		
U-235/236	3.3E-05	3.8E+00			U-235/236	0.42	1.8E+03		
U-238	7.3E-04	8.5E+01			U-238	9.31	4.1E+04		
		Total Pathway:		0.0E+00			Total Pathway:		0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil					Ingestion/Soil				
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard	Compound	Conc'n (mg/kg	Intake	RfD(o)	Hazard
Arsenic	5.73E-07	3.7E-08			Arsenic	7.27	1.8E-05	3.0E-04	6.0E-02
Beryllium	7.43E-08	4.8E-09			Beryllium	0.94	2.3E-06	5.0E-03	4.6E-04
Chromium	1.12E-06	7.2E-08			Chromium	14.18	3.5E-05	5.0E-03	7.0E-03
U-TOTAL	0.00E+00	0.0E+00			U-TOTAL	30.56	7.5E-05	3.0E-03	0.0
Benzo(a)anthracene	0.00E+00	0.0E+00			Benzo(a)anthracene	2.50	6.2E-06		
Benzo(a)pyrene	1.97E-07	1.3E-08			Benzo(a)pyrene	4.70	1.2E-05		
Benzo(b)fluoranthene	3.70E-07	2.4E-08			Benzo(b)fluoranthene	3.90	9.6E-06		
Benzo(k)fluoranthene	0.00E+00	0.0E+00			Benzo(k)fluoranthene	3.30	8.1E-06		
Chrysene	0.00E+00	0.0E+00			Chrysene	3.20	7.9E-06		
Dibenzo(a,h)anthracene	2.52E-07	1.6E-08			Dibenzo(a,h)anthracene	1.10	2.7E-06		
Indeno(1,2,3-cd)pyrene	0.00E+00	0.0E+00			Indeno(1,2,3-cd)pyrene	3.00	7.4E-06		
Aroclor-1254	0.00E+00	0.0E+00			Aroclor-1254	0.09	2.2E-07		
Aroclor-1260	7.03E-09	4.6E-10			Aroclor-1260	0.04	9.4E-08		
Dieldrin	9.00E-00	1.0E-10			Dieldrin	0.01	2.5E-08	5.0E-05	4.0E-04
Endrin ketone	7.07E-10	5.0E-12			Endrin ketone	0.00	0.0E+00	3.0E-04	0.0E+00
		Total Pathway:		0.0E+00			Total Pathway:		9.3E-02
		Total Rad + Chem		0.0E+00			Total Rad + Chem		9.3E-02

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TABLE A.III-18 (continued)
FUTURE, ON-PROPERTY RESIDENT FARMER (RME VALUES)
SOUTH FIELD: SURFACE SOIL [50% vegetative cover; unlimited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	2.2E+01			
	NP-237	1.0E+01			
	RA-226	9.0E+02			
	RA-228	8.0E+01			
	TC-99	5.9E+03			
	TH-228	1.8E+02			
	TH-230	5.7E+02			
	TH-232	1.7E+02			
	U-234	3.6E+02			
	U-235/236	1.7E+01			
	U-238	3.9E+02			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				Total
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	5.7E-07	2.9E-04	2.0E-03					6.2E-02
Beryllium	7.4E-07	5.0E-05	1.5E-02					1.5E-02
Chromium.	1.1E-05	2.3E-03	5.0E-03	Not applicable				1.2E-02
U-TOTAL	2.4E-05	1.5E-04	0.2					1.9E-01
Benzo(a)anthracene	0.0E+00							
Benzo(a)pyrene	0.0E+00							
Benzo(b)fluoranthene	0.0E+00							
Benzo(k)fluoranthene	0.0E+00							
Chrysene	0.0E+00							
Dibenzo(a,h)anthracene	0.0E+00							
Indeno(1,2,3-cd)pyrene	0.0E+00							
Aroclor-1254	2.1E-06							
Aroclor-1260	9.0E-07							
Dieldrin	2.0E-07	4.5E-05	5.0E-03					5.0E-03
Endrinketone	0.0E+00	2.7E-04	0.0E+00					0.0E+00
Total Pathway: 1.9E-01				Total Pathway: 0.0E+00				
Total Rad + Chem 1.9E-01							0.0E+00	*Total:* 2.80E-01

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TABLE A.III-19
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: HOME GROWN PRODUCE (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
CS-137	8.50E-03	1.3E+01	2.8E-11	3.6E-10	3.6E-10
NP-237	3.96E-03	5.9E+00	2.2E-10	1.3E-09	1.3E-09
RA-226	3.47E-01	5.2E+02	1.2E-10	6.2E-08	6.2E-08
RA-228	3.08E-02	4.6E+01	1.0E-10	4.6E-09	4.6E-09
TC-99	3.87E+00	5.8E+03	1.3E-12	7.5E-09	7.5E-09
TH-228	7.04E-02	1.1E+02	5.5E-11	5.8E-09	5.8E-09
TH-230	2.20E-01	3.3E+02	1.3E-11	4.3E-09	4.3E-09
TH-232	6.37E-02	9.5E+01	1.2E-11	1.1E-09	1.1E-09
U-234	1.39E-01	2.1E+02	1.6E-11	3.3E-09	3.3E-09
U-235	6.70E-03	1.0E+01	1.6E-11	1.6E-10	1.6E-10
U-238	1.49E-01	2.2E+02	2.8E-11	6.2E-09	6.2E-09
			Total Pathway:	9.7E-08	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	1.17E-04	9.8E-08	1.8E+00	1.7E-07	1.7E-07
Beryllium	1.51E-05	1.3E-08	4.3E+00	5.4E-08	5.4E-08
Chromium	2.26E-04	1.9E-07			
U-TOTAL	4.89E-04	4.1E-07			
Benzo(a)anthracene	3.90E-05	3.3E-08	1.1E+00	3.6E-08	3.6E-08
Benzo(a)pyrene	7.27E-05	6.1E-08	7.3E+00	4.4E-07	4.4E-07
Benzo(b)fluoranthene	6.06E-05	5.1E-08	9.0E+01	4.6E-08	4.6E-08
Benzo(k)fluoranthene	5.23E-05	4.4E-08	3.8E-01	1.7E-08	1.7E-08
Chrysene	5.03E-05	4.2E-08	3.2E-02	1.3E-09	1.3E-09
Dibenzo(a,h)anthracene	1.73E-05	1.4E-08	8.1E+00	1.2E-07	1.2E-07
Indeno(1,2,3-cd)pyrene	4.68E-05	3.9E-08	2.0E+00	7.8E-08	7.8E-08
Aroclor 1254	1.42E-06	1.2E-09	7.7E+00	9.2E-09	9.2E-09
Aroclor 1260	6.10E-07	5.1E-10	7.7E+00	3.9E-09	3.9E-09
Dieldrin	1.59E-07	1.3E-10	1.6E+01	2.1E-09	2.1E-09
			Total Pathway:	9.8E-07	
			Total Rad + Chem	1.1E-06	*Total:* 1.1E-06

TABLE A.III-19 (continued)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: HOME GROWN PRODUCE (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Noncarcinogenic Hazard

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	8.5E-03				
NP-237	4.0E-03				
RA-226	3.5E-01				
RA-228	3.1E-02				
TC-99	3.9E+00				
TH-228	7.0E-02				
TH-230	2.2E-01				
TH-232	6.4E-02				
U-234	1.4E-01				
U-235	6.7E-03				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	1.2E-04	9.8E-08	3.0E-04	3.3E-04	3.3E-04
Beryllium	1.5E-05	1.3E-08	5.0E-03	2.5E-06	2.5E-06
Chromium	2.3E-04	1.9E-07	5.0E-03	3.8E-05	3.8E-05
U-TOTAL	4.9E-04	4.1E-07	3.0E-03	1.4E-04	1.4E-04
Benzo(a)anthracene	3.9E-05	3.3E-08			
Benzo(a)pyrene	7.3E-05	6.1E-08			
Benzo(b)fluoranthene	6.1E-05	5.1E-08			
Benzo(k)fluoranthene	5.2E-05	4.4E-08			
Chrysene	5.0E-05	4.2E-08			
Dibenzo(a,h)anthracene	1.7E-05	1.4E-08			
Indeno(1,2,3-cd)pyrene	4.7E-05	3.9E-08			
Aroclor 1254	1.4E-06	1.2E-09			
Aroclor 1260	6.1E-07	5.1E-10			
Dieldrin	1.6E-07	1.3E-10	5.0E-05	2.7E-06	2.7E-06
			Total Pathway:	5.1E-04	
			Total Rad + Chem	5.1E-04	*Total:* 5.1E-04

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TABLE A.III-20
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Carcinogenic Risk

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
CS-137	1.09E-02	2.0E+01	2.8E-11	5.6E-10	CS-137	3.81E-03	2.8E+01	2.8E-11	7.8E-10	1.3E-09
NP-237	1.38E-05	2.5E-02	2.2E-10	5.6E-12	NP-237	1.26E-06	9.2E-03	2.2E-10	2.0E-12	7.6E-12
RA-226	5.62E-03	1.0E+01	1.2E-10	1.2E-09	RA-226	1.01E-02	7.4E+01	1.2E-10	8.9E-09	1.0E-08
RA-228	4.82E-04	8.9E-01	1.0E-10	8.9E-11	RA-228	8.68E-04	6.4E+00	1.0E-10	6.4E-10	7.3E-10
TC-99	1.50E+00	2.8E+03	1.3E-12	3.6E-09	TC-99	1.77E+00	1.3E+04	1.3E-12	1.7E-08	2.0E-08
TH-228	2.50E-05	4.6E-02	5.5E-11	2.5E-12	TH-228	2.08E-05	1.5E-01	5.5E-11	8.4E-12	1.1E-11
TH-230	8.59E-05	1.6E-01	1.3E-11	2.1E-12	TH-230	7.16E-05	5.3E-01	1.3E-11	6.8E-12	8.9E-12
TH-232	2.49E-05	4.6E-02	1.2E-11	5.5E-13	TH-232	2.07E-05	1.5E-01	1.2E-11	1.8E-12	2.4E-12
U-234	1.81E-03	3.3E+00	1.6E-11	5.3E-11	U-234	5.42E-03	4.0E+01	1.6E-11	6.4E-10	6.9E-10
U-235	8.72E-05	1.6E-01	1.6E-11	2.6E-12	U-235	2.62E-04	1.9E+00	1.6E-11	3.1E-11	3.3E-11
U-238	1.94E-03	3.6E+00	2.8E-11	1.0E-10	U-238	5.82E-03	4.3E+01	2.8E-11	1.2E-09	1.3E-09
			Total Pathway:	5.6E-09				Total Pathway:	2.9E-08	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	1.51E-05	1.6E-08	1.8E+00	2.7E-08	Arsenic	4.53E-07	1.9E-09	1.8E+00	3.3E-09	3.0E-08
Beryllium	9.83E-07	1.0E-09	4.3E+00	4.3E-09	Beryllium	8.85E-10	3.6E-12	4.3E+00	1.6E-11	4.4E-09
Chromium	8.10E-05	8.3E-08			Chromium	2.21E-05	9.1E-08			
U-TOTAL	6.36E-06	6.5E-09			U-TOTAL	1.91E-05	7.8E-08			
Benzo(a)anthracene	1.55E-05	1.6E-08	1.1E+00	1.7E-08	Benzo(a)anthracene	4.89E-06	2.0E-08	1.1E+00	2.2E-08	4.0E-08
Benzo(a)pyrene	6.92E-05	7.1E-08	7.3E+00	5.2E-07	Benzo(a)pyrene	2.19E-05	9.0E-08	7.3E+00	6.6E-07	1.2E-06
Benzo(b)fluoranthene	2.24E-04	2.3E-07	9.0E-01	2.1E-07	Benzo(b)fluoranthene	7.08E-05	2.9E-07	9.0E-01	2.6E-07	4.7E-07
Benzo(k)fluoranthene	3.85E-04	4.0E-07	3.8E-01	1.5E-07	Benzo(k)fluoranthene	1.22E-04	5.0E-07	3.8E-01	1.9E-07	3.4E-07
Chrysene	1.99E-05	2.0E-08	3.2E-02	6.6E-10	Chrysene	6.30E-06	2.6E-08	3.2E-02	8.3E-10	1.5E-09
Dibenzo(a,h)anthracene	1.60E-05	1.6E-08	8.1E+00	1.3E-07	Dibenzo(a,h)anthracene	5.05E-06	2.1E-08	8.1E+00	1.7E-07	3.0E-07
Indeno(1,2,3-cd)pyrene	2.12E-03	2.2E-06	2.0E+00	4.3E-06	Indeno(1,2,3-cd)pyrene	6.69E-04	2.8E-06	2.0E+00	5.5E-06	9.8E-06
Aroclor 1254	2.50E-06	2.6E-09	7.7E+00	2.0E-08	Aroclor 1254	7.90E-07	3.2E-09	7.7E+00	2.5E-08	4.5E-08
Aroclor 1260	1.29E-06	1.3E-09	7.7E+00	1.0E-08	Aroclor 1260	4.07E-07	1.7E-09	7.7E+00	1.3E-08	2.3E-08
Dieldrin	0.00E+00	0.0E+00	1.6E+01	0.0E+00	Dieldrin	0.00E+00	0.0E+00	1.6E+01	0.0E+00	0.0E+00
			Total Pathway:	5.4E-06				Total Pathway:	6.8E-06	
			Total Rad + Chem	5.4E-06				Total Rad + Chem	6.9E-06	*Total:* 1.2E-05

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TABLE A.III-20 (continued)
FUTURE ON-PROPERTY FARMER (RME VALUES)
SOUTH FIELD: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Noncarcinogenic Hazard

Radiation Hazard

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n-Milk (pCi/L)	Intake	RfD(o)	Hazard	
CS-137	1.1E-02	2.0E+01			CS-137	3.81E-03				
NP-237	1.4E-05	2.5E-02			NP-237	1.26E-06				
RA-226	5.6E-03	1.0E+01			RA-226	1.01E-02				
RA-228	4.8E-04	8.9E-01			RA-228	8.68E-04				
TC-99	1.5E+00	2.8E+03			TC-99	1.77E+00				
TH-228	2.5E-05	4.6E-02			TH-228	2.08E-05				
TH-230	8.6E-05	1.6E-01			TH-230	7.16E-05				
TH-232	2.5E-05	4.6E-02			TH-232	2.07E-05				
U-234	1.8E-03	3.3E+00			U-234	5.42E-03				
U-235	8.7E-05	1.6E-01			U-235	2.62E-04				
U-238	1.9E-03	3.6E+00								
			Total Pathway:	0.0E+00						

Chemical Hazard

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n-Milk (mg/L)	Intake	RfD(o)	Hazard	
Arsenic	1.5E-05	1.6E-08	3.0E-04	5.2E-05	Arsenic	4.5E-07	1.9E-09	3.0E-04	6.2E-06	5.8E-05
Beryllium	9.8E-07	1.0E-09	5.0E-03	2.0E-07	Beryllium	8.8E-10	3.6E-12	5.0E-03	7.3E-10	2.0E-07
Chromium	8.1E-05	8.3E-08	5.0E-03	1.7E-05	Chromium	2.2E-05	9.1E-08	5.0E-03	1.8E-05	3.5E-05
U-TOTAL	6.4E-06	6.5E-09	3.0E-03	2.2E-06	U-TOTAL	1.9E-05	7.8E-08	3.0E-03	2.6E-05	2.8E-05
Benzo(a)anthracene	1.5E-05	1.6E-08			Benzo(a)anthracene	4.9E-06	2.0E-08			
Benzo(a)pyrene	6.9E-05	7.1E-08			Benzo(a)pyrene	2.2E-05	9.0E-08			
Benzo(b)fluoranthene	2.2E-04	2.3E-07			Benzo(b)fluoranthene	7.1E-05	2.9E-07			
Benzo(k)fluoranthene	3.8E-04	4.0E-07			Benzo(k)fluoranthene	1.2E-04	5.0E-07			
Chrysene	2.0E-05	2.0E-08			Chrysene	6.3E-06	2.6E-08			
Dibenzo(a,h)anthracene	1.6E-05	1.6E-08			Dibenzo(a,h)anthracene	5.0E-06	2.1E-08			
Indeno(1,2,3-cd)pyrene	2.1E-03	2.2E-06			Indeno(1,2,3-cd)pyrene	6.7E-04	2.8E-06			
Aroclor 1254	2.5E-06	2.6E-09			Aroclor 1254	7.9E-07	3.2E-09			
Aroclor 1260	1.3E-06	1.3E-09			Aroclor 1260	4.1E-07	1.7E-09			
Dieldrin	0.0E+00	0.0E+00	5.0E-05	0.0E+00	Dieldrin	0.0E+00	0.0E+00	5.0E-05	0.0E+00	0.0E+00
			Total Pathway:	7.1E-05				Total Pathway:	5.1E-05	
			Total Rad + Chem	7.1E-05				Total Rad + Chem	5.1E-05	*Total:* 1.2E-04

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TABLE A.III-21
FUTURE, EXPANDED TRESPASSER
INACTIVE FLYASH PILE: SURFACE SOIL [85% vegetative cover; limited erosion]
CARCINOGENIC RISK

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	1.26E-06	4.1E-03	1.9E-11	7.8E-14
NP-237	2.70E-07	8.8E-04	2.9E-08	2.5E-11
RA-226	3.90E-06	1.3E-02	3.0E-09	3.8E-11
RA-228	4.42E-06	1.4E-02	6.9E-10	9.9E-12
TH-228	5.35E-06	1.7E-02	7.8E-08	1.4E-09
TH-230	5.47E-06	1.8E-02	2.9E-08	5.2E-10
TH-232	4.60E-06	1.5E-02	2.8E-08	4.2E-10
U-234	1.86E-05	6.1E-02	2.6E-08	1.6E-09
U-235/236	9.06E-07	2.9E-03	2.5E-08	7.4E-11
U-238	1.91E-05	6.2E-02	5.2E-08	3.2E-09
			Total Pathway:	7.2E-09

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	0.64	1.6E+01	2.8E-11	4.4E-10
NP-237	0.14	3.4E+00	2.2E-10	7.4E-10
RA-226	1.98	4.8E+01	1.2E-10	5.8E-09
RA-228	2.24	5.5E+01	1.0E-10	5.5E-09
TH-228	2.7	6.6E+01	5.5E-11	3.7E-09
TH-230	2.77	6.8E+01	1.3E-11	8.8E-10
TH-232	2.33	5.7E+01	1.2E-11	6.9E-10
U-234	9.43	2.3E+02	1.6E-11	3.7E-09
U-235/236	0.46	1.1E+01	1.6E-11	1.8E-10
U-238	9.68	2.4E+02	2.8E-11	6.6E-09
			Total Pathway:	2.8E-08

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	SF(i)	Risk
Arsenic	6.55E-08	1.7E-10	1.5E+01	2.6E-09
Beryllium	4.14E-09	1.1E-11	8.4E+00	9.0E-11
U-TOTAL	5.62E-08	1.5E-10		
Dibenzo(a,h)anthracene	4.34E-09	1.1E-11	6.8E+00	7.6E-11
			Total Pathway:	2.7E-09
			Total Rad + Chem	1.0E-08

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	33.20	6.5E-07	1.8E+00	1.1E-06
Beryllium	2.10	4.1E-08	4.3E+00	1.8E-07
U-TOTAL	28.50	5.6E-07		
Dibenzo(a,h)anthracene	2.20	4.3E-08	8.1E+00	3.5E-07
			Total Pathway:	1.7E-06
			Total Rad + Chem	1.7E-06

TABLE A.III-21 (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil					Total
	Compound	c'n (p	Intake	SF(e)	Risk	
Not applicable	CS-137	0.64	2.9E-01	2.0E-06	5.7E-07	5.7E-07
	NP-237	0.14	6.1E-02	4.3E-07	2.6E-08	2.7E-08
	RA-226	1.98	8.8E-01	1.2E-08	1.1E-08	1.6E-08
	RA-228	2.24	1.0E+00	2.9E-06	2.9E-06	2.9E-06
	TH-228	2.71	1.2E+00	5.6E-06	6.8E-06	6.8E-06
	TH-230	2.77	1.2E+00	5.4E-11	6.7E-11	1.5E-09
	TH-232	2.33	1.0E+00	2.6E-11	2.7E-11	1.1E-09
	U-234	9.43	4.2E+00	3.0E-11	1.3E-10	5.4E-09
	U-235/236	0.46	2.1E-01	2.4E-07	4.9E-08	5.0E-08
	U-238	9.68	4.3E+00	3.6E-08	1.6E-07	1.7E-07
Total Pathway: 0.0E+00					Total Pathway: 1.1E-05	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil					
Compound	Intake	SF(derm)	Risk	Compound	'n (m	Intake	SF(o)	Risk	
Arsenic	3.0E-07	1.8E+00	5.6E-07						1.7E-06
Beryllium	1.9E-07	4.3E+02	8.3E-05						8.3E-05
U-TOTAL	2.6E-06								
Dibenzo(a,h)anthracene	0.0E+00	1.9E+01	0.0E+00						3.5E-07
Total Pathway: 8.3E-05				Total Pathway: 0.0E+00					

Total Rad + Chem 8.3E-05 1.1E-05 *Total:* 9.5E-05

TABLE A.III-21 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3	Intake	RfD(i)	Hazard
CS-137	1.26E-06	4.1E-03		
NP-237	2.70E-07	8.8E-04		
RA-226	3.90E-06	1.3E-02		
RA-228	4.42E-06	1.4E-02		
TH-228	5.35E-06	1.7E-02		
TH-230	5.47E-06	1.8E-02		
TH-232	4.60E-06	1.5E-02		
U-234	1.86E-05	6.1E-02		
U-235/236	9.06E-07	2.9E-03		
U-238	1.91E-05	6.2E-02		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.64	1.6E+01		
NP-237	0.14	3.4E+00		
RA-226	1.98	4.8E+01		
RA-228	2.24	5.5E+01		
TH-228	2.71	6.6E+01		
TH-230	2.77	6.8E+01		
TH-232	2.33	5.7E+01		
U-234	9.43	2.3E+02		
U-235/236	0.46	1.1E+01		
U-238	9.68	2.4E+02		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(i)	Hazard
Arsenic	6.55E-08	8.5E-10		
Beryllium	4.14E-09	5.4E-11		
U-TOTAL	5.62E-08	7.3E-10		
Dibenzo(a,h)anthracene	4.34E-09	5.6E-11		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	33.20	3.6E-06	3.0E-04	1.2E-02
Beryllium	2.10	2.3E-07	5.0E-03	4.5E-05
U-TOTAL	28.50	3.1E-06	3.0E-03	1.0E-03
Dibenzo(a,h)anthracene	2.20	2.4E-07		

Total Pathway: 1.3E-02

Total Rad + Chem 0.0E+00

Total Rad + Chem. 1.3E-02

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TABLE A.III-21 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	2.9E-01			
	NP-237	6.1E-02			
	RA-226	8.8E-01			
	RA-228	1.0E+00			
	TH-228	1.2E+00			
	TH-230	1.2E+00			
	TH-232	1.0E+00			
	U-234	4.2E+00			
	U-235/236	2.1E-01			
	U-238	4.3E+00			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	1.3E-06	2.9E-04	4.5E-03					1.6E-02
Beryllium	8.1E-07	5.0E-05	1.6E-02					1.6E-02
U-TOTAL	1.1E-05	1.5E-04	7.3E-02					7.4E-02
Dibenzo(a,h)anthracene	0.0E+00							
		Total Pathway:	9.4E-02			Total Pathway:	0.0E+00	
								1.1E-01
		Total Rad + Chem	9.4E-02				0.0E+00	otal: 1.1E-01

TABLE A.III-22

INACTIVE FLYASH PILE: SURFACE SOIL

FUTURE OFF-PROPERTY FARMER [85% vegetative cover; limited erosion]

Carcinogenic Risk

Radiation Risk					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
CS-137	2.08E-07	2.4E-02	1.9E-11	4.6E-13	4.6E-13
NP-237	4.44E-08	5.1E-03	2.9E-08	1.5E-10	1.5E-10
RA-226	6.40E-07	7.4E-02	3.0E-09	2.2E-10	2.2E-10
RA-228	7.27E-07	8.4E-02	6.9E-10	5.8E-11	5.8E-11
TH-228	8.78E-07	1.0E-01	7.8E-08	7.9E-09	7.9E-09
TH-230	8.98E-07	1.0E-01	2.9E-08	3.0E-09	3.0E-09
TH-232	7.55E-07	8.8E-02	2.8E-08	2.5E-09	2.5E-09
U-234	3.06E-06	3.5E-01	2.6E-08	9.2E-09	9.2E-09
U-235/236	1.49E-07	1.7E-02	2.5E-08	4.3E-10	4.3E-10
U-238	3.14E-06	3.6E-01	5.2E-08	1.9E-08	1.9E-08
			Total Pathway:	4.2E-08	

Chemical Risk					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	1.08E-08	7.0E-10	1.5E+01	1.1E-08	1.1E-08
Beryllium	6.81E-10	4.4E-11	8.4E+00	3.7E-10	3.7E-10
U-TOTAL	9.24E-09	6.0E-10			
Dibenzo(a,h)anthracene	7.13E-10	4.6E-11	6.8E+00	3.1E-10	3.1E-10
			Total Pathway:	1.1E-08	

Total Rad + Chem	5.4E-08	*Total:*	5.4E-08

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TABLE A.III-22 (continued)

INACTIVE FLYASH PILE: SURFACE SOIL

FUTURE OFF-PROPERTY FARMER [85% vegetative cover; limited erosion]

Non-carcinogenic Hazard

Radiation Hazard				
Inhalation of Particulates/Soil				
Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	2.08E-07			
NP-237	4.44E-08			
RA-226	6.40E-07			
RA-228	7.27E-07			
TH-228	8.78E-07			
TH-230	8.98E-07			
TH-232	7.55E-07			
U-234	3.06E-06			
U-235/236	1.49E-07			
U-238	3.14E-06			
			Total Pathway:	0.0E+00

Chemical Hazard				
Inhalation of Particulates/Soil				
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	1.08E-08	7.0E-10		
Beryllium	6.81E-10	4.4E-11		
U-TOTAL	9.24E-09	6.0E-10		
Dibenzo(a,h)anthracene	7.13E-10	4.6E-11		
			Total Pathway:	0.0E+00

			Total
			0.0E+00
Total Rad + Chem	0.0E+00	*Total:*	0.0E+00

TABLE A.III-23

FUTURE, ON-PROPERTY (SOUTH FIELD) RESIDENT FARMER (RME VALUES)

INACTIVE FLYASH PILE: SURFACE SOIL [50% vegetative cover; unlimited erosion]

CARCINOGENIC RISK

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	3.3E-05	3.8E+00	1.9E-11	7.2E-11
NP-237	6.9E-06	8.0E-01	2.9E-08	2.3E-08
RA-226	1.0E-04	1.2E+01	3.0E-09	3.5E-08
RA-228	1.1E-04	1.3E+01	6.6E-10	8.7E-09
TH-228	1.4E-04	1.6E+01	7.8E-08	1.2E-06
TH-230	1.4E-04	1.6E+01	2.9E-08	4.7E-07
TH-232	1.2E-04	1.4E+01	2.8E-08	3.8E-07
U-234	4.8E-04	5.5E+01	2.6E-08	1.4E-06
U-235/236	2.3E-05	2.7E+00	2.5E-08	6.8E-08
U-238	4.9E-04	5.7E+01	5.2E-08	3.0E-06
			Total Pathway:	6.6E-06

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	0.64	2.8E+03	2.8E-11	7.9E-08
NP-237	0.14	6.0E+02	2.2E-10	1.3E-07
RA-226	1.98	8.7E+03	1.2E-10	1.0E-06
RA-228	2.24	9.9E+03	1.0E-10	9.9E-07
TH-228	2.7	1.2E+04	5.5E-11	6.6E-07
TH-230	2.77	1.2E+04	1.3E-11	1.6E-07
TH-232	2.33	1.0E+04	1.2E-11	1.2E-07
U-234	9.43	4.2E+04	1.6E-11	6.7E-07
U-235/236	0.46	2.0E+03	1.6E-11	3.2E-08
U-238	9.68	4.3E+04	2.8E-11	1.2E-06
			Total Pathway:	5.1E-06

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	SF(i)	Risk
Arsenic	1.7E-06	1.1E-07	1.5E+01	1.6E-06
Beryllium	1.1E-07	6.9E-09	8.4E+00	5.8E-08
U-TOTAL	1.4E-06	9.4E-08		
Dibenzo(a,h)anthracene	1.1E-07	7.2E-09	6.8E+00	4.9E-08
			Total Pathway:	1.8E-06

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	33.20	8.2E-05	1.8E+00	1.4E-04
Beryllium	2.10	5.2E-06	4.3E+00	2.2E-05
U-TOTAL	28.50	7.0E-05		
Dibenzo(a,h)anthracene	2.20	5.4E-06	8.1E+00	4.4E-05
			Total Pathway:	2.1E-04

Total Rad + Chem 8.4E-06

Total Rad + Chem 2.1E-04

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TABLE A.III-23 (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil					Total
	Compound	Conc'n (pCi/g)	Intake	SF(e)	Risk	
Not applicable	CS-137	0.64	2.7E+01	2.0E-06	5.3E-05	5.3E-05
	NP-237	0.14	5.7E+00	4.3E-07	2.4E-06	2.6E-06
	RA-226	1.98	8.2E+01	1.2E-08	9.8E-07	2.1E-06
	RA-228	2.24	9.3E+01	2.9E-06	2.7E-04	2.7E-04
	TH-228	2.71	1.1E+02	5.6E-06	6.3E-04	6.3E-04
	TH-230	2.77	1.2E+02	5.4E-11	6.2E-09	6.4E-07
	TH-232	2.33	9.7E+01	2.6E-11	2.5E-09	5.1E-07
	U-234	9.43	3.9E+02	3.0E-11	1.2E-08	2.1E-06
	U-235/236	0.46	1.9E+01	2.4E-07	4.6E-06	4.7E-06
	U-238	9.68	4.0E+02	3.6E-08	1.4E-05	1.9E-05
Total Pathway:	0.0E+00		Total Pathway:		9.8E-04	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil					
Compound	Intake	SF(derm)	Risk	Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk	
Arsenic	2.6E-06	1.8E+00	4.8E-06						1.5E-04
Beryllium	1.7E-06	4.3E+02	7.1E-04						7.3E-04
U-TOTAL	2.2E-05								
Dibenzo(a,h)anthracene	0.0E+00	1.9E+01	0.0E+00						4.4E-05
Total Pathway:	7.2E-04			Total Pathway:				0.0E+00	

Total Rad + Chem 7.2E-04 9.8E-04 *Total:* 1.9E-03

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TABLE A.III-23 (continued)
FUTURE, ON-PROPERTY (SOUTH FIELD) RESIDENT FARMER (RME VALUES)
INACTIVE FLYASH PILE: SURFACE SOIL [50% vegetative cover; unlimited erosion]

Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	3.3E-05	3.8E+00		
NP-237	6.9E-06	8.0E-01		
RA-226	1.0E-04	1.2E+01		
RA-228	1.1E-04	1.3E+01		
TH-228	1.4E-04	1.6E+01		
TH-230	1.4E-04	1.6E+01		
TH-232	1.2E-04	1.4E+01		
U-234	4.8E-04	5.5E+01		
U-235/236	2.3E-05	2.7E+00		
U-238	4.9E-04	5.7E+01		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.64	2.8E+03		
NP-237	0.14	6.0E+02		
RA-226	1.98	8.7E+03		
RA-228	2.24	9.9E+03		
TH-228	2.71	1.2E+04		
TH-230	2.77	1.2E+04		
TH-232	2.33	1.0E+04		
U-234	9.43	4.2E+04		
U-235/236	0.46	2.0E+03		
U-238	9.68	4.3E+04		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(i)	Hazard
Arsenic	1.68E-06	1.1E-07		
Beryllium	1.06E-07	6.9E-09		
U-TOTAL	1.44E-06	9.4E-08		
Dibenzo(a,h)anthracene	1.12E-07	7.2E-09		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	33.20	8.2E-05	3.0E-04	2.7E-01
Beryllium	2.10	5.2E-06	5.0E-03	1.0E-03
U-TOTAL	28.50	7.0E-05	3.0E-03	2.3E-02
Dibenzo(a,h)anthracene	2.20	5.4E-06		

Total Pathway: 3.0E-01

Total Rad + Chem 0.0E+00

Total Rad + Chem 3.0E-01

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TABLE A.III-23 (continued)

CARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil

Not applicable

Total Pathway: 0.0E+00

External Radiation/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(e)	Hazard
CS-137	0.64	2.7E+01		
NP-237	0.14	5.7E+00		
RA-226	1.98	8.2E+01		
RA-228	2.24	9.3E+01		
TH-228	2.71	1.1E+02		
TH-230	2.77	1.2E+02		
TH-232	2.33	9.7E+01		
U-234	9.43	3.9E+02		
U-235/236	0.46	1.9E+01		
U-238	9.68	4.0E+02		

Total Pathway: 0.0E+00

Chemical Hazard

Dermal Contact/Soil

Compound	Intake	RfD(derm)	Hazard	Total
Arsenic	2.6E-06	2.9E-04	9.2E-03	0.3
Beryllium	1.7E-06	5.0E-05	3.3E-02	3.4E-02
U-TOTAL	2.2E-05	1.5E-04	1.5E-01	0.2
Dibenzo(a,h)anthracene	0.0E+00			

Total Pathway: 1.9E-01

External Radiation/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard

Total Pathway: 0.0E+00

Total Rad + Chem 1.9E-01 0.0E+00 *Total:* 0.5

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TABLE A.III-24

FUTURE ON-PROPERTY (SOUTH FIELD) FARMER (RME VALUES) [50% vegetative cover; unlimited erosion]

INACTIVE FLYASH PILE: HOMEGROWN PRODUCE (DUST AFFECTED)

CARCINOGENIC RISK

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
CS-137	6.43E-03	9.6E+00	2.8E-11	2.7E-10	2.7E-10
NP-237	1.38E-03	2.1E+00	2.2E-10	4.5E-10	4.5E-10
RA-226	1.94E-02	2.9E+01	1.2E-10	3.5E-09	3.5E-09
RA-228	2.20E-02	3.3E+01	1.0E-10	3.3E-09	3.3E-09
TH-228	2.65E-02	4.0E+01	5.5E-11	2.2E-09	2.2E-09
TH-230	2.71E-02	4.1E+01	1.3E-11	5.3E-10	5.3E-10
TH-232	2.28E-02	3.4E+01	1.2E-11	4.1E-10	4.1E-10
U-234	9.25E-02	1.4E+02	1.6E-11	2.2E-09	2.2E-09
U-235/236	4.51E-03	6.7E+00	1.6E-11	1.1E-10	1.1E-10
U-238	9.49E-02	1.4E+02	2.8E-11	4.0E-09	4.0E-09
			Total Pathway:	1.7E-08	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	3.29E-01	2.7E-04	1.8E+00	4.8E-04	4.8E-04
Beryllium	2.06E-02	1.7E-05	4.3E+00	7.4E-05	7.4E-05
U-TOTAL	2.80E-01	2.3E-04			
Dibenzo(a,h)anthracene	2.12E-02	1.8E-05	8.1E+00	1.4E-04	1.4E-04
			Total Pathway:	7.0E-04	

Total Rad + Chem	7.0E-04	*Total:*	7.0E-04

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TABLE A.III-24 (continued)

INACTIVE FLYASH PILE: HOMEGROWN PRODUCE (DUST AFFECTED)

NONCARCINOGENIC HAZARD

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	6.4E-03				
NP-237	1.4E-03				
RA-226	1.9E-02				
RA-228	2.2E-02				
TH-228	2.7E-02				
TH-230	2.7E-02				
TH-232	2.3E-02				
U-234	9.3E-02				
U-235/236	4.5E-03				
U-238	9.5E-02				
			Total Pathway:	0.0E+00	

Chemical Hazard					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	3.3E-01	2.7E-04	3.0E-04	9.2E-01	9.2E-01
Beryllium	2.1E-02	1.7E-05	5.0E-03	3.4E-03	3.4E-03
U-TOTAL	2.8E-01	2.3E-04	3.0E-03	7.8E-02	7.8E-02
Dibenzo(a,h)anthracene	2.1E-02	1.8E-05			
			Total Pathway:	1.0E+00	

Total Rad + Chem 1.0E+00 *Total:* 1.0E+00

TABLE A.III-25

FUTURE ON-PROPERTY (SOUTH FIELD) FARMER (RME VALUES) [50% vegetative cover; unlimited erosion]

INACTIVE FLYASH PILE: BEEF AND MILK (DUST AFFECTED)

CARCINOGENIC RISK

Radiation Risk

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L)	Intake	SF(o)	Risk	
CS-137	8.24E-03	1.5E+01	2.8E-11	4.2E-10	CS-137	2.88E-03	2.1E+01	2.8E-11	5.9E-10	1.0E-09
NP-237	4.82E-06	8.9E-03	2.2E-10	1.9E-12	NP-237	4.38E-07	3.2E-03	2.2E-10	7.1E-13	2.7E-12
RA-226	3.14E-04	5.8E-01	1.2E-10	6.9E-11	RA-226	5.65E-04	4.2E+00	1.2E-10	5.0E-10	5.7E-10
RA-228	3.45E-04	6.3E-01	1.0E-10	6.3E-11	RA-228	6.20E-04	4.6E+00	1.0E-10	4.6E-10	5.2E-10
TH-228	9.40E-06	1.7E-02	5.5E-11	9.5E-13	TH-228	7.84E-06	5.8E-02	5.5E-11	3.2E-12	4.1E-12
TH-230	1.06E-05	1.9E-02	1.3E-11	2.5E-13	TH-230	8.82E-06	6.5E-02	1.3E-11	8.4E-13	1.1E-12
TH-232	8.90E-06	1.6E-02	1.2E-11	2.0E-13	TH-232	7.42E-06	5.5E-02	1.2E-11	6.5E-13	8.5E-13
U-234	1.20E-03	2.2E+00	1.6E-11	3.5E-11	U-234	3.61E-03	2.7E+01	1.6E-11	4.2E-10	4.6E-10
U-235/236	5.86E-05	1.1E-01	1.6E-11	1.7E-12	U-235/236	1.76E-04	1.3E+00	1.6E-11	2.1E-11	2.2E-11
U-238	1.23E-03	2.3E+00	2.8E-11	6.4E-11	U-238	3.70E-03	2.7E+01	2.8E-11	7.6E-10	8.3E-10
			Total Pathway:	6.6E-10				Total Pathway:	2.8E-09	

Chemical Risk

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	4.24E-02	4.4E-05	1.8E+00	7.6E-05	Arsenic	1.27E-03	5.2E-06	1.8E+00	9.1E-06	8.5E-05
Beryllium	1.34E-03	1.4E-06	4.3E+00	5.9E-06	Beryllium	1.20E-06	4.9E-09	4.3E+00	2.1E-08	5.9E-06
U-TOTAL	3.64E-03	3.7E-06			U-TOTAL	1.09E-02	4.5E-05			
Dibenzo(a,h)anthracene	1.96E-02	2.0E-05	8.1E+00	1.6E-04	Dibenzo(a,h)anthracene	6.19E-03	2.5E-05	8.1E+00	2.1E-04	3.7E-04
			Total Pathway:	2.4E-04				Total Pathway:	2.2E-04	
			Total Rad + Chem	2.4E-04				Total Rad + Chem	2.2E-04	*Total:* 4.6E-04

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TABLE A.III-25 (continued)

INACTIVE FLYASH PILE: BEEF AND MILK (DUST AFFECTED)

NONCARCINOGENIC HAZARD

Radiation Hazard

Ingestion/Beef					Ingestion/Milk					Total
Compound	Conc'n in Beef (pCi/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n in Milk (pCi/L)	Intake	RfD(o)	Risk	
CS-137	8.2E-03				CS-137	2.88E-03				
NP-237	4.8E-06				NP-237	4.38E-07				
RA-226	3.1E-04				RA-226	5.65E-04				
RA-228	3.4E-04				RA-228	6.20E-04				
TH-228	9.4E-06				TH-228	7.84E-06				
TH-230	1.1E-05				TH-230	8.82E-06				
TH-232	8.9E-06				TH-232	7.42E-06				
U-234	1.2E-03				U-234	3.61E-03				
U-235/236	5.9E-05				U-235/236	1.76E-04				
U-238	1.2E-03				U-238	3.70E-03				
			Total Pathway:	0.0E+00				Total Pathway:	0.0E+00	

Chemical Hazard

Ingestion/Beef					Ingestion/Milk					
Compound	Conc'n in Beef (mg/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n in Milk (mg/L)	Intake	RfD(o)	Risk	
Arsenic	4.2E-02	4.4E-05	3.0E-04	1.5E-01	Arsenic	1.27E-03	5.2E-06	3.0E-04	1.7E-02	0.2
Beryllium	1.3E-03	1.4E-06	5.0E-03	2.7E-04	Beryllium	1.20E-06	4.9E-09	5.0E-03	9.9E-07	2.8E-04
U-TOTAL	3.6E-03	3.7E-06	3.0E-03	1.2E-03	U-TOTAL	1.09E-02	4.5E-05	3.0E-03	1.5E-02	1.6E-02
Dibenzo(a,h)anthracene	2.0E-02	2.0E-05			Dibenzo(a,h)anthracene	6.19E-03	2.5E-05			
			Total Pathway:	0.1				Total Pathway:	3.2E-02	
			Total Rad + Chem	0.1				Total Rad + Chem	3.2E-02	*Total:* 0.2

TABLE A.III-26
FUTURE, EXPANDED TRESPASSER
SOLID WASTE LANDFILL: SURFACE SOIL [85% vegetative cover; limited erosion]
Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	6.17E-07	2.0E-03	1.9E-11	3.8E-14
NP-237	8.17E-06	2.7E-02	2.9E-08	7.7E-10
PU-238	1.85E-06	6.0E-03	3.9E-08	2.3E-10
RA-226	5.42E-06	1.8E-02	3.0E-09	5.3E-11
RA-228	4.03E-06	1.3E-02	6.6E-10	8.7E-12
TH-228	3.89E-06	1.3E-02	7.8E-08	9.9E-10
TH-230	1.54E-05	5.0E-02	2.9E-08	1.5E-09
TH-232	3.62E-06	1.2E-02	2.8E-08	3.3E-10
U-234	1.01E-04	3.3E-01	2.6E-08	8.5E-09
U-235/236	6.81E-06	2.2E-02	2.5E-08	5.5E-10
U-238	1.85E-04	6.0E-01	5.2E-08	3.1E-08
			Total Pathway:	4.4E-08

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	0.26	6.3E+00	2.8E-11	1.8E-10
NP-237	3.41	8.3E+01	2.2E-10	1.8E-08
PU-238	0.77	1.9E+01	2.2E-10	4.2E-09
RA-226	2.26	5.5E+01	1.2E-10	6.6E-09
RA-228	1.68	4.1E+01	1.0E-10	4.1E-09
TH-228	1.62	4.0E+01	5.5E-11	2.2E-09
TH-230	6.42	1.6E+02	1.3E-11	2.0E-09
TH-232	1.51	3.7E+01	1.2E-11	4.4E-10
U-234	42.12	1.0E+03	1.6E-11	1.7E-08
U-235/236	2.84	7.0E+01	1.6E-11	1.1E-09
U-238	77.1500	1.9E+03	2.8E-11	5.3E-08
			Total Pathway:	1.1E-07

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	1.6E-08	4.2E-11	1.5E+01	6.4E-10
Beryllium	1.7E-09	4.3E-12	8.4E+00	3.6E-11
Chromium	3.7E-08	9.6E-11	4.1E+01	3.9E-09
U-TOTAL	5.4E-07	1.4E-09		
4,4'-DDE	2.9E-11	7.5E-14		
Benzo(a)pyrene	1.8E-09	4.7E-12	6.1E+00	2.9E-11
Benzo(b)fluoranthene	1.7E-09	4.4E-12	7.5E-01	3.3E-12
Carbazole	1.9E-10	4.8E-13		
Dibenzo(a,h)anthracene	4.8E-10	1.2E-12	6.8E+00	8.4E-12
Indeno(1,2,3-cd)pyrene	1.2E-09	3.0E-12	1.7E+00	5.1E-12
			Total Pathway:	4.7E-09
			Total Rad + Chem	4.9E-08

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	6.786	1.3E-07	1.8E+00	2.3E-07
Beryllium	0.698	1.4E-08	4.3E+00	5.9E-08
Chromium	15.5	3.0E-07		
U-TOTAL	225	4.4E-06		
4,4'-DDE	0.012	2.3E-10	3.4E-01	8.0E-11
Benzo(a)pyrene	0.760	1.5E-08	7.3E+00	1.1E-07
Benzo(b)fluoranthene	0.710	1.4E-08	9.0E-01	1.2E-08
Carbazole	0.077	1.5E-09	2.0E-02	3.0E-11
Dibenzo(a,h)anthracene	0.200	3.9E-09	8.1E+00	3.2E-08
Indeno(1,2,3-cd)pyrene	0.480	9.4E-09	2.0E+00	1.9E-08
			Total Pathway:	4.6E-07
			Total Rad + Chem	5.7E-07

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TABLE A.III-26 (continued)
FUTURE, EXPANDED TRESPASSER
SOLID WASTE LANDFILL: SURFACE SOIL [85% vegetative cover; limited erosion]
Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil					Total
	Compound	c'n (p	Intake	SF(e)	Risk	
Not applicable	CS-137	0.26	1.2E-01	2.00E-06	2.3E-07	2.3E-07
	NP-237	3.41	1.5E+00	4.30E-07	6.6E-07	6.7E-07
	PU-238	0.77	3.5E-01	2.80E-11	9.7E-12	4.4E-09
	RA-226	2.26	1.0E+00	1.20E-08	1.2E-08	1.9E-08
	RA-228	1.68	7.5E-01	2.90E-06	2.2E-06	2.2E-06
	TH-228	1.62	7.3E-01	5.60E-06	4.1E-06	4.1E-06
	TH-230	6.42	2.9E+00	5.40E-11	1.6E-10	3.7E-09
	TH-232	1.51	6.7E-01	2.60E-11	1.8E-11	7.9E-10
	U-234	42.12	1.9E+01	3.00E-11	5.7E-10	2.6E-08
	U-235/236	2.84	1.3E+00	2.40E-07	3.0E-07	3.1E-07
	U-238	77.15	3.5E+01	3.60E-08	1.2E-06	1.3E-06
Total Pathway: 0.0E+00					Total Pathway: 8.7E-06	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil					
Compound	Intake	SF(derm)	Risk	Compound	c'n (mg	Intake	SF(o)	Risk	
Arsenic	6.2E-08	1.8E+00	1.1E-07						3.5E-07
Beryllium	6.4E-08	4.3E+02	2.7E-05						2.8E-05
Chromium	1.4E-06			Not applicable					3.9E-09
U-TOTAL	2.1E-05								
4,4'-DDE	3.3E-08	3.8E-01	1.2E-08						1.3E-08
Benzo(a)pyrene	0.0E+00	1.7E+01	0.0E+00						1.1E-07
Benzo(b)fluoranthene	0.0E+00	2.1E+00	0.0E+00						1.2E-08
Carbazole	0.0E+00								
Dibenzo(a,h)anthracene	0.0E+00	1.9E+01	0.0E+00						3.2E-08
Indeno(1,2,3-cd)pyrene	0.0E+00	4.7E+00	0.0E+00						1.9E-08
		Total Pathway:	2.8E-05				Total Pathway:	0.0E+00	3.7E-05
		Total Rad + Chem	2.8E-05					8.7E-06	*Total:* 3.7E-05

TABLE A.III-26 (continued)
FUTURE, EXPANDED TRESPASSER
SOLID WASTE LANDFILL: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	6.2E-07	2.0E-03		
NP-237	8.2E-06	2.7E-02		
PU-238	1.9E-06	6.0E-03		
RA-226	5.4E-06	1.8E-02		
RA-228	4.0E-06	1.3E-02		
TH-228	3.9E-06	1.3E-02		
TH-230	1.5E-05	5.0E-02		
TH-232	3.6E-06	1.2E-02		
U-234	1.0E-04	3.3E-01		
U-235/236	6.8E-06	2.2E-02		
U-238	1.9E-04	6.0E-01		
		Total Pathway:		0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.26	6.3E+00		
NP-237	3.41	8.3E+01		
PU-238	0.77	1.9E+01		
RA-226	2.26	5.5E+01		
RA-228	1.68	4.1E+01		
TH-228	1.62	4.0E+01		
TH-230	6.42	1.6E+02		
TH-232	1.51	3.7E+01		
U-234	42.12	1.0E+03		
U-235/236	2.84	7.0E+01		
U-238	77.15	1.9E+03		
		Total Pathway:		0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	1.6E-08	2.1E-10		
Beryllium	1.7E-09	2.2E-11		
Chromium	3.7E-08	4.8E-10		
U-TOTAL	5.4E-07	7.0E-09		
4,4'-DDE	2.9E-11	3.7E-13		
Benzo(a)pyrene	1.8E-09	2.4E-11		
Benzo(b)fluoranthene	1.7E-09	2.2E-11		
Carbazole	1.9E-10	2.4E-12		
Dibenzo(a,h)anthracene	4.8E-10	6.2E-12		
Indeno(1,2,3-cd)pyrene	1.2E-09	1.5E-11		
		Total Pathway:		0.0E+00
		Total Rad + Chem		0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	6.79	7.3E-07	3.0E-04	2.4E-03
Beryllium	0.70	7.5E-08	5.0E-03	1.5E-05
Chromium	15.46	1.7E-06	5.0E-03	3.3E-04
U-TOTAL	225.22	2.4E-05	3.0E-03	8.0E-03
4,4'-DDE	0.01	1.3E-09		
Benzo(a)pyrene	0.76	8.1E-08		
Benzo(b)fluoranthene	0.71	7.6E-08		
Carbazole	0.08	8.3E-09		
Dibenzo(a,h)anthracene	0.20	2.1E-08		
Indeno(1,2,3-cd)pyrene	0.48	5.1E-08		
		Total Pathway:		1.1E-02
		Total Rad + Chem		1.1E-02

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TABLE A.III-26 (continued)
FUTURE, EXPANDED TRESPASSER
SOLID WASTE LANDFILL: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	1.2E-01			
	NP-237	1.5E+00			
	PU-238	3.5E-01			
	RA-226	1.0E+00			
	RA-228	7.5E-01			
	TH-228	7.3E-01			
	TH-230	2.9E+00			
	TH-232	6.7E-01			
	U-234	1.9E+01			
	U-235/236	1.3E+00			
	U-238	3.5E+01			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	2.6E-07	2.9E-04	9.2E-04					3.3E-03
Beryllium	2.7E-07	5.0E-05	5.4E-03					5.4E-03
Chromium	5.9E-06	2.3E-03	2.6E-03	Not applicable				3.0E-03
U-TOTAL	8.7E-05	1.5E-04	0.6					0.6
4,4'-DDE	1.4E-07							
Benzo(a)pyrene	0.0E+00							
Benzo(b)fluoranthene	0.0E+00							
Carbazole	0.0E+00							
Dibenzo(a,h)anthracene	0.0E+00							
Indeno(1,2,3-cd)pyrene	0.0E+00							
Total Pathway:			0.6	Total Pathway:			0.0E+00	
Total Rad + Chem			0.6				0.0E+00	*Total:* 0.6

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TABLE A.III-27
FUTURE, OFF-PROPERTY FARMER
SOLID WASTE LANDFILL: SURFACE SOIL [85% vegetative cover; limited erosion]
Carcinogenic Risk

Radiation Risk					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
CS-137	1.68E-08	1.9E-03	1.9E-11	3.7E-14	3.7E-14
NP-237	2.22E-07	2.6E-02	2.9E-08	7.5E-10	7.5E-10
PU-238	5.04E-08	5.8E-03	3.9E-08	2.3E-10	2.3E-10
RA-226	1.48E-07	1.7E-02	3.0E-09	5.1E-11	5.1E-11
RA-228	1.10E-07	1.3E-02	6.9E-10	8.8E-12	8.8E-12
TH-228	1.06E-07	1.2E-02	7.8E-08	9.6E-10	9.6E-10
TH-230	4.19E-07	4.9E-02	2.9E-08	1.4E-09	1.4E-09
TH-232	9.83E-08	1.1E-02	2.8E-08	3.2E-10	3.2E-10
U-234	2.75E-06	3.2E-01	2.6E-08	8.3E-09	8.3E-09
U-235/236	1.85E-07	2.1E-02	2.5E-08	5.4E-10	5.4E-10
U-238	5.04E-06	5.8E-01	5.2E-08	3.0E-08	3.0E-08
			Total Pathway:	4.3E-08	

Chemical Risk					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	4.43E-10	2.9E-11	1.5E+01	4.3E-10	4.3E-10
Beryllium	4.56E-11	3.0E-12	8.4E+00	2.5E-11	2.5E-11
Chromium	1.01E-09	6.5E-11	4.1E+01	2.7E-09	2.7E-09
U-TOTAL	1.47E-08	9.5E-10			
4,4'-DDE	7.83E-13	5.1E-14			
Benzo(a)pyrene	4.96E-11	3.2E-12	6.1E+00	2.0E-11	2.0E-11
Benzo(b)fluoranthene	4.63E-11	3.0E-12	7.5E-01	2.3E-12	2.3E-12
Carbazole	5.03E-12	3.3E-13			
Dibenzo(a,h)anthracene	1.31E-11	8.5E-13	6.8E+00	5.8E-12	5.8E-12
Indeno(1,2,3-cd)pyrene	3.13E-11	2.0E-12	1.7E+00	3.4E-12	3.4E-12
			Total Pathway:	3.2E-09	4.6E-08
			Total Rad + Chem	4.6E-08	*Total:* 4.6E-08

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TABLE A.III-27 (continued)
FUTURE, OFF-PROPERTY FARMER
SOLID WASTE LANDFILL: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard					Total
Inhalation of Particulates/Soil					
Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard	
CS-137	1.68E-08	1.9E-03			
NP-237	2.22E-07	2.6E-02			
PU-238	5.04E-08	5.8E-03			
RA-226	1.48E-07	1.7E-02			
RA-228	1.10E-07	1.3E-02			
TH-228	1.06E-07	1.2E-02			
TH-230	4.19E-07	4.9E-02			
TH-232	9.83E-08	1.1E-02			
U-234	2.75E-06	3.2E-01			
U-235/236	1.85E-07	2.1E-02			
U-238	5.04E-06	5.8E-01			
				Total Pathway:	0.0E+00

Chemical Hazard					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard	
Arsenic	4.43E-10	2.9E-11			
Beryllium	4.56E-11	3.0E-12			
Chromium	1.01E-09	6.5E-11			
U-TOTAL	1.47E-08	9.5E-10			
4,4'-DDE	7.83E-13	5.1E-14			
Benzo(a)pyrene	4.96E-11	3.2E-12			
Benzo(b)fluoranthene	4.63E-11	3.0E-12			
Carbazole	5.03E-12	3.3E-13			
Dibenzo(a,h)anthracene	1.31E-11	8.5E-13			
Indeno(1,2,3-cd)pyrene	3.13E-11	2.0E-12			
				Total Pathway:	0.0E+00

			0.0E+00
Total Rad + Chem	0.0E+00	*Total:*	0.0E+00

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TABLE A.III-28
FUTURE, ON-PROPERTY FARMER (RME VALUES)
SOLID WASTE LANDFILL: SURFACE SOIL [50% vegetative cover; unlimited erosion]
CARCINOGENIC RISK

Radiation Risk

Inhalation of Particulates/Soil					Ingestion/Soil				
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	6.80E-06	7.9E-01	1.9E-11	1.5E-11	CS-137	0.257	1.1E+03	2.8E-11	3.2E-08
NP-237	9.00E-05	1.0E+01	2.9E-08	3.0E-07	NP-237	3.406	1.5E+04	2.2E-10	3.3E-06
PU-238	2.04E-05	2.4E+00	3.9E-08	9.2E-08	PU-238	0.772	3.4E+03	2.2E-10	7.5E-07
RA-226	5.97E-05	6.9E+00	3.0E-09	2.1E-08	RA-226	2.260	1.0E+04	1.2E-10	1.2E-06
RA-228	4.43E-05	5.1E+00	6.9E-10	3.5E-09	RA-228	1.681	7.4E+03	1.0E-10	7.4E-07
TH-228	4.27E-05	4.9E+00	7.8E-08	3.9E-07	TH-228	1.621	7.1E+03	5.5E-11	3.9E-07
TH-230	1.69E-04	2.0E+01	2.9E-08	5.7E-07	TH-230	6.417	2.8E+04	1.3E-11	3.7E-07
TH-232	3.97E-05	4.6E+00	2.8E-08	1.3E-07	TH-232	1.507	6.6E+03	1.2E-11	8.0E-08
U-234	1.11E-03	1.3E+02	2.6E-08	3.4E-06	U-234	42.1	1.9E+05	1.6E-11	3.0E-06
U-235/236	7.50E-05	8.7E+00	2.5E-08	2.2E-07	U-235/236	2.838	1.3E+04	1.6E-11	2.0E-07
U-238	2.04E-03	2.4E+02	5.2E-08	1.2E-05	U-238	77.2	3.4E+05	2.8E-11	9.5E-06
			Total Pathway:	1.7E-05				Total Pathway:	2.0E-05

Chemical Risk

Inhalation of Particulates/Soil					Ingestion/Soil				
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	1.79E-07	1.2E-08	1.5E+01	1.8E-07	Arsenic	6.79	1.7E-05	1.8E+00	2.9E-05
Beryllium	1.84E-08	1.2E-09	8.4E+00	1.0E-08	Beryllium	0.70	1.7E-06	4.3E+00	7.4E-06
Chromium	4.07E-07	2.6E-08	4.1E+01	1.1E-06	Chromium	15.46	3.8E-05		
U-TOTAL	5.93E-06	3.8E-07			U-TOTAL	225.22	5.6E-04		
4,4'-DDE	3.17E-10	2.1E-11			4,4'-DDE	0.01	3.0E-08	3.4E-01	1.0E-08
Benzo(a)pyrene	2.01E-08	1.3E-09	6.1E+00	7.9E-09	Benzo(a)pyrene	0.76	1.9E-06	7.3E+00	1.4E-05
Benzo(b)fluoranthene	1.87E-08	1.2E-09	7.5E-01	9.1E-10	Benzo(b)fluoranthene	0.71	1.8E-06	9.0E-01	1.6E-06
Carbazole	2.03E-09	1.3E-10			Carbazole	0.08	1.9E-07	2.0E-02	3.8E-09
Dibenzo(a,h)anthracene	5.27E-09	3.4E-10	6.8E+00	2.3E-09	Dibenzo(a,h)anthracene	0.20	4.9E-07	8.1E+00	4.0E-06
Indeno(1,2,3-cd)pyrene	1.27E-08	8.2E-10	1.7E+00	1.4E-09	Indeno(1,2,3-cd)pyrene	0.48	1.2E-06	2.0E+00	2.4E-06
			Total Pathway:	1.3E-06				Total Pathway:	5.8E-05
			Total Rad + Chem	1.9E-05				Total Rad + Chem	7.8E-05

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TABLE A.III-28 (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	1.1E+01	2.0E-06	2.1E-05	2.1E-05
	NP-237	1.4E+02	4.3E-07	6.1E-05	6.4E-05
	PU-238	3.2E+01	2.8E-11	9.0E-10	8.4E-07
	RA-226	9.4E+01	1.2E-08	1.1E-06	2.3E-06
	RA-228	7.0E+01	2.9E-06	2.0E-04	2.0E-04
	TH-228	6.7E+01	5.6E-06	3.8E-04	3.8E-04
	TH-230	2.7E+02	5.4E-11	1.4E-08	9.5E-07
	TH-232	6.3E+01	2.6E-11	1.6E-09	2.1E-07
	U-234	1.7E+03	3.0E-11	5.2E-08	6.4E-06
	U-235/236	1.2E+02	2.4E-07	2.8E-05	2.9E-05
	U-238	3.2E+03	3.6E-08	1.2E-04	1.4E-04
Total Pathway: 0.0E+00			Total Pathway:	8.1E-04	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	5.3E-07	1.8E+00	9.8E-07					3.0E-05
Beryllium	5.5E-07	4.3E+02	2.4E-04					2.4E-04
Chromium	1.2E-05							1.1E-06
U-TOTAL	1.8E-04							
4,4'-DDE	2.8E-07	3.8E-01	1.1E-07					1.2E-07
Benzo(a)pyrene	0.0E+00	1.7E+01	0.0E+00					1.4E-05
Benzo(b)fluoranthene	0.0E+00	2.1E+00	0.0E+00					1.6E-06
Carbazole	0.0E+00	2.0E-02	0.0E+00					3.8E-09
Dibenzo(a,h)anthracene	0.0E+00	1.9E+01	0.0E+00					4.0E-06
Indeno(1,2,3-cd)pyrene	0.0E+00	4.7E+00	0.0E+00					2.4E-06
		Total Pathway:	2.4E-04			Total Pathway:	0.0E+00	
		Total Rad + Chem	2.4E-04				8.1E-04	*Total:* 1.1E-03

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TABLE A.III-28 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
NP-237	6.80E-06	7.9E-01		
PU-238	9.00E-05	1.0E+01		
PU-239/240	2.04E-05	2.4E+00		
RA-228	5.97E-05	6.9E+00		
SR-90	4.43E-05	5.1E+00		
TH-230	4.27E-05	4.9E+00		
TH-232	1.69E-04	2.0E+01		
U-234	3.97E-05	4.6E+00		
U-235/236	1.11E-03	1.3E+02		
U-238	7.50E-05	8.7E+00		
U-239	2.04E-03	2.4E+02		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
NP-237	0.26	1.1E+03		
PU-238	3.41	1.5E+04		
PU-239/240	0.77	3.4E+03		
RA-228	2.26	1.0E+04		
SR-90	1.68	7.4E+03		
TH-230	1.62	7.1E+03		
TH-232	6.42	2.8E+04		
U-234	1.51	6.6E+03		
U-235/236	42.12	1.9E+05		
U-238	2.84	1.3E+04		
U-239	77.15	3.4E+05		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	1.79E-07	1.2E-08		
Beryllium	1.84E-08	1.2E-09		
Chromium	4.07E-07	2.6E-08		
U-TOTAL	5.93E-06	3.8E-07		
4,4'-DDE	3.17E-10	2.1E-11		
Benzo(a)pyrene	2.01E-08	1.3E-09		
Benzo(b)fluoranthene	1.87E-08	1.2E-09		
Carbazole	2.03E-09	1.3E-10		
Dibenzo(a,h)anthracene	5.27E-09	3.4E-10		
Indeno(1,2,3-cd)pyrene	1.27E-08	8.2E-10		

Total Pathway: 0.0E+00

Total Rad + Chem 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	6.79	1.7E-05	3.0E-04	0.1
Beryllium	0.70	1.7E-06	5.0E-03	3.4E-04
Chromium	15.46	3.8E-05	5.0E-03	7.6E-03
U-TOTAL	225.22	5.6E-04	3.0E-03	0.2
4,4'-DDE	0.01	3.0E-08		
Benzo(a)pyrene	0.76	1.9E-06		
Benzo(b)fluoranthene	0.71	1.8E-06		
Carbazole	0.08	1.9E-07		
Dibenzo(a,h)anthracene	0.20	4.9E-07		
Indeno(1,2,3-cd)pyrene	0.48	1.2E-06		

Total Pathway: 0.2

Total Rad + Chem 0.2

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TABLE A.III-28 (continued)

NONCARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	NP-237	1.1E+01			
	PU-238	1.4E+02			
	PU-239/24	3.2E+01			
	RA-228	9.4E+01			
	SR-90	7.0E+01			
	TH-230	6.7E+01			
	TH-232	2.7E+02			
	U-234	6.3E+01			
	U-235/236	1.7E+03			
	U-238	1.2E+02			
	U-239	3.2E+03			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				Total
Compound	Intake	RfD(derm	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	5.3E-07	2.9E-04	1.9E-03					5.8E-02
Beryllium	5.5E-07	5.0E-05	1.1E-02					1.1E-02
Chromium	1.2E-05	2.3E-03	5.4E-03					1.3E-02
U-TOTAL	1.8E-04	1.5E-04	1.2					1.4
4,4'-DDE	2.8E-07							
Benzo(a)pyrene	0.0E+00							
Benzo(b)fluoranthene	0.0E+00							
Carbazole	0.0E+00							
Dibenzo(a,h)anthracene	0.0E+00							
Indeno(1,2,3-cd)pyrene	0.0E+00							
		Total Pathway:	1.2			Total Pathway:	0.0E+00	
		Total Rad + Chem	1.2				0.0E+00	*Total:* 1.4

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TABLE A.III-29
FUTURE, ON-PROPERTY FARMER (RME VALUES)
SOLID WASTE LANDFILL: HOMEGROWN PRODUCE (DUST AFFECTED) [50% vegetative cover; unlimited erosion]

Carcinogenic Risk

Radiation Risk					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	SF(o)	Risk	
CS-137	1.49E-03	2.2E+00	2.8E-11	6.2E-11	6.2E-11
NP-237	1.98E-02	3.0E+01	2.2E-10	6.5E-09	6.5E-09
PU-238	4.36E-03	6.5E+00	2.2E-10	1.4E-09	1.4E-09
RA-226	1.28E-02	1.9E+01	1.2E-10	2.3E-09	2.3E-09
RA-228	9.53E-03	1.4E+01	1.0E-10	1.4E-09	1.4E-09
TC-99	1.42E-03	2.1E+00	1.30E-12	2.8E-12	2.8E-12
TH-228	9.15E-03	1.4E+01	5.5E-11	7.5E-10	7.5E-10
TH-230	3.62E-02	5.4E+01	1.3E-11	7.0E-10	7.0E-10
TH-232	8.52E-03	1.3E+01	1.2E-11	1.5E-10	1.5E-10
U-234	2.39E-01	3.6E+02	1.6E-11	5.7E-09	5.7E-09
U-235/236	1.60E-02	2.4E+01	1.6E-11	3.7E-10	3.7E-10
U-238	4.37E-01	6.5E+02	2.8E-11	1.8E-08	1.8E-08
			Total Pathway:	3.8E-08	

Chemical Risk					
Ingestion/Homegrown Produce					
Compound	Conc'n in Plants (mg/kg)	Intake	SF(o)	Risk	
Arsenic	3.89E-05	3.2E-08	1.5E+01	4.9E-07	4.9E-07
Beryllium	3.95E-06	3.3E-09	8.4E+00	2.8E-08	2.8E-08
Chromium	8.75E-05	7.3E-08			
U-TOTAL	1.27E-03	1.1E-06			
4,4'-DDE	6.78E-08	5.7E-11			
Benzo(a)pyrene	4.16E-06	3.5E-09	6.1E+00	2.1E-08	2.1E-08
Benzo(b)fluoranthene	3.90E-06	3.3E-09	7.5E-01	2.4E-09	2.4E-09
Carbazole	4.42E-07	3.7E-10			
Dibenzo(a,h)anthracene	1.11E-06	9.3E-10	6.8E+00	6.3E-09	6.3E-09
Indeno(1,2,3-cd)pyrene	2.65E-06	2.2E-09	1.7E+00	3.8E-09	3.8E-09
			Total Pathway:	5.5E-07	
			Total Rad + Chem	5.9E-07	*Total:* 5.9E-07

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TABLE A.III-29 (continued)
FUTURE, ON-PROPERTY FARMER (RME VALUES)
OLID WASTE LANDFILL: HOMEGROWN PRODUCE (DUST AFFECTED) [50% vegetative cover; unlimited erosio
Non-carcinogenic Hazard

Radiation Hazard					
Ingestion/Homegrown Produce					Total
Compound	Conc'n in Plants (pCi/kg)	Intake	RfD(o)	Hazard	
CS-137	1.5E-03	2.2E+00			
NP-237	2.0E-02	3.0E+01			
PU-238	4.4E-03	6.5E+00			
RA-226	1.3E-02	1.9E+01			
RA-228	9.5E-03	1.4E+01			
TC-99	1.4E-03	2.1E+00			
TH-228	9.2E-03	1.4E+01			
TH-230	3.6E-02	5.4E+01			
TH-232	8.5E-03	1.3E+01			
U-234	2.4E-01	3.6E+02			
U-235/236	1.6E-02	2.4E+01			
U-238	4.4E-01	6.5E+02			
				Total Pathway:	0.0E+00

Chemical Hazard					
Inhalation of Particulates/Soil					
Compound	Conc'n in Plants (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	3.89E-05	3.2E-08	3.0E-04	1.1E-04	1.1E-04
Beryllium	3.95E-06	3.3E-09	5.0E-03	6.6E-07	6.6E-07
Chromium	8.75E-05	7.3E-08	5.0E-03	1.5E-05	1.5E-05
U-TOTAL	1.27E-03	1.1E-06	3.0E-03	3.6E-04	3.6E-04
4,4'-DDE	6.78E-08	5.7E-11			
Benzo(a)pyrene	4.16E-06	3.5E-09			
Benzo(b)fluoranthene	3.90E-06	3.3E-09			
Carbazole	4.42E-07	3.7E-10			
Dibenzo(a,h)anthracene	1.11E-06	9.3E-10			
Indeno(1,2,3-cd)pyrene	2.65E-06	2.2E-09			
				Total Pathway:	4.8E-04
				Total Rad + Chem	4.8E-04

Total:	4.8E-04

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TABLE A.III-30
FUTURE, ON-PROPERTY FARMER (RME VALUES)
SOLID WASTE LANDFILL: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Carcinogenic Risk

Radiation Risk

Ingestion of Beef					Ingestion/Milk					Total
Compound	Conc'n-Beef (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (pCi/L)	Intake	SF(o)	Risk	
CS-137	1.9E-03	3.5E+00	2.8E-11	9.8E-11	CS-137	6.7E-04	4.9E+00	2.8E-11	1.4E-10	2.4E-10
NP-237	6.9E-05	1.3E-01	2.2E-10	2.8E-11	NP-237	6.3E-06	4.6E-02	2.2E-10	1.0E-11	3.8E-11
PU-238	1.4E-07	2.6E-04	2.2E-10	5.7E-14	PU-238	2.8E-08	2.1E-04	2.2E-10	4.6E-14	1.0E-13
RA-226	2.1E-04	3.8E-01	1.2E-10	4.6E-11	RA-226	3.7E-04	2.7E+00	1.2E-10	3.3E-10	3.7E-10
RA-228	1.5E-04	2.7E-01	1.0E-10	2.7E-11	RA-228	2.7E-04	2.0E+00	1.0E-10	2.0E-10	2.2E-10
TC-99	6.4E-04	1.2E+00	1.30E-12	1.5E-12	TC-99	7.5E-04	5.5E+00	1.3E-12	7.2E-12	8.7E-12
TH-228	3.2E-06	6.0E-03	5.5E-11	3.3E-13	TH-228	2.7E-06	2.0E-02	5.5E-11	1.1E-12	1.4E-12
TH-230	1.4E-05	2.6E-02	1.3E-11	3.4E-13	TH-230	1.2E-05	8.7E-02	1.3E-11	1.1E-12	1.5E-12
TH-232	3.3E-06	6.1E-03	1.2E-11	7.3E-14	TH-232	2.8E-06	2.0E-02	1.2E-11	2.4E-13	3.2E-13
U-234	3.1E-03	5.7E+00	1.6E-11	9.1E-11	U-234	9.3E-03	6.9E+01	1.6E-11	1.1E-09	1.2E-09
U-235/236	2.1E-04	3.8E-01	1.6E-11	6.1E-12	U-235/236	6.3E-04	4.6E+00	1.6E-11	7.4E-11	8.0E-11
U-238	5.7E-03	1.0E+01	2.8E-11	2.9E-10	U-238	1.7E-02	1.3E+02	2.8E-11	3.5E-09	3.8E-09
			Total Pathway:	5.9E-10				Total Pathway:	5.4E-09	

Chemical Risk

Ingestion of Beef					Ingestion/Milk					
Compound	Conc'n-Beef (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n-Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	5.0E-06	5.1E-09	1.8E+00	9.0E-09	Arsenic	1.5E-07	6.2E-10	1.8E+00	1.1E-09	1.0E-08
Beryllium	2.6E-07	2.6E-10	4.3E+00	1.1E-09	Beryllium	2.3E-10	9.5E-13	4.3E+00	4.1E-12	1.1E-09
Chromium	3.1E-05	3.2E-08			Chromium	8.5E-06	3.5E-08			
U-TOTAL	1.7E-05	1.7E-08			U-TOTAL	5.0E-05	2.0E-07			
4,4'-DDE	1.7E-13	1.8E-16	3.4E-01	6.0E-17	4,4'-DDE	5.4E-08	2.2E-10	3.4E-01	7.6E-11	7.6E-11
Benzo(a)pyrene	4.0E-06	4.1E-09	7.3E+00	3.0E-08	Benzo(a)pyrene	1.3E-06	5.1E-09	7.3E+00	3.8E-08	6.7E-08
Benzo(b)fluoranthene	1.4E-05	1.5E-08	9.0E-01	1.3E-08	Benzo(b)fluoranthene	4.6E-06	1.9E-08	9.0E-01	1.7E-08	3.0E-08
Carbazole	2.9E-07	3.0E-10	2.0E-02	6.0E-12	Carbazole	9.2E-08	3.8E-10	2.0E-02	7.6E-12	1.4E-11
Dibenzo(a,h)anthracene	1.0E-06	1.1E-09	8.1E+00	8.5E-09	Dibenzo(a,h)anthracene	3.2E-07	1.3E-09	8.1E+00	1.1E-08	1.9E-08
Indeno(1,2,3-cd)pyrene	1.2E-04	1.2E-07	2.0E+00	2.5E-07	Indeno(1,2,3-cd)pyrene	3.8E-05	1.6E-07	2.0E+00	3.1E-07	5.6E-07
			Total Pathway:	3.1E-07				Total Pathway:	3.8E-07	6.9E-07
			Total Rad + Chem	3.1E-07				Total Rad + Chem	3.8E-07	*Total:* 6.9E-07

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TABLE A.III-30 (continued)
FUTURE, ON-PROPERTY FARMER (RME VALUES)
SOLID WASTE LANDFILL: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Ingestion of Beef					Ingestion/Milk					Total
Compound	Conc'n-Beef (pCi/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n-Milk (pCi/L)	Intake	RfD(o)	Risk	
CS-137	1.91E-03	3.5E+00			CS-137	6.7E-04	4.9E+00			
NP-237	6.90E-05	1.3E-01			NP-237	6.3E-06	4.6E-02			
PU-238	1.41E-07	2.6E-04			PU-238	2.8E-08	2.1E-04			
RA-226	2.07E-04	3.8E-01			RA-226	3.7E-04	2.7E+00			
RA-228	1.49E-04	2.7E-01			RA-228	2.7E-04	2.0E+00			
TC-99	6.37E-04	1.2E+00			TC-99	7.5E-04	5.5E+00			
TH-228	3.24E-06	6.0E-03			TH-228	2.7E-06	2.0E-02			
TH-230	1.41E-05	2.6E-02			TH-230	1.2E-05	8.7E-02			
TH-232	3.32E-06	6.1E-03			TH-232	2.8E-06	2.0E-02			
U-234	3.11E-03	5.7E+00			U-234	9.3E-03	6.9E+01			
U-235/236	2.09E-04	3.8E-01			U-235/236	6.3E-04	4.6E+00			
U-238	5.68E-03	1.0E+01			U-238	1.7E-02	1.3E+02			
			Total Pathway:	0.0E+00				Total Pathway:	0.0E+00	

Chemical Hazard

Ingestion of Beef					Ingestion/Milk					Total
Compound	Conc'n-Beef (mg/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n-Milk (mg/L)	Intake	RfD(o)	Hazard	
Arsenic	5.01E-06	5.1E-09	3.0E-04	1.7E-05	Arsenic	1.5E-07	6.2E-10	3.0E-04	2.1E-06	1.9E-05
Beryllium	2.56E-07	2.6E-10	5.0E-03	5.3E-08	Beryllium	2.3E-10	9.5E-13	5.0E-03	1.9E-10	5.3E-08
Chromium	3.13E-05	3.2E-08	5.0E-03	6.4E-06	Chromium	8.5E-06	3.5E-08	5.0E-03	7.0E-06	1.3E-05
U-TOTAL	1.66E-05	1.7E-08	3.0E-03	5.7E-06	U-TOTAL	5.0E-05	2.0E-07	3.0E-03	6.8E-05	7.4E-05
4,4'-DDE	1.72E-13	1.8E-16			4,4'-DDE	5.4E-08	2.2E-10			
Benzo(a)pyrene	3.96E-06	4.1E-09			Benzo(a)pyrene	1.3E-06	5.1E-09			
Benzo(b)fluoranthene	1.44E-05	1.5E-08			Benzo(b)fluoranthene	4.6E-06	1.9E-08			
Carbazole	2.90E-07	3.0E-10			Carbazole	9.2E-08	3.8E-10			
Dibenzo(a,h)anthracene	1.03E-06	1.1E-09			Dibenzo(a,h)anthracene	3.2E-07	1.3E-09			
Indeno(1,2,3-cd)pyrene	1.20E-04	1.2E-07			Indeno(1,2,3-cd)pyrene	3.8E-05	1.6E-07			
			Total Pathway:	2.9E-05				Total Pathway:	7.7E-05	
			Total Rad + Chem	2.9E-05				Total Rad + Chem	7.7E-05	*Total:* 1.1E-04

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TABLE A.III-31
FUTURE, EXPANDED TRESPASSER
LIME SLUDGE PONDS: SURFACE SOIL [85% vegetative cover; limited erosion]
Carcinogenic Risk

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	1.84E-06	6.0E-03	1.9E-11	1.1E-13
NP-237	2.02E-06	6.6E-03	2.9E-08	1.9E-10
RA-226	5.37E-06	1.7E-02	3.0E-09	5.2E-11
RA-228	4.58E-06	1.5E-02	6.9E-10	1.0E-11
TH-228	7.61E-06	2.5E-02	7.8E-08	1.9E-09
TH-230	1.17E-04	3.8E-01	2.9E-08	1.1E-08
TH-232	3.69E-06	1.2E-02	2.8E-08	3.4E-10
U-234	5.49E-05	1.8E-01	2.6E-08	4.6E-09
U-235/236	4.56E-06	1.5E-02	2.5E-08	3.7E-10
U-238	1.87E-04	6.1E-01	5.2E-08	3.2E-08
			Total Pathway:	5.0E-08

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	0.70	1.7E+01	2.8E-11	4.8E-10
NP-237	0.77	1.9E+01	2.2E-10	4.2E-09
RA-226	2.05	5.0E+01	1.2E-10	6.0E-09
RA-228	1.75	4.3E+01	1.0E-10	4.3E-09
TH-228	2.91	7.1E+01	5.5E-11	3.9E-09
TH-230	44.80	1.1E+03	1.3E-11	1.4E-08
TH-232	1.41	3.5E+01	1.2E-11	4.1E-10
U-234	21.00	5.1E+02	1.6E-11	8.2E-09
U-235/236	1.74	4.3E+01	1.6E-11	6.8E-10
U-238	71.39	1.7E+03	2.8E-11	4.9E-08
			Total Pathway:	9.1E-08

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	SF(i)	Risk
Arsenic	1.9E-08	5.0E-11	1.5E+01	7.5E-10
Beryllium	4.2E-09	1.1E-11	8.4E+00	9.0E-11
Chromium	4.5E-08	1.2E-10	4.1E+01	4.8E-09
U-TOTAL	5.6E-07	1.4E-09		
Aroclor-1254	1.5E-09	4.0E-12		
Benzo(a)pyrene	2.9E-09	7.5E-12	6.1	4.5E-11
Benzo(b)fluoranthene	2.6E-09	6.8E-12	7.5E-01	5.1E-12
Dibenzo(a,h)anthracene	8.4E-10	2.2E-12	6.8E+00	1.5E-11
Indeno(1,2,3-cd)pyrene	1.9E-09	4.9E-12	1.7E+00	8.3E-12
			Total Pathway:	5.7E-09
			Total Rad + Chem	5.6E-08

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	7.379	1.4E-07	1.8E+00	2.5E-07
Beryllium	1.588	3.1E-08	4.3E+00	1.3E-07
Chromium	17.3	3.4E-07		
U-TOTAL	214	4.2E-06		
Aroclor-1254	0.590	1.1E-08	7.7E+00	8.9E-08
Benzo(a)pyrene	1.100	2.1E-08	7.3E+00	1.6E-07
Benzo(b)fluoranthene	1.000	1.9E-08	9.0E-01	1.8E-08
Dibenzo(a,h)anthracene	0.320	6.2E-09	8.1E+00	5.1E-08
Indeno(1,2,3-cd)pyrene	0.720	1.4E-08	2.0E+00	2.8E-08
			Total Pathway:	7.5E-07
			Total Rad + Chem	8.4E-07

TABLE A.III-31 (continued)
FUTURE, EXPANDED TRESPASSER
LIME SLUDGE PONDS: SURFACE SOIL [85% vegetative cover; limited erosion]
Carcinogenic Risk

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	3.1E-01	2.0E-06	6.3E-07	6.3E-07
	NP-237	3.5E-01	4.3E-07	1.5E-07	1.5E-07
	RA-226	9.2E-01	1.2E-08	1.1E-08	1.7E-08
	RA-228	7.8E-01	2.9E-06	2.3E-06	2.3E-06
	TH-228	1.3E+00	5.6E-06	7.3E-06	7.3E-06
	TH-230	2.0E+01	5.4E-11	1.1E-09	2.6E-08
	TH-232	6.3E-01	2.6E-11	1.6E-11	7.7E-10
	U-234	9.4E+00	3.0E-11	2.8E-10	1.3E-08
	U-235/236	7.8E-01	2.4E-07	1.9E-07	1.9E-07
	U-238	3.2E+01	3.6E-08	1.2E-06	1.2E-06
Total Pathway: 0.0E+00			Total Pathway:	1.2E-05	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	6.8E-08	1.8E+00	1.2E-07					3.8E-07
Beryllium	1.5E-07	4.3E+02	6.3E-05					6.3E-05
Chromium	1.6E-06			Not applicable				4.8E-09
U-TOTAL	2.0E-05							
Aroclor-1254	1.6E-06	1.0E+01	1.7E-05					1.7E-05
Benzo(a)pyrene	0.0E+00	1.7E+01	0.0E+00					1.6E-07
Benzo(b)fluoranthene	0.0E+00	2.1E+00	0.0E+00					1.8E-08
Dibenzo(a,h)anthracene	0.0E+00	1.9E+01	0.0E+00					5.1E-08
Indeno(1,2,3-cd)pyrene	0.0E+00	4.7E+00	0.0E+00					2.8E-08
		Total Pathway:	7.9E-05			Total Pathway:	0.0E+00	
		Total Rad + Chem	7.9E-05				1.2E-05	*Total:* 9.2E-05

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TABLE A.III-31 (continued)
FUTURE, EXPANDED TRESPASSER
LIME SLUDGE PONDS: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3	Intake	RfD(i)	Hazard
CS-137	1.8E-06	6.0E-03		
NP-237	2.0E-06	6.6E-03		
RA-226	5.4E-06	1.7E-02		
RA-228	4.6E-06	1.5E-02		
TH-228	7.6E-06	2.5E-02		
TH-230	1.2E-04	3.8E-01		
TH-232	3.7E-06	1.2E-02		
U-234	5.5E-05	1.8E-01		
U-235/236	4.6E-06	1.5E-02		
U-238	1.9E-04	6.1E-01		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.70	1.7E+01		
NP-237	0.77	1.9E+01		
RA-226	2.05	5.0E+01		
RA-228	1.75	4.3E+01		
TH-228	2.91	7.1E+01		
TH-230	44.80	1.1E+03		
TH-232	1.41	3.5E+01		
U-234	21.00	5.1E+02		
U-235/236	1.74	4.3E+01		
U-238	71.39	1.7E+03		

Total Pathway: 0.0E+00

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(i)	Hazard
Arsenic	1.9E-08	5.0E-11		
Beryllium	4.2E-09	1.1E-11		
Chromium	4.5E-08	1.2E-10		
U-TOTAL	5.6E-07	1.4E-09		
Aroclor-1254	1.5E-09	4.0E-12		
Benzo(a)pyrene	2.9E-09	7.5E-12		
Benzo(b)fluoranthene	2.6E-09	6.8E-12		
Dibenzo(a,h)anthracene	8.4E-10	2.2E-12		
Indeno(1,2,3-cd)pyrene	1.9E-09	4.9E-12		

Total Pathway: 0.0E+00

Total Rad + Chem 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	7.38	7.9E-07	3.0E-04	2.6E-03
Beryllium	1.59	1.7E-07	5.0E-03	3.4E-05
Chromium	17.34	1.9E-06	5.0E-03	3.7E-04
U-TOTAL	214.32	2.3E-05	3.0E-03	7.7E-03
Aroclor-1254	0.59	6.3E-08		
Benzo(a)pyrene	1.10	1.2E-07		
Benzo(b)fluoranthene	1.00	1.1E-07		
Dibenzo(a,h)anthracene	0.32	3.4E-08		
Indeno(1,2,3-cd)pyrene	0.72	7.7E-08		

Total Pathway: 1.1E-02

Total Rad + Chem 1.1E-02

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TABLE A.III-31 (continued)
FUTURE, EXPANDED TRESPASSER
LIME SLUDGE PONDS: SURFACE SOIL [85% vegetative cover; limited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	3.1E-01			
	NP-237	3.5E-01			
	RA-226	9.2E-01			
	RA-228	7.8E-01			
	TH-228	1.3E+00			
	TH-230	2.0E+00			
	TH-232	6.3E-01			
	U-234	9.4E+00			
	U-235/236	7.8E-01			
	U-238	3.2E+01			
Total Pathway: 0.0E+00	Total Pathway: 0.0E+00				

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	RfD(derm)	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	2.8E-07	2.9E-04	1.0E-03					3.6E-03
Beryllium	6.1E-07	5.0E-05	1.2E-02					1.2E-02
Chromium	6.7E-06	2.3E-03	3.0E-03	Not applicable				3.3E-03
U-TOTAL	8.2E-05	1.5E-04	0.5					0.6
Aroclor-1254	6.8E-06							
Benzo(a)pyrene	0.0E+00							
Benzo(b)fluoranthene	0.0E+00							
Dibenzo(a,h)anthracene	0.0E+00							
Indeno(1,2,3-cd)pyrene	0.0E+00							
	Total Pathway:		0.6		Total Pathway:		0.0E+00	
	Total Rad + Chem		0.6				0.0E+00	*Total:* 0.6

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TABLE A.III-32
FUTURE, OFF-PROPERTY FARMER (RME VALUES)
LIME SLUDGE PONDS: SURFACE SOIL [85% vegetative cover; limited erosion]
CARCINOGENIC RISK

Radiation Risk					
Inhalation of Particulates/Soil					Total
Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk	
CS-137	3.35E-08	3.9E-03	1.9E-11	7.4E-14	7.4E-14
NP-237	3.69E-08	4.3E-03	2.9E-08	1.2E-10	1.2E-10
RA-226	9.80E-08	1.1E-02	3.0E-09	3.4E-11	3.4E-11
RA-228	8.35E-08	9.7E-03	6.6E-10	6.4E-12	6.4E-12
TH-228	1.39E-07	1.6E-02	7.8E-08	1.3E-09	1.3E-09
TH-230	2.14E-06	2.5E-01	2.9E-08	7.2E-09	7.2E-09
TH-232	6.73E-08	7.8E-03	2.8E-08	2.2E-10	2.2E-10
U-234	1.00E-06	1.2E-01	2.6E-08	3.0E-09	3.0E-09
U-235/236	8.31E-08	9.6E-03	2.5E-08	2.4E-10	2.4E-10
U-238	3.41E-06	4.0E-01	5.20E-08	2.1E-08	2.1E-08
			Total Pathway:	3.3E-08	

Chemical Risk					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk	
Arsenic	3.5E-10	2.3E-11	1.5E+01	3.4E-10	3.4E-10
Beryllium	7.6E-11	4.9E-12	8.4E+00	4.1E-11	4.1E-11
Chromium	8.3E-10	5.4E-11	4.1E+00	2.2E-10	2.2E-10
U-TOTAL	1.0E-08	6.6E-10			
Aroclor-1254	2.8E-11	1.8E-12			0.0E+00
Benzo(a)pyrene	5.3E-11	3.4E-12	6.1	2.1E-11	2.1E-11
Benzo(b)fluoranthene	4.8E-11	3.1E-12	7.5E-01	2.3E-12	2.3E-12
Dibenzo(a,h)anthracene	1.5E-11	9.9E-13	6.8E+00	6.7E-12	6.7E-12
Indeno(1,2,3-cd)pyrene	3.4E-11	2.2E-12	1.7E+00	3.8E-12	3.8E-12
			Total Pathway:	6.4E-10	

Total Rad + Chem 3.3E-08 *Total:* 3.3E-08

TABLE A.III-32 (continued)

NON-CARCINOGENIC HAZARD

Radiation Hazard					
Inhalation of Particulates/Soil					Total
Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard	
CS-137	3.35E-08	3.9E-03			
NP-237	3.69E-08	4.3E-03			
RA-226	9.80E-08	1.1E-02			
RA-228	8.35E-08	9.7E-03			
TH-228	1.39E-07	1.6E-02			
TH-230	2.14E-06	2.5E-01			
TH-232	6.73E-08	7.8E-03			
U-234	1.00E-06	1.2E-01			
U-235/236	8.31E-08	9.6E-03			
U-238	3.41E-06	4.0E-01			
				Total Pathway:	0.0E+00

Chemical Hazard					
Inhalation of Particulates/Soil					
Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard	
Arsenic	3.52E-10	2.3E-11			0.0E+00
Beryllium	7.57E-11	4.9E-12			0.0E+00
Chromium	8.27E-10	5.4E-11			0.0E+00
U-TOTAL	1.02E-08	6.6E-10			0.0
Aroclor-1254	2.81E-11	1.8E-12			
Benzo(a)pyrene	5.25E-11	3.4E-12			
Benzo(b)fluoranthene	4.77E-11	3.1E-12			
Dibenzo(a,h)anthracene	1.53E-11	9.9E-13			
Indeno(1,2,3-cd)pyrene	3.43E-11	2.2E-12			0.0E+00
				Total Pathway:	0.0E+00

Total Rad + Chem 0.0E+00 *Total:* 0.0E+00

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TABLE A.III-33
FUTURE, ON-PROPERTY FARMER (RME VALUES)
LIME SLUDGE PONDS: SURFACE SOIL [50% vegetative cover; unlimited erosion]
CARCINOGENIC RISK

Radiation Risk

Inhalation of Particulates/Soil

Compound	Conc'n in Air (pCi/m3)	Intake	SF(i)	Risk
CS-137	2.47E-05	2.9E+00	1.9E-11	5.4E-11
NP-237	2.72E-05	3.2E+00	2.9E-08	9.2E-08
RA-226	7.23E-05	8.4E+00	3.0E-09	2.5E-08
RA-228	6.17E-05	7.1E+00	6.6E-10	4.7E-09
TH-228	1.02E-04	1.2E+01	7.8E-08	9.3E-07
TH-230	1.58E-03	1.8E+02	2.9E-08	5.3E-06
TH-232	4.97E-05	5.8E+00	2.8E-08	1.6E-07
U-234	7.40E-04	8.6E+01	2.6E-08	2.2E-06
U-235/236	6.13E-05	7.1E+00	2.5E-08	1.8E-07
U-238	2.51E-03	2.9E+02	5.20E-08	1.5E-05
			Total Pathway:	2.4E-05

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	SF(o)	Risk
CS-137	0.702	3.1E+03	2.8E-11	8.7E-08
NP-237	0.773	3.4E+03	2.2E-10	7.5E-07
RA-226	2.1	9.1E+03	1.2E-10	1.1E-06
RA-228	1.750	7.7E+03	1.0E-10	7.7E-07
TH-228	2.910	1.3E+04	5.5E-11	7.1E-07
TH-230	44.8	2.0E+05	1.3E-11	2.6E-06
TH-232	1.411	6.2E+03	1.2E-11	7.5E-08
U-234	21.0	9.3E+04	1.6E-11	1.5E-06
U-235/236	1.743	7.7E+03	1.6E-11	1.2E-07
U-238	71.388	3.1E+05	2.8E-11	8.8E-06
			Total Pathway:	1.6E-05

Chemical Risk

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	SF(i)	Risk
Arsenic	2.6E-07	1.7E-08	1.5E+01	2.5E-07
Beryllium	5.6E-08	3.6E-09	8.4E+00	3.0E-08
Chromium	6.1E-07	4.0E-08	4.1E+00	1.6E-07
U-TOTAL	7.5E-06	4.9E-07		
Aroclor-1254	2.1E-08	1.3E-09		
Benzo(a)anthracene	3.2E-08	2.1E-09	8.9E-01	1.8E-09
Benzo(a)pyrene	3.9E-08	2.5E-09	6.1	1.5E-08
Benzo(b)fluoranthene	3.5E-08	2.3E-09	7.5E-01	1.7E-09
Dibenzo(a,h)anthracene	1.1E-08	7.3E-10	6.8E+00	5.0E-09
Indeno(1,2,3-cd)pyrene	2.5E-08	1.6E-09	1.7E+00	2.8E-09
			Total Pathway:	4.7E-07
			Total Rad + Chem	2.5E-05

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk
Arsenic	7.379	1.8E-05	1.8E+00	3.2E-05
Beryllium	1.588	3.9E-06	4.3E+00	1.7E-05
Chromium	17.34	4.3E-05		
U-TOTAL	214.3	5.3E-04		
Aroclor-1254	0.590	1.5E-06	7.7E+00	1.1E-05
Benzo(a)anthracene	0.910	2.2E-06	1.1E+00	2.5E-06
Benzo(a)pyrene	1.100	2.7E-06	7.3E+00	2.0E-05
Benzo(b)fluoranthene	1.000	2.5E-06	9.0E-01	2.2E-06
Dibenzo(a,h)anthracene	0.320	7.9E-07	8.1E+00	6.4E-06
Indeno(1,2,3-cd)pyrene	0.720	1.8E-06	2.0E+00	3.6E-06
			Total Pathway:	9.4E-05
			Total Rad + Chem	1.1E-04

TABLE A.III-33 (continued)

CARCINOGENIC RISK

Radiation Risk

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	SF(e)	Risk	
Not applicable	CS-137	2.9E+01	2.0E-06	5.8E-05	5.8E-05
	NP-237	3.2E+01	4.3E-07	1.4E-05	1.5E-05
	RA-226	8.5E+01	1.2E-08	1.0E-06	2.1E-06
	RA-228	7.3E+01	2.9E-06	2.1E-04	2.1E-04
	TH-228	1.2E+02	5.6E-06	6.8E-04	6.8E-04
	TH-230	1.9E+03	5.4E-11	1.0E-07	8.0E-06
	TH-232	5.9E+01	2.6E-11	1.5E-09	2.4E-07
	U-234	8.7E+02	3.0E-11	2.6E-08	3.7E-06
	U-235/236	7.2E+01	2.4E-07	1.7E-05	1.8E-05
	U-238	3.0E+03	3.6E-08	1.1E-04	1.3E-04
Total Pathway: 0.0E+00				Total Pathway: 1.1E-03	

Chemical Risk

Dermal Contact/Soil				External Radiation/Soil				
Compound	Intake	SF(derm)	Risk	Compound	Intake	SF(o)	Risk	
Arsenic	5.8E-07	1.8E+00	1.1E-06					3.3E-05
Beryllium	1.3E-06	4.3E+02	5.4E-04					5.5E-04
Chromium	1.4E-05							1.6E-07
U-TOTAL	1.7E-04							
Aroclor-1254	1.4E-05	1.0E+01	1.4E-04					1.5E-04
Benzo(a)anthracene	0.0E+00	2.6E+00	0.0E+00					2.5E-06
Benzo(a)pyrene	0.0E+00	1.7E+01	0.0E+00		Not applicable			2.0E-05
Benzo(b)fluoranthene	0.0E+00	2.1E+00	0.0E+00					2.2E-06
Dibenzo(a,h)anthracene	0.0E+00	1.9E+01	0.0E+00					6.4E-06
Indeno(1,2,3-cd)pyrene	0.0E+00	4.7E+00	0.0E+00					3.6E-06
		Total Pathway:	6.8E-04			Total Pathway:	0.0E+00	
		Total Rad + Chem	6.8E-04				1.1E-03	*Total:* 1.9E-03

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TABLE A.III-33 (continued)

NON-CARCINOGENIC HAZARD

Radiation Hazard

Inhalation of Particulates/Soil

Compound	Conc'n-Air (pCi/m3)	Intake	RfD(i)	Hazard
CS-137	2.47E-05	2.9E+00		
NP-237	2.72E-05	3.2E+00		
RA-226	7.23E-05	8.4E+00		
RA-228	6.17E-05	7.1E+00		
TH-228	1.02E-04	1.2E+01		
TH-230	1.58E-03	1.8E+02		
TH-232	4.97E-05	5.8E+00		
U-234	7.40E-04	8.6E+01		
U-235/236	6.13E-05	7.1E+00		
U-238	2.51E-03	2.9E+02		

Total Pathway: 0.0E+00

Ingestion/Soil

Compound	Conc'n (pCi/g)	Intake	RfD(o)	Hazard
CS-137	0.702	3.1E+03		
NP-237	0.773	3.4E+03		
RA-226	2.054	9.1E+03		
RA-228	1.750	7.7E+03		
TH-228	2.910	1.3E+04		
TH-230	44.800	2.0E+05		
TH-232	1.411	6.2E+03		
U-234	21.003	9.3E+04		
U-235/236	1.743	7.7E+03		
U-238	71.388	3.1E+05		

Total Pathway: ######

Chemical Hazard

Inhalation of Particulates/Soil

Compound	Conc'n (mg/m3)	Intake	RfD(i)	Hazard
Arsenic	2.60E-07	1.7E-08		
Beryllium	5.60E-08	3.6E-09		
Chromium	6.10E-07	4.0E-08		
U-TOTAL	7.53E-06	4.9E-07		
Aroclor-1254	2.08E-08	1.3E-09		
Benzo(a)anthracene	3.20E-08	2.1E-09		
Benzo(a)pyrene	3.87E-08	2.5E-09		
Benzo(b)fluoranthene	3.53E-08	2.3E-09		
Dibenzo(a,h)anthracene	1.13E-08	7.3E-10		
Indeno(1,2,3-cd)pyrene	2.54E-08	1.6E-09		

Total Pathway: 0.0E+00

Total Rad + Chem 0.0E+00

Ingestion/Soil

Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard
Arsenic	7.379	1.8E-05	3.0E-04	6.1E-02
Beryllium	1.588	3.9E-06	5.0E-03	7.8E-04
Chromium	17.342	4.3E-05	5.0E-03	8.6E-03
U-TOTAL	214.323	5.3E-04	3.0E-03	0.2
Aroclor-1254	0.590	1.5E-06		
Benzo(a)anthracene	0.910	2.2E-06		
Benzo(a)pyrene	1.100	2.7E-06		
Benzo(b)fluoranthene	1.000	2.5E-06		
Dibenzo(a,h)anthracene	0.320	7.9E-07		
Indeno(1,2,3-cd)pyrene	0.720	1.8E-06	2.0E+00	8.9E-07

Total Pathway: 2.5E-01

Total Rad + Chem 2.5E-01

TABLE A.III-33 (continued)

NON-CARCINOGENIC HAZARD

Radiation Hazard

Dermal Contact/Soil	External Radiation/Soil				Total
	Compound	Intake	RfD(e)	Hazard	
Not applicable	CS-137	2.9E+01			
	NP-237	3.2E+01			
	RA-226	8.5E+01			
	RA-228	7.3E+01			
	TH-228	1.2E+02			
	TH-230	1.9E+03			
	TH-232	5.9E+01			
	U-234	8.7E+02			
	U-235/236	7.2E+01			
	U-238	3.0E+03			
Total Pathway: 0.0E+00				Total Pathway: 0.0E+00	

Chemical Hazard

Dermal Contact/Soil				External Radiation/Soil				Total
Compound	Intake	RfD(derm	Hazard	Compound	Intake	RfD(o)	Hazard	
Arsenic	5.8E-07	2.9E-04	1.7E-10					6.1E-02
Beryllium	1.3E-06	5.0E-05	6.3E-11					7.8E-04
Chromium	1.4E-05	2.3E-03	3.1E-08					8.6E-03
U-TOTAL	1.7E-04	1.5E-04	2.5E-08					0.2
Aroclor-1254	1.4E-05							
Benzo(a)anthracene	0.0E+00							
Benzo(a)pyrene	0.0E+00			Not applicable				
Benzo(b)fluoranthene	0.0E+00							
Dibenzo(a,h)anthracene	0.0E+00							
Indeno(1,2,3-cd)pyrene	0.0E+00	4.7E+00	0.0E+00					8.9E-07
		Total Pathway:	5.6E-08			Total Pathway:	0.0E+00	
		Total Rad + Chem	5.6E-08				0.0E+00	*Total:* 2.5E-01

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TABLE A.III-34
FUTURE, ON-PROPERTY FARMER (RME VALUES) [50% vegetative cover; unlimited erosion]
LIME SLUDGE PONDS: HOMEGROWN PRODUCE (DUST AFFECTED)
Carcinogenic Risk

Radiation Risk					
Ingestion of Homegrown Produce					Total
Compound	Conc'n (pCi/kg)	Intake	SF(o)	Risk	
CS-137	4.83E-03	7.2E+00	2.8E-11	2.0E-10	2.0E-10
NP-237	5.36E-03	8.0E+00	2.2E-10	1.8E-09	1.8E-09
RA-226	1.38E-02	2.1E+01	1.2E-10	2.5E-09	2.5E-09
RA-228	1.17E-02	1.8E+01	1.0E-10	1.8E-09	1.8E-09
TH-228	1.95E-02	2.9E+01	5.5E-11	1.6E-09	1.6E-09
TH-230	3.01E-01	4.5E+02	1.3E-11	5.8E-09	5.8E-09
TH-232	9.47E-03	1.4E+01	1.2E-11	1.7E-10	1.7E-10
U-234	1.41E-01	2.1E+02	1.6E-11	3.4E-09	3.4E-09
U-235/236	1.17E-02	1.8E+01	1.6E-11	2.8E-10	2.8E-10
U-238	4.80E-01	7.2E+02	2.8E-11	2.0E-08	2.0E-08
			Total Pathway:	3.8E-08	

Chemical Risk					
Ingestion of Homegrown Produce					
Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk	
Arsenic	5.0E-05	4.2E-08	1.8E+00	7.3E-08	7.3E-08
Beryllium	1.1E-05	8.9E-09	4.3E+00	3.8E-08	3.8E-08
Chromium	1.2E-04	9.8E-08			
U-TOTAL	1.4E-03	1.2E-06			
Aroclor-1254	4.0E-06	3.3E-09	7.7E+00	2.6E-08	2.6E-08
Benzo(a)pyrene	7.2E-06	6.0E-09	7.3E+00	4.4E-08	4.4E-08
Benzo(b)fluoranthene	6.5E-06	5.5E-09	9.0E-01	4.9E-09	4.9E-09
Dibenzo(a,h)anthracene	2.1E-06	1.8E-09	8.1E+00	1.4E-08	1.4E-08
Indeno(1,2,3-cd)pyrene	4.7E-06	3.9E-09	2.0E+00	7.9E-09	7.9E-09
			Total Pathway:	2.1E-07	

Total Rad + Chem	2.5E-07	*Total:*	2.5E-07

TABLE A.III-34 (continued)
FUTURE, ON-PROPERTY FARMER (RME VALUES) [50% vegetative cover; unlimited erosion]
LIME SLUDGE PONDS: HOMEGROWN PRODUCE (DUST AFFECTED)

Non-carcinogenic Hazard

Radiation Hazard					
Ingestion of Homegrown Produce					Total
Compound	Conc'n (pCi/kg)	Intake	RfD(i)	Hazard	
CS-137	4.8E-03	7.2E+00			
NP-237	5.4E-03	8.0E+00			
RA-226	1.4E-02	2.1E+01			
RA-228	1.2E-02	1.8E+01			
TH-228	2.0E-02	2.9E+01			
TH-230	3.0E-01	4.5E+02			
TH-232	9.5E-03	1.4E+01			
U-234	1.4E-01	2.1E+02			
U-235/236	1.2E-02	1.8E+01			
U-238	4.8E-01	7.2E+02			
				Total Pathway:	0.0E+00

Chemical Hazard					
Ingestion of Homegrown Produce					
Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard	
Arsenic	5.0E-05	4.2E-08	3.0E-04	1.4E-04	1.4E-04
Beryllium	1.1E-05	8.9E-09	5.0E-03	1.8E-06	1.8E-06
Chromium	1.2E-04	9.8E-08	5.0E-03	2.0E-05	2.0E-05
U-TOTAL	1.4E-03	1.2E-06	3.0E-03	4.0E-04	4.0E-04
Aroclor-1254	4.0E-06	3.3E-09			
Benzo(a)pyrene	7.2E-06	6.0E-09			
Benzo(b)fluoranthene	6.5E-06	5.5E-09			
Dibenzo(a,h)anthracene	2.1E-06	1.8E-09			
Indeno(1,2,3-cd)pyrene	4.7E-06	3.9E-09			
				Total Pathway:	5.6E-04
			Total Rad + Chem	5.6E-04	*Total:* 5.6E-04

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TABLE A.III-35
FUTURE, ON-PROPERTY FARMER (RME VALUES)
LIME SLUDGE PONDS: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Carcinogenic Risk

Radiation Risk

Ingestion of Beef					Ingestion/Milk					Total
Compound	Conc'n (pCi/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (pCi/L	Intake	SF(o)	Risk	
CS-137	6.19E-03	1.1E+01	2.8E-11	3.2E-10	CS-137	2.17E-03	1.6E+01	2.8E-11	4.5E-10	7.6E-10
NP-237	1.87E-05	3.4E-02	2.2E-10	7.5E-12	NP-237	1.70E-06	1.2E-02	2.2E-10	2.7E-12	1.0E-11
RA-226	2.24E-04	4.1E-01	1.2E-10	4.9E-11	RA-226	4.02E-04	3.0E+00	1.2E-10	3.5E-10	4.0E-10
RA-228	1.84E-04	3.4E-01	1.0E-10	3.4E-11	RA-228	3.31E-04	2.4E+00	1.0E-10	2.4E-10	2.8E-10
TH-228	6.91E-06	1.3E-02	5.5E-11	7.0E-13	TH-228	5.76E-06	4.2E-02	5.5E-11	2.3E-12	3.0E-12
TH-230	1.17E-04	2.2E-01	1.3E-11	2.8E-12	TH-230	9.78E-05	7.2E-01	1.3E-11	9.3E-12	1.2E-11
TH-232	3.69E-06	6.8E-03	1.2E-11	8.1E-14	TH-232	3.08E-06	2.3E-02	1.2E-11	2.7E-13	3.5E-13
U-234	1.84E-03	3.4E+00	1.6E-11	5.4E-11	U-234	5.51E-03	4.0E+01	1.6E-11	6.5E-10	7.0E-10
U-235/236	1.52E-04	2.8E-01	1.6E-11	4.5E-12	U-235/236	4.57E-04	3.4E+00	1.6E-11	5.4E-11	5.8E-11
U-238	6.25E-03	1.1E+01	2.8E-11	3.2E-10	U-238	1.87E-02	1.4E+02	2.8E-11	3.9E-09	4.2E-09
			Total Pathway:	7.9E-10				Total Pathway:	5.6E-09	

Chemical Risk

Ingestion of Beef					Ingestion/Milk					
Compound	Conc'n (mg/kg)	Intake	SF(o)	Risk	Compound	Conc'n in Milk (mg/L)	Intake	SF(o)	Risk	
Arsenic	6.5E-06	6.6E-09	1.8E+00	1.2E-08	Arsenic	1.9E-07	8.0E-10	1.8E+00	1.4E-09	1.3E-08
Beryllium	6.9E-07	7.1E-10	4.3E+00	3.1E-09	Beryllium	6.2E-10	2.6E-12	4.3E+00	1.1E-11	3.1E-09
Chromium	4.2E-05	4.3E-08			Chromium	1.1E-05	4.7E-08			
U-TOTAL	1.9E-05	1.9E-08			U-TOTAL	5.6E-05	2.3E-07			
Aroclor-1254	7.0E-06	7.2E-09	7.7E+00	5.5E-08	Aroclor-1254	2.2E-06	9.1E-09	7.7E+00	7.0E-08	1.3E-07
Benzo(a)pyrene	6.8E-06	7.0E-09	7.3E+00	5.1E-08	Benzo(a)pyrene	2.2E-06	8.8E-09	7.3E+00	6.5E-08	1.2E-07
Benzo(b)fluoranthene	2.4E-05	2.5E-08	9.0E-01	2.2E-08	Benzo(b)fluoranthene	7.6E-06	3.1E-08	9.0E-01	2.8E-08	5.0E-08
Dibenzo(a,h)anthracene	1.9E-06	2.0E-09	8.1E+00	1.6E-08	Dibenzo(a,h)anthracene	6.2E-07	2.5E-09	8.1E+00	2.0E-08	3.7E-08
Indeno(1,2,3-cd)pyrene	2.1E-04	2.2E-07	2.0E+00	4.4E-07	Indeno(1,2,3-cd)pyrene	6.8E-05	2.8E-07	2.0E+00	5.6E-07	9.9E-07
			Total Pathway:	6.0E-07				Total Pathway:	7.4E-07	
			Total Rad + Chem	6.0E-07				Total Rad + Chem	7.5E-07	*Total:* 1.3E-06

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TABLE A.III-35 (continued)
FUTURE, ON-PROPERTY FARMER (RME VALUES)
LIME SLUDGE PONDS: BEEF AND MILK (DUST AFFECTED) [50% vegetative cover; unlimited erosion]
Non-carcinogenic Hazard

Radiation Hazard

Ingestion of Beef					Ingestion/Milk					
Compound	Conc'n (pCi/kg)	Intake	RfD(o)	Hazard	Compound	onc'n in Milk (pCi/L	Intake	RfD(o)	Hazard	Total
CS-137	6.2E-03	1.1E+01			CS-137	2.17E-03	1.6E+01			
NP-237	1.9E-05	3.4E-02			NP-237	1.70E-06	1.2E-02			
RA-226	2.2E-04	4.1E-01			RA-226	4.02E-04	3.0E+00			
RA-228	1.8E-04	3.4E-01			RA-228	3.31E-04	2.4E+00			
TH-228	6.9E-06	1.3E-02			TH-228	5.76E-06	4.2E-02			
TH-230	1.2E-04	2.2E-01			TH-230	9.78E-05	7.2E-01			
TH-232	3.7E-06	6.8E-03			TH-232	3.08E-06	2.3E-02			
U-234	1.8E-03	3.4E+00			U-234	5.51E-03	4.0E+01			
U-235/236	1.5E-04	2.8E-01			U-235/236	4.57E-04	3.4E+00			
U-238	6.2E-03	1.1E+01			U-238	1.87E-02	1.4E+02			
		Total Pathway:		0.0E+00				Total Pathway:		0.0E+00

Chemical Hazard

Ingestion of Beef					Ingestion/Milk					
Compound	Conc'n (mg/kg)	Intake	RfD(o)	Hazard	Compound	Conc'n in Milk (mg/L	Intake	RfD(o)	Hazard	
Arsenic	6.5E-06	6.6E-09	3.0E-04	2.2E-05	Arsenic	1.9E-07	8.0E-10	3.0E-04	2.7E-06	2.5E-05
Beryllium	6.9E-07	7.1E-10	5.0E-03	1.4E-07	Beryllium	6.2E-10	2.6E-12	5.0E-03	5.1E-10	1.4E-07
Chromium	4.2E-05	4.3E-08	5.0E-03	8.6E-06	Chromium	1.1E-05	4.7E-08	5.0E-03	9.4E-06	1.8E-05
U-TOTAL	1.9E-05	1.9E-08	3.0E-03	6.4E-06	U-TOTAL	5.6E-05	2.3E-07	3.0E-03	7.7E-05	8.4E-05
Aroclor-1254	7.0E-06	7.2E-09			Aroclor-1254	2.2E-06	9.1E-09			
Benzo(a)pyrene	6.8E-06	7.0E-09			Benzo(a)pyrene	2.2E-06	8.8E-09			
Benzo(b)fluoranthene	2.4E-05	2.5E-08			Benzo(b)fluoranthene	7.6E-06	3.1E-08			
Dibenzo(a,h)anthracene	1.9E-06	2.0E-09			Dibenzo(a,h)anthracene	6.2E-07	2.5E-09			
Indeno(1,2,3-cd)pyrene	2.1E-04	2.2E-07			Indeno(1,2,3-cd)pyrene	6.8E-05	2.8E-07			
		Total Pathway:		3.7E-05				Total Pathway:		8.9E-05
		Total Rad + Chem		3.7E-05				Total Rad + Chem		8.9E-05

Total: 1.3E-04

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FIGURE A.III-1

SAMPLE AIR CONCENTRATION/DEPOSITION CONVERSION CALCULATIONS

SAMPLE CALCULATIONS:

ON-PROPERTY FARMER RECEPTOR

ESTIMATION 50% VEGETATIVE COVER; UNLIMITED EROSION AIR CONCENTRATION USING 85% VEGETATIVE COVER; LIMITED EROSION POTENTIAL DATA FOR ARSENIC

$$[Air_{fs50\%}] = (X)\,[Air_{fs85\%}]$$

where:

$[Air_{fs50\%}]$	=	Air concentration of COC assuming 50% vegetative cover and unlimited erosion potential ($\mu g/m^3$; pCi/m^3)
X	=	Ratio of 50% vegetative cover to 85% vegetative cover (3.33) (unitless)
$[Air_{fs85\%}]$	=	Air concentration of COC assuming 85% vegetative cover and limited erosion potential ($\mu g/m^3$; pCi/m^3)

$[Air_{fs50\%}]$	=	$[Air_{fs85\%}]$
$[Air_{fs85\%}]_{Ar}$	=	5.05E-04 $\mu g/m^3$ [a]
$[Air_{fs50\%}]$	=	(3.33) (5.05E-04 $\mu g/m^3$)
	=	1.68E-0 $\mu g/m^3$

Conversion to mg/m^3

$$\left(1.68E\text{-}03\ \frac{\mu g}{m^3}\right)\left(\frac{1\ mg}{1000\ \mu g}\right) = 1.68E\text{-}06\ mg/m^3$$

[a] Concentrations for Arsenic taken from John Pehrson's 3/2/94 data set. Fluor-Daniel 04424331-2AFS1, 3/2/94

FIGURE A.III-1 (Continued)

SAMPLE AIR CONCENTRATION/DEPOSITION CONVERSION CALCULATIONS

SAMPLE CALCULATION:

ON-PROPERTY FARMER RECEPTOR

ESTIMATION 50% VEGETATIVE COVER; UNLIMITED EROSION DEPOSITION RATE USING 85% VEGETATIVE COVER; LIMITED EROSION POTENTIAL DATA FOR ARSENIC

$$dd_{fs50\%} = (dd_{fs85\%})\ (X)\ (Y)$$

where:

$dd_{fs50\%}$	=	Deposition rate on-property for unlimited erosion potential and 50% vegetative cover
$dd_{fs85\%}$	=	Deposition rate off-property for limited erosion potential and 85% vegetative cover
X	=	Ratio of 50% vegetative cover to 85% vegetative cover (3.33) (unitless)
Y	=	Ratio of unlimited to limited erosion potential (3.95) (unitless)

$dd_{fa50\%}$	=	$(dd_{fs50\%})$ (X) (Y)
$dd_{fs50\%}AR$	=	3.95E-01 $\mu g/m^2/yr$[b]
	=	(3.95E-01 $\mu g/m^2/yr$) (3.33) (3.95)
	=	5.19 $\mu g/m^2/yr$

Conversion to $mg/m^2/r$:

$$\left(\frac{5.195}{m^2}\right)\left(\frac{1\ mg}{1000}\right)\left(\frac{1}{365\ days}\right)\left(\frac{1}{24\ HR}\right) = 5.9E{-}07\ mg/m^2/hr$$

[b] Deposition rate for arsenic taken from John Pehr5son's 3/16/94 IFP data set. Flour-Daniel 04424331-2AFS1 3/16/94

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FIGURE A.III-2

SAMPLE INTAKE/RISK CALCULATIONS

SAMPLE CALCULATIONS (Calculations do not reflect values used to calculate PRG)

ON-PROPERTY FARMER

ESTIMATION OF DIRECT CONTACT AND INDIRECT CONTACT SOIL RISK FOR ARSENIC:

INGESTION[b] $= (C_s)(IR)(FI)(EF)(ED)(CF)/(BW)(AT)$

$$= \frac{(6.9\ mg/kg)\ (180\ mg)\ (1.0)\ (350)\ (70)\ (10^{-6}\ kg/mg)}{(70\ kg)\ (25550\ days)}$$

$$= \frac{3.04E{+}01\ mg}{1.8E{+}06\ kg\text{-}day}$$

$$= 1.7E{-}05\ mg/kg\text{-}day$$

INGESTION RISK $= (CDI)(SF) = (1.75E{-}05\ mg/kg\text{-}day)(1.8E{+}00\ (mg/kg\text{-}day)^{-1}) = 3.15E{-}05$

DERMAL CONTACT[b] $= \dfrac{(C_s)(CF)(SA)(AF)(ABS)(EF)(ED)}{(BW)(AT)}$

$$= \frac{(6.9\ mg/kg)(10^{-6}\ kg/mg)(5750\ cm^2)(1.0\ mg/cm^2)(10^{-3})(350\ events/yr)(70\ yrs)}{(70\ kg)(25550\ days)}$$

$$= \frac{9.72E{-}01\ mg}{1.8E{+}06\ kg\text{-}day}$$

$$= 5.4E{-}07\ mg/kg\text{-}day$$

FIGURE A.III-2 (Continued)

SAMPLE INTAKE/RISK CALCULATIONS

ON-PROPERTY FARMER

DERMAL CONTACT RISK = $(CDI)(SF) = (5.4E\text{-}07\ mg/kg\text{-}day)(1.8(mg/kg\text{-}day^{-1})) = 9.72E\text{-}07$

INHALATION OF PARTICULATES = $(C_A)(IR)(ET)(EF)(ED)/(BW)(AT)$

$$= \frac{(1.68E\text{-}06\ mg/m^3)(0.83m^3/hr)(5.7\ hr/day)(350\ days/yr)(70\ yr)}{(70\ kg)(25550\ day)}$$

$$= 1.95E\text{-}01\ mg/1.8E\text{+}06\ kg\text{-}day = 1.08E\text{-}07\ mg/kg\text{-}day$$

INHALATION RISK = $(CD)(SF) = (1.08E\text{-}07\ mg/kg\text{-}day)(1.5E\text{+}01(mg/kg\text{-}day)^{-1}) = 1.62E\text{-}06$

INGESTION OF DUST AFFECTED[c,d] HOMEGROWN PRODUCE = $(C_{IV})(CF)(IR)(FI)(EF)(ED)/(BW)(AT)$

$$= \frac{(3.29E\text{-}01\ mg/kg)(.001\ kg/g)(122\ g/day)(0.5)(350\ days/yr)(70\ yrs)}{(70\ kg)(25550\ days)}$$

$$= \frac{4.92E\text{+}02\ mg}{1.8E\text{+}06\ kg\text{-}day}$$

$$= 2.73E\text{-}04\ mg/kg\text{-}day$$

RISK DUE TO INGESTION OF DUST AFFECTED HOMEGROWN PRODUCE = $(CDI)(SF) = (2.73E\text{-}04\ mg/kg\text{-}day)(1.8(mg/kg\text{-}day)^{-1})$

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FIGURE A.III-2 (Continued)

SAMPLE INTAKE/RISK CALCULATIONS

ON-PROPERTY FARMER

INGESTION OF DUST[b, c] AFFECTED BEEF

$$= \frac{(C_{IA})(CF)(IR)(EF)(ED)}{(BW)(AT)}$$

$$= \frac{(4.24E-02\ mg/kg)(.001\ kg/g)(75\ g/day)(350\ days/yr)(70\ yrs)}{(70\ kg)(25550\ days)}$$

$$= \frac{7.79E+01\ mg}{1.8E+06\ kg-day}$$

$$= 4.33E-05\ mg/kg-day$$

RISK DUE TO INGESTION OF DUST AFFECTED BEEF

$$= (CDF)(SF) = (4.33E-05\ mg/kg-day)(1.8\ (mg/kg-day^{-1}))$$

$$= 7.79E-05$$

FIGURE A.III-2 (Continued)

SAMPLE INTAKE/RISK CALCULATIONS

ON-PROPERTY FARMER

INGESTION OF DUST[b, c] AFFECTED MILK $= (C_{IM})(IR)(EF)(ED)/(BW)(AT)$

$$= \frac{(1.27E-03\ mg/L)(0.3\ L/day)(350\ days/yr)(70\ yrs)}{(70\ kg)(25550\ days)}$$

$$= \frac{9.33\ mg}{1.8E+06\ kg-day}$$

$$= 5.19E-06\ mg/kg-day$$

RISK DUE TO INGESTION OF DUST AFFECTED MILK $= (CDI)(SF) = (5.19E-06\ mg/kg-day)(1.8(mg/kg-day)^{-1}) = 9.34E-06$

TOTAL RISK FROM ARSENIC SOIL EXPOSURE = INHALATION RISK + INGESTION OF SOIL RISK + INGESTION RISK DUST AFFECTED PRODUCE + DERMAL CONTACT SOIL + INGESTION RISK DUST AFFECTED BEEF + INGESTION RISK DUST AFFECTED MILK

$$= (1.62E-06)+(3.15E-05)+(9.72E-07)+(4.91E-04)+(7.79E-05)+(9.34E-06)$$

$$= 6.12E-04$$

[a] Concentration for arsenic taken from John Perhrson's 3/2/94 data set. Fluor-Daniel 04424334-2AFS1, 3/2/94
[b] For parameter values, please refer to Attachment 1, Fernald Risk Assessment Policy
[c] Refer to Section 2.0 of the February 18, 1994 BLRA for detailed discussion on calculation of contaminants in homegrown produce, and animal products

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LIST OF ACRONYMS

ASL	Analytical Support Level
ASTM	American Society for Testing and Materials
CERCLA	Comprehensive Environmental Response, Compensation, and Stability Act of 1980
CLP	Contract Laboratory Program
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
E_h	Oxidation/reduction potential
FEMP	Fernald Environmental Management Project
FS	Feasibility Study
IT	International Technology Corporation
ITAS	International Technology Corporation Analytical Services
K_d	Partition coefficients
Kg	Kilogram
L	Liter
mg	Milligram
mL	Milliliter
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
μg/g	Micrograms per gram

APPENDIX D.1

MODIFIED PRELIMINARY REMEDIATION GOAL DEVELOPMENT

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APPENDIX D.1

MODIFIED PRELIMINARY REMEDIATION GOAL DEVELOPMENT

D.1.1 INTRODUCTION

The purpose of Appendix D.1 is to present the details of the approach used to determine the Operable Unit 2 FS modified soil Preliminary Remediation Goals (PRGs), which are protective of the perched groundwater and Great Miami Aquifer groundwater. A modified soil PRG is defined as the concentration of a contaminant in soil which is allowed to remain in place above background concentrations that will not create a groundwater concentration which exceeds a selected risk-based water criteria at the exposure point. A modified soil PRG considers inter-media migration of contamination and it is typically developed using a fate and transport model. In contrast, PRGs are media specific (i.e., groundwater, soil, etc.) allowable contaminant concentrations. PRG development does not consider inter-media migration of contamination and are not developed using fate and transport models. Groundwater PRGs are typically used as the criteria at the selected exposure point for the development of modified soil PRGs.

Modified soil PRGs are required to evaluate the two Operable Unit 2 proposed land use scenarios, private ownership, and continued federal ownership. For each land use scenario there are potential receptors, such as on- and off-property resident farmers and the expanded trespasser. The future land use scenario with private ownership evaluates remediation strategies which are protective of the on- and off-property resident farmer. The future land use scenario with federal ownership evaluates remediation strategies which are protective of the expanded trespasser and the off-property resident farmer.

For each land use scenario, modified soil PRGs can be used to evaluate alternatives for remediation of Operable Unit 2 waste units. Engineering analyses can then be completed for each alternative to develop final designs for the alternative. A final design for an alternative includes an estimate of residual contaminant concentrations to be left in place and an estimate of the contaminant concentrations to be remediated. The residual contaminant concentrations would be less than or equal to modified soil PRL. A modified PRL is equal to modified soil PRG plus background soil concentration. The collective impact of these alternatives can then be evaluated, using a more

complex fate and transport model, to ensure that the final design is in compliance with health-based criteria.

D.1.1.1 Technical Approach

The approach to the fate and transport modeling used for modified soil PRG development is discussed within the following subsections. The approach is presented in four subsections including objective, two-step approach, model capabilities, and confirmation modeling.

Objective

Modified soil PRLs which are protective of perched and GMA groundwater are required to determine the preliminary vertical and horizontal extent of remediation required for a specific land use and potential receptor being evaluated for a waste unit and/or the appropriate technologies to be used for remediation. Modified soil PRLs can be compared with current soil contaminant concentrations in the waste and the underlying geological units of the waste unit to determine the necessary extent of remediation.

The approach to the fate and transport modeling was to conduct modified soil PRG development using a screening model in order to evaluate numerous conditions in a time efficient manner. Modified soil PRGs were required for the Solid Waste Landfill, Inactive Flyash Pile, South Field and Active Flyash Pile waste units since each of these waste units had COCs which had the potential to adversely impact groundwater. The Lime Sludge Pond had no COCs which impacted groundwater therefore no modified soil PRGs were necessary for this Operable Unit 2 waste unit.

The COCs which impacted groundwater are listed in the Baseline Risk Assessment, Section 6.3 of the Operable Unit 2 RI. The Solid Waste Landfill had COCs which impacted the perched water while the Inactive Flyash Pile, South Field and Active Flyash Pile had COCs which impacted the GMA. The COCs for each waste unit will be presented in the model input section for the individual waste unit. A detailed description of the approach for development for modified soil PRGs which are protective of perched groundwater is presented in Section D.1.1.2, while a description of the approach for development modified soil PRGs which are protective of GMA groundwater is given in Section D.1.1.3.

Two-Step Approach

A "Two-Step Approach" to modified soil PRG development was used for the Operable Unit 2 FS. The approach includes developing modified soil PRGs for Operable Unit 2 waste units using a screening model and then confirming the cumulative impact of the remedial alternatives which are based on modified soil PRGs, with a more complex fate and transport model. The screening model used for modified soil PRG development was the ECTran model. This model is described in detail in the following subsection. The confirmation modeling to quantify the collective impact of the remedial alternatives (i.e., alternatives based on the modified soil PRGs) was performed using the ODAST/SWIFT model. A brief description of the ODAST/SWIFT models' capabilities is given in the ODAST/SWIFT Model Confirmation subsection.

The ECTran model was used for modified soil PRG development because it can evaluate numerous fate and transport conditions in a time efficient manner due to the simplified equations used in the model. The run time to evaluate one alternative using ECTran, which involves multiple iterations, is approximately 3 minutes. The ECTran model is effective for evaluating individual waste unit modified soil PRGs, without including the impact of other waste unit's contamination. The ODAST/SWIFT model, which takes a considerable amount of time to execute, was used to quantify the residual future impact under post-remediation conditions of the waste units. The run time to use the ODAST/SWIFT model is almost 27 hours for only one iteration. Multiple iterations are typically required to determine an acceptable modified soil PRG, therefore the ODAST/SWIFT model could not be used effectively to develop numerous modified soil PRGs for multiple remedial scenarios. In addition, ODAST/SWIFT was not used to verify all modified soil PRGs developed using ECTran since this would defeat the purpose of using a simplified, time-efficient model to develop modified soil PRGs. The ODAST/SWIFT model also considers the cumulative impact of adjacent waste units, once residual contaminant concentrations are determined for the waste units.

The modified soil PRGs, which were developed using ECTran, are the soil COC concentrations which can be left in addition to background COC concentrations. Background soil concentrations can be added to modified soil PRGs because background soil concentrations are assumed to have a minimal contribution to the liquid phase (dissolved) concentration in the groundwater. The following paragraphs describe the rationale that was used to support the use of this approach.

Although the contaminant adsorption/desorption process is usually considered to be reversible in fate and transport modeling, in general, the longer a chemical remains adsorbed to the surface of a solid the more likely it is to be chemically incorporated into the solid by surface reactions (i.e, absorption) where it is no longer available for desorption under normal environmental conditions. For example, natural uranium that is absorbed to soil is not readily leachable when reacting with rain water, therefore background uranium in the soil is a negligible source to the dissolved uranium concentration in the groundwater. An indication of this phenomena at the FEMP is the high ratio (i.e., K_d above 1200 L/kg) between the background solid and liquid phase uranium concentrations. In contrast, uranium in the solid waste material and its leachate has a much lower partition coefficient (i.e., K_d below 200 L/kg) and higher mobility in the subsurface environment, when compared to the natural background uranium, due to its chemical forms and relatively short contact time with soil. This difference between natural/background and contaminant uranium is considered in the modified soil PRG development process.

During the modified soil PRG development process, the uranium from the waste material is considered the sole source of future groundwater contamination at the FEMP. Therefore, area-specific partition coefficients and other geochemical parameters (i.e., retardation factor and portion of leachable mass) for the contaminant uranium instead of the natural uranium are used in the ECTran model for modified soil PRG development. As a result, the modified soil PRGs determined by the model represent the acceptable uranium concentration above the background concentration and not the total uranium (i.e., the modified soil PRG plus the background concentration).

The large scale GO/UGMAS model, which was developed by Operable Unit 5 to evaluate 3-dimensional contaminant migration in the large coarse-grain material lenses in the glacial overburden, was not used for the Operable Unit 2 FS modified soil PRG development. For Operable Unit 2, an alternative method was used to quantify the local lateral migration of perched water toward the edge of till in the South Field area where the glacial till pinches out and the perched water can vertically migrate into the GMA. The HELP model in conjunction with current perched water contours were used to estimate the total flow rate of migrating perched water. The HELP model was used to estimate the amount of lateral infiltration migrating on top of the till. An average gradient from the perched water contours along with an average hydraulic conductivity was used to estimate the flow rate in the perched water zone. The HELP model was also used to estimate local vertical infiltration rates for the four Operable Unit 2 waste units for which modified soil PRGs were developed.

ECTran Model Capabilities and Data Requirements

The ECTran model is a groundwater contaminant fate and transport model, implemented in Excel 4.0®, a registered trademark of Microsoft. ECTran which was developed to support the Remedial Investigation/Feasibility Study (RI/FS) processes at the FEMP. The Crystal Ball 3.0 ® add on module for Excel, a registered trademark of Decisioneering, Inc., can be used with the ECTran model to perform Monte Carlo simulations. The ECTran model is a screening-level model that can be utilized to supplement more complex fate and transport models during parameter estimation, risk assessment, cleanup goal development, Alternate Concentration Limit (ACL) determination, and stoichastic sensitivity analysis. The model is based on straight-forward mass-balances and advection/dispersion analytical equations, but can be used to simulate a variety of complex conditions. Earlier versions of the ECTran model, which were unnamed and used for sites unrelated to the FEMP, have been employed to determine soil cleanup goals, ACLs, cleanup time estimations, and to support baseline risk assessments for both CERCLA and RCRA sites in U.S. EPA Regions III, VI, and X. The types of sites for which the earlier versions of ECTran were used include landfill sites, chemical manufacturing facilities, and several U.S. Air Force bases. The complete summary of the ECTran model's capabilities, development processes, and the proposed applications of the screening-level spreadsheet-based groundwater contaminant fate and transport model are presented in Attachment D.1.I of this appendix.

Highlights of the ECTran model's capabilities include the following:

- Analytical 1-dimensional flow and transport model without dispersion in the vadose zone.
- Analytical 1-dimensional flow and transport model with 2-dimensional dispersion in the saturated zone.
- Accepts zone-specific and layer-specific contaminant initial concentrations, decay rates and distribution coefficients.
- Can be separately and flexibly applied in any localized source area.
- Age of source can be considered to estimate the current down-gradient concentrations.
- Capability of including an additional/secondary source loading from the glacial overburden into the lower unsaturated layer.
- Can be used to consider impacts of pumping and/or containment in the source area on the exposure point concentrations.

- Uses any specified groundwater flow conditions directly.
- Considers contaminated or clean up-gradient groundwater recharge.
- Uses mixing depth concept in the saturated zone instead of the thickness of the entire saturated zone in the aquifer.
- Calculates layer-specific and zone-specific contaminant concentrations versus time.
- Presents the output statistically and graphically without the need for post-processing.
- Calculates concentrations at the projected centerline of the contaminant plume at the FEMP fence/property line.
- Layer-specific and zone-specific PRGs can be developed using the model.
- The model requires minimal run time so that many scenarios can be investigated.

The ECTran model inputs include site-specific hydrogeologic and chemical information as well as physical information about the site. Hydrogeologic information such as vertical and horizontal hydraulic conductivity, hydraulic gradient, porosity, vertical and horizontal groundwater velocities, percent saturation, soil density, fraction of organic content, dispersion coefficient and infiltration rate are all necessary model inputs. The typical chemical information for model input varies depending on the type of chemical to be modeled (i.e., radionuclide, organic, or inorganic). For the Operable Unit 2 FS the only COCs which impacted the groundwater were radionuclides and organics. The typical chemical input for radionuclides includes distribution coefficient (K_d), half-life, specific activity, and current soil COC concentrations. Chemical input for organics includes K_d, half-life, and current soil COC concentrations. Necessary physical information about the site, which would be used as model input, includes the dimensions of the waste unit, detailed description of the waste unit's underlying geology, the waste units orientation with respect to groundwater flow, and its distance from the selected exposure point.

ODAST/SWIFT Model Confirmation of the Final Impacts

The ODAST and improved SWIFT models were used to perform confirmation modeling. The confirmation modeling was performed for the selected Operable Unit 2 FS remedial alternatives and the results are presented in Appendix D.3.

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The ODAST/SWIFTLOAD model was used in the Operable Unit 2 FS confirmation modeling to define vertical contaminant transport from contaminated soil or perched water to the GMA. The ODAST model, which is a subroutine of SWIFTLOAD, evaluates the basic one dimensional analytical solute transport equation as a function of seepage velocity, dispersion coefficient, source decay, retardation factor, depletion time, and source rate.

The improved SWIFT model, which was used for the Operable Unit 2 FS, is a revised version of the model used for the Operable Unit 2 RI. The model was revised to incorporate the improvements specified in the Groundwater Modeling Evaluation Report and Improvement Plan, April 1993. Several improvements were made to the SWIFT model and they include: (1) increasing the vertical resolution (i.e., more layers), (2) recalibration of the flow and transport portions of the model based on the results of the South Plume Pump Test Study and Kriging analysis, respectively, and (3) incorporating a larger model area to the south and east to include the Great Miami River and the SOWC collections wells. The SWIFT code was used for simulating three dimensional contaminant transport in the GMA. The SWIFT code is a fully coupled, transient, 3-dimensional finite difference model for groundwater flow and transport through both porous and fractured media.

The Operable Unit 1 confirmation modeling task was performed for the Operable Unit 1 FS. The results of modeling showed that the modified soil PRGs based on the ECTran model's results were reasonable but conservative. Residual concentrations after remediation were used to evaluate the cumulative impact of the selected alternatives using the ODAST/SWIFT model. The ODAST/SWIFT model's simulated groundwater concentrations were consistently lower for modified soil PRG development and cumulative impact modeling. Similar results were also found during the Operable Unit 2 FS confirmation modeling task (see Appendix D.3).

D.1.1.2 Modified Soil PRGs Which Are Protective of Perched Groundwater

Contaminant concentrations in soil layers which overlie the perched groundwater zone must be reduced to levels which will not create contaminant concentrations in the perched groundwater which exceed health-based standards. Modified soil PRGs are the acceptable soil concentrations which can be left in addition to background in the soil layers overlying the perched groundwater zone. Figure D.1-1 shows the logic used for the development of modified soil PRGs which are protective of perched groundwater. Modified soil PRG development is influenced by several factors, including the COCs, future land use scenarios, potential exposure points, remedial alternatives, risk-based water

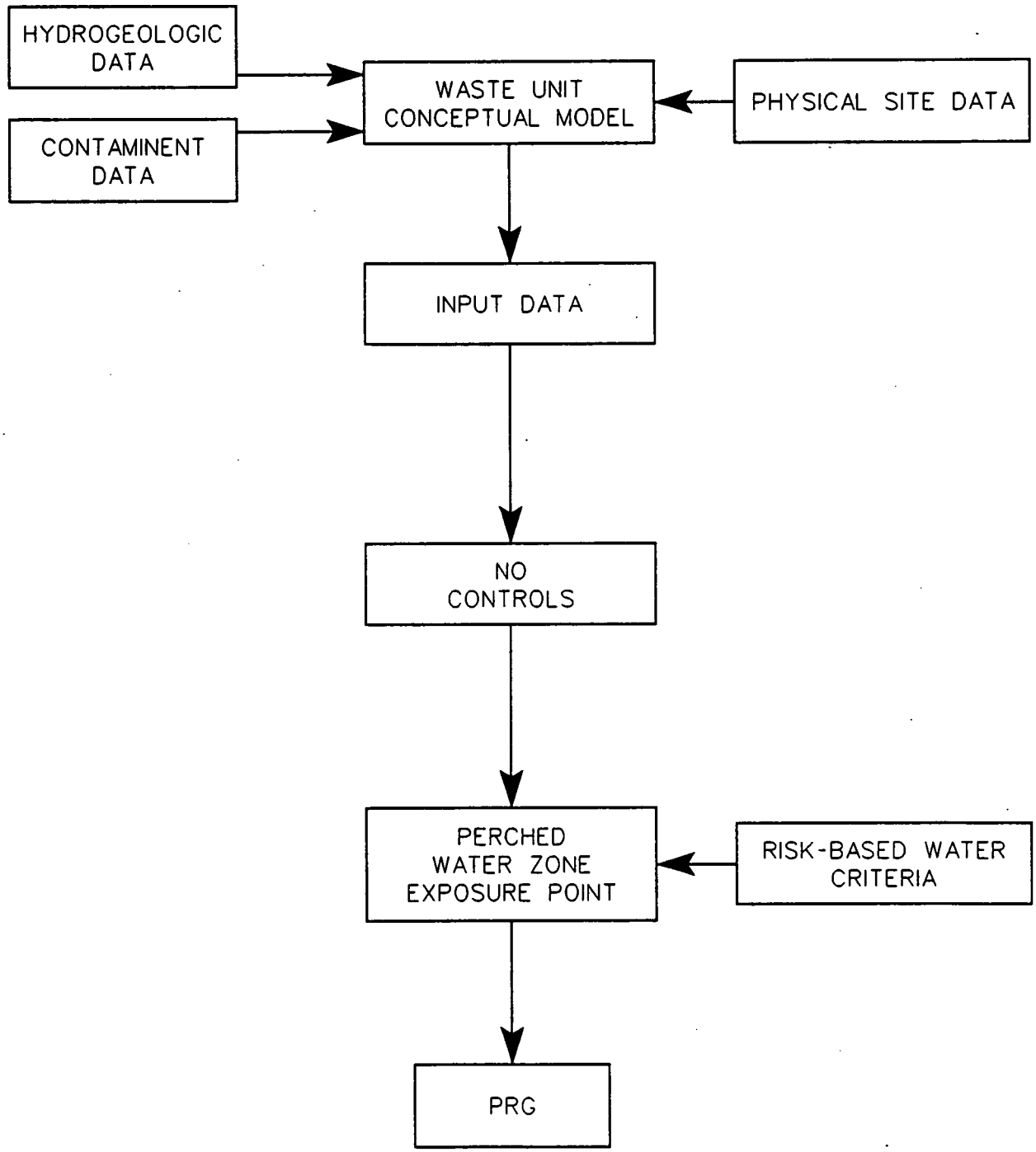

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FIGURE D.1-1
FLOW CHART OF THE MODIFIED PRELIMINARY
REMEDIATION GOAL MODELING PROCESS
FOR THE PROTECTION OF PERCHED GROUNDWATER

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criteria, the conceptual model used for representing the waste unit and transport media, and the analytical or numerical model used in the modified soil PRG development modeling. Each of these factors, which are applicable to the Solid Waste Landfill, are discussed in Section D.1.2.

The Solid Waste Landfill source area size used for modified soil PRG development was the actual dimensions of the waste unit. The reason for using the actual size is that the source dimensions are well defined for the Solid Waste Landfill unlike the other three Operable Unit 2 waste units for which modified soil PRGs were developed. Hydrogeologic and geologic information for the Solid Waste Landfill were taken from a typical SWIFT grid block used to depict the Solid Waste Landfill and were assumed to be applicable for the entire Solid Waste Landfill .

The approach for using the ECTran model for modified soil PRG development for protection of perched groundwater is outlined below:

- Develop the appropriate conceptual model for the Solid Waste Landfill. As part of the conceptual model, summarize COC, exposure point, remedial alternative, and risk-based water criteria information for the Solid Waste Landfill .

- Determine all of the appropriate ECTran model input for the scenario which is to be evaluated and enter data into the model.

- Assign the risk-based water criteria as the acceptable groundwater concentration at the selected perched groundwater exposure point in the ECTran model.

- Assuming the source area is at background (i.e., no source), use the ECTran model to iteratively back calculate the acceptable soil concentrations in the till/glacial overburden (i.e, gray clay) so that the perched groundwater concentration does not exceed the risk-based water criteria at the perched groundwater exposure point. The acceptable level for glacial overburden is constrained by the current soil concentration. In other words, modified soil PRGs in the till/glacial overburden will be less than or equal to the current soil concentrations.

- Assuming glacial overburden is at the modified PRG concentration developed in step (4), use the ECTran model to iteratively back calculate the acceptable soil concentration (modified PRG) for waste/fill, so that the perched water concentration does not exceed the risk-based water criteria at the exposure point.

- Continue procedure until modified soil PRGs are developed for all Solid Waste Landfill COCs.

D.1.1.3 <u>Modified Soil PRGs Which Are Protective of GMA Groundwater</u>

Contaminant concentrations in soil layers which overlie the GMA must be reduced to levels which will not create contaminant concentrations in the GMA groundwater which exceed health-based standards. Modified soil PRGs are the acceptable soil concentrations which can be left in addition to background in the soil layers overlying the GMA. Figure D.1-2 outlines the technical approach used for the development of modified soil PRGs which are protective of GMA groundwater.

Modified soil PRG development is influenced by several factors, including the COCs, potential exposure points, remedial alternatives, risk-based water criteria, the conceptual model used for representing the waste unit and transport media, and the analytical or numerical model used in the PRG development modeling. These factors are discussed in Sections D.1.3, D.1.4 and D.1.5, which are the sections which present specific information for the Inactive Flyash Pile, South Field, and Active Flyash Pile, respectively.

The size of the area assumed to be a source for the Inactive Flyash Pile, South Field, and Active Flyash Pile waste units during modified soil PRG development was 38 x 38 meters (125 x 125 feet). This source size was chosen because it is the same size as the SWIFT grid block used to model the GMA. There are several reasons for adopting the SWIFT grid block size and they include: (1) The geologic and hydrogeologic information used in the ODAST/SWIFT model was available for each SWIFT grid block and could be easily obtained and used in the ECTran model; (2) The HELP model was used to estimate lateral and vertical infiltration rates for each SWIFT grid block in the Inactive Flyash Pile, South Field and Active Flyash Pile areas and these values were used in the ECTran model; and (3) In general, each waste unit may include several small source areas which act independently and approximating the size of a typical "worst case" single source within a waste unit is a reasonable estimation.

The conceptual model used to describe a waste unit for modified soil PRG development to protect GMA groundwater identifies and incorporates the key hydrogeologic characteristics of the vadose and saturated zones of the waste unit, COC source information, and factors that control transport of the COCs to be modeled. Section 5 and Appendix A.2 of the Operable Unit 2 RI discuss the conceptual models used for the RI contaminant fate and transport modeling for the Inactive Flyash Pile, South Field and Active Flyash Pile. These conceptual models were also used for the Operable Unit 2 FS modified soil PRG development modeling. A general description of the vadose zone portion of the conceptual model used for the Operable Unit 2 FS is presented within this section to help describe the

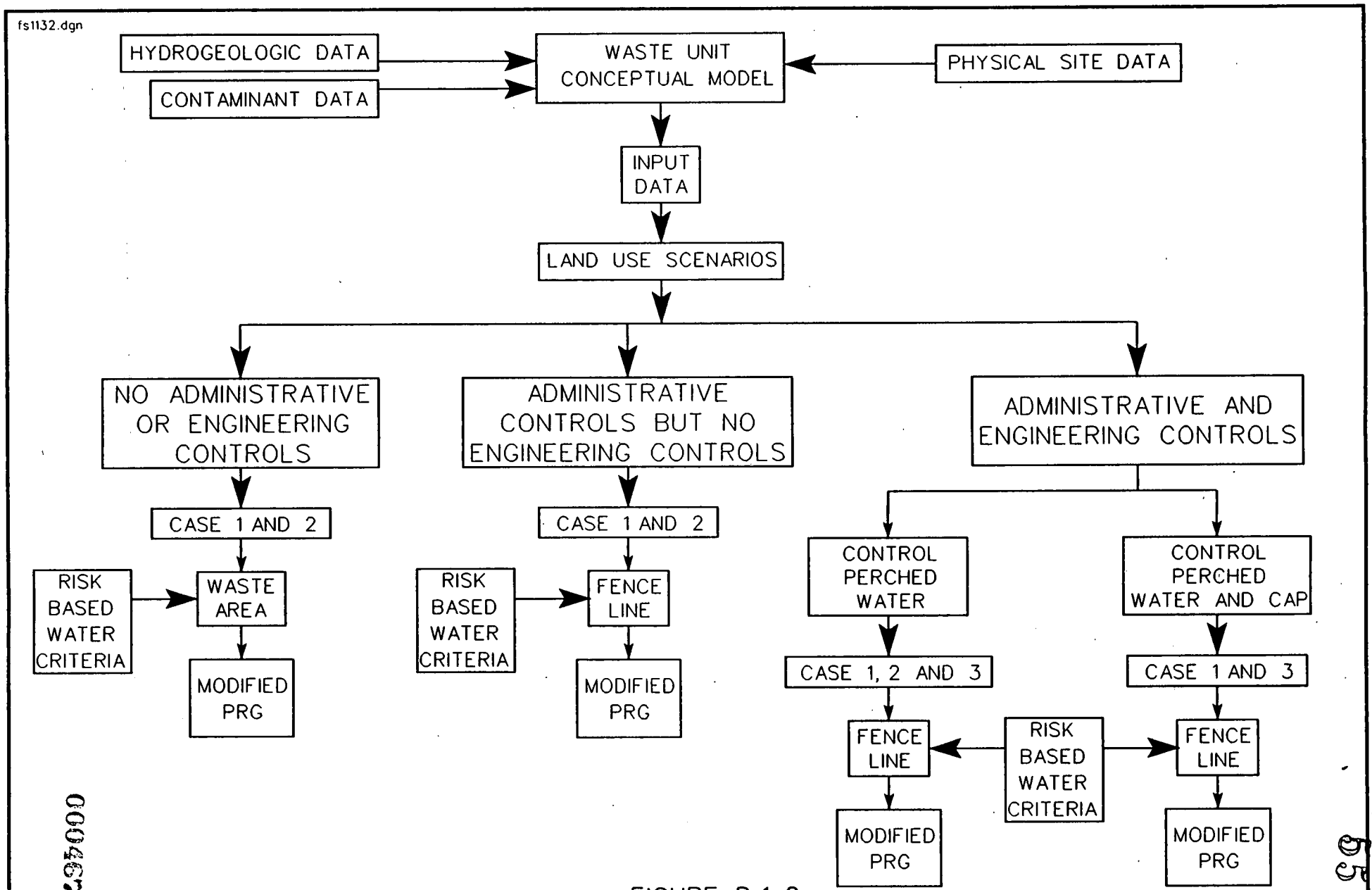

FIGURE D.1-2
FLOW CHART OF THE MODIFIED PRELIMINARY REMEDIATION GOAL MODELING PROCESS FOR THE PROTECTION OF GMA GROUNDWATER

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cases selected for modified soil PRG development. Conceptual models for each waste unit (i.e., Inactive Flyash Pile, South Field, and Active Flyash Pile) are presented later in each appropriate waste unit subsection.

The conceptual model for vadose zone transport is highly dependent upon the available vertical drainage pathways through each waste unit. Section 5.4.2.2, Vadose Zone Modeling, of the Operable Unit 2 RI presents a conceptual model of lateral drainage infiltrating to the unsaturated GMA. Figure D.1-3 shows the conceptual model of lateral drainage. The model shows that there are several pathways for infiltration and perched water to reach the GMA. For areas with glacial overburden/till, infiltration can migrate vertically or laterally across the top of the till. From the infiltration that migrates vertically, a portion will be intercepted in the perched water zone, while another fraction of it will continue to migrate vertically to the GMA. The perched water migrates laterally and discharges along the terrace of the till, mixes with the laterally migrating infiltration, and then discharges to the GMA in the area with no till. For areas with no till, infiltration migrates vertically to the GMA along with the lateral infiltration and perched water from the areas with till. Based on these various infiltration pathways, three different conceptual flow models were constructed for the three Operable Unit 2 waste units for which modified soil PRGs were developed.

The first case (Case 1) investigated areas of the waste units where there was no till and flow into the area included vertical infiltration, substantial lateral infiltration and perched water from other contaminated areas which had significant amounts of till. The south-eastern portions of the Active Flyash Pile, Inactive Flyash Pile, and South Field were typical Case 1 areas. Figure D.1-4 shows the Case 1 areas. The second case (Case 2) examined the same areas as Case 1 except with the assumption that the source material in the Case 1 area was removed and the lateral infiltration and perched water discharge into the area was the only source of contamination. The purpose of Case 2 was to determine the feasibility of removing waste overlying the unsaturated GMA in Case 1 areas and not controlling contaminated lateral infiltration and perched water coming from areas with significant till (i.e., Case 3). The third case (Case 3) analyzed areas where there is significant till and no appreciable lateral infiltration coming in from other areas. The north-western portions of the Active Flyash Pile, Inactive Flyash Pile, and South Field were typical Case 3 areas. Figure D.1-4 also shows the Case 3 areas. For modified PRG development, several remedial alternatives under each future land use scenario created different flow conditions which in turn had to be considered for each case (i.e., Case 1, 2, or 3). For the private ownership (no administrative or source controls)

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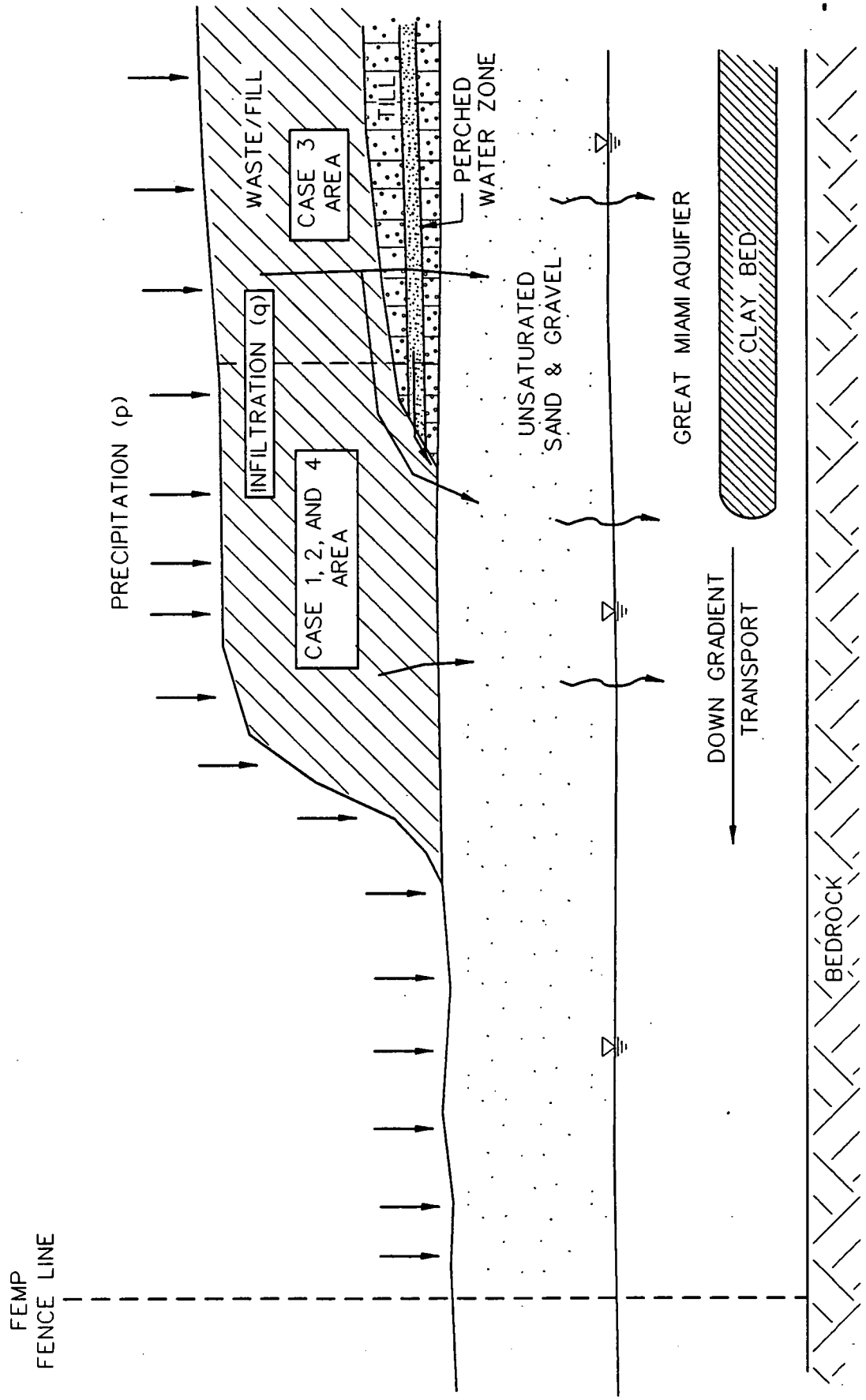

FIGURE D.1-3
CONCEPTUAL MODEL OF VERTICAL AND LATERAL INFILTRATION FOR THE OU2 WASTE UNITS

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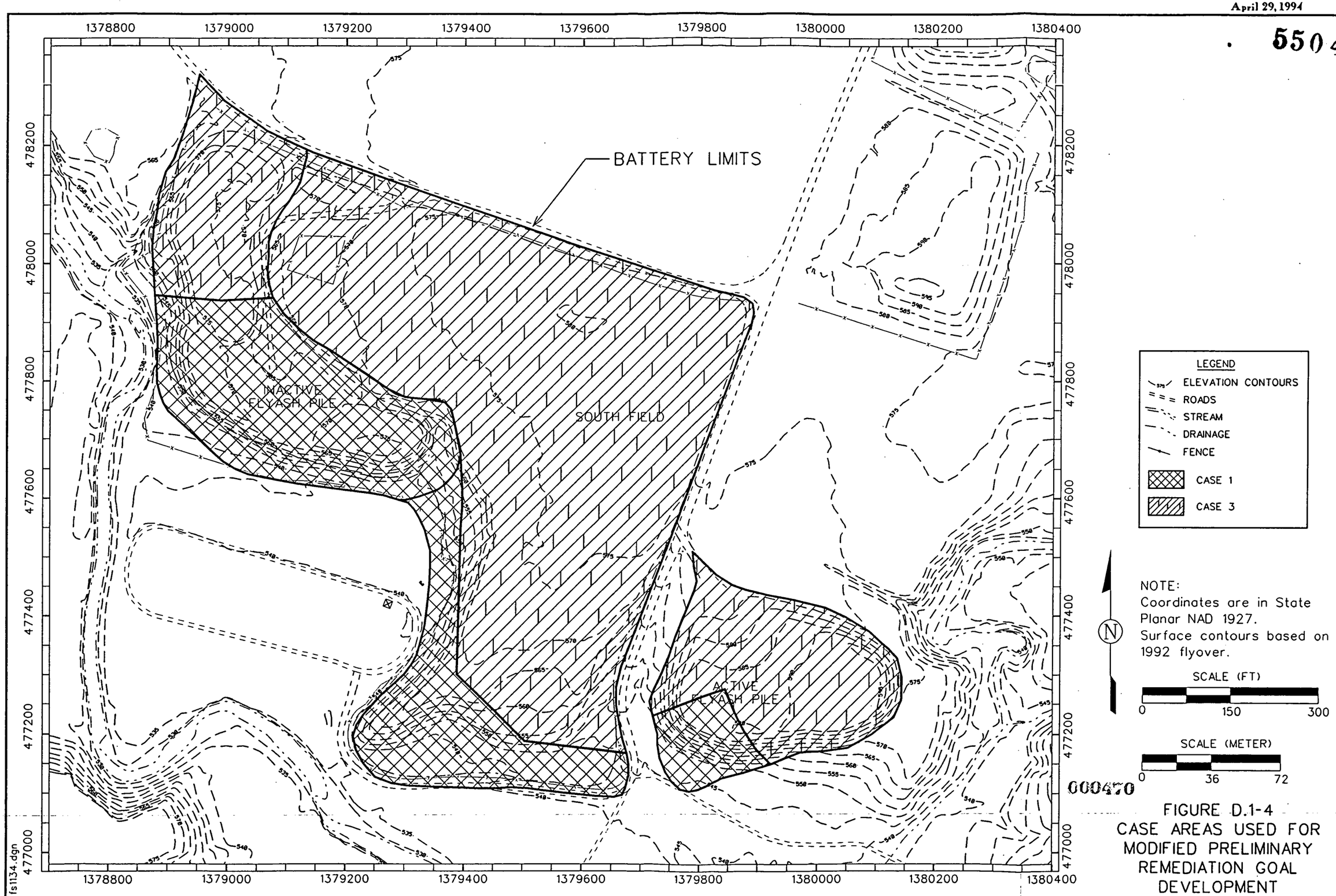

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FIGURE D.1-4
CASE AREAS USED FOR MODIFIED PRELIMINARY REMEDIATION GOAL DEVELOPMENT

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land use, the flow conditions were considered to be as they are currently presented in Figure D.1-3. However, under continued federal ownership (either administrative or source controls) land use, the flow conditions may be significantly different. For example, due to source controls, the perched water could be collected and not allowed to migrate laterally, consequently removing it as a migration pathway. Another alternative could be to cap an area and reduce vertical infiltration, which in turn would reduce the lateral infiltration which could come from the Case 3 area. Modified soil PRGs were developed for several combinations of each of these alternatives and a complete summary of all the modified PRGs which were developed are presented in each waste unit's section.

The approach for using the ECTran model for modified soil PRG development which is protective of GMA groundwater is outlined below:

- Develop the appropriate conceptual models for the Inactive Flyash Pile, South Field and Active Flyash Pile. As part of the conceptual models, summarize COC, exposure point, remedial alternative, and risk-based water criteria information for the Inactive Flyash Pile, South Field, and Active Flyash Pile .

- Determine all of the appropriate ECTran model input and enter the data into separate models; one for the Inactive Flyash Pile, South Field and Active Flyash Pile .

- Assign the appropriate risk-based water criteria as the acceptable groundwater concentration at the selected GMA exposure point in the ECTran model.

- Assume that glacial overburden/till and waste/fill is at background COC concentration, use the ECTran model to iteratively back calculate the acceptable soil concentrations in the unsaturated GMA (i.e., model layer 2) so that the GMA groundwater concentration does not exceed the risk-based water criteria at the selected exposure point. Use current unsaturated GMA concentrations as the upper limit on the acceptable soil concentrations.

- Assuming the unsaturated GMA is at the modified PRG concentration developed in Step (4), use the ECTran model to iteratively back calculate the acceptable soil concentration (modified PRG) for glacial overburden/till that the GMA concentration does not exceed the risk-based water criteria at the exposure point. The glacial overburden/till modified soil PRG is constrained by the current glacial overburden/till concentration.

- Assuming the unsaturated GMA and glacial overburden are at the modified PRG concentrations estimated in steps (4) and (5), use the ECTran model to iteratively back calculate the acceptable soil concentration for the source/waste material so that the GMA concentration does not exceed the risk-based water criteria at the exposure point. The source waste modified PRG is not constrained by current concentrations.

- Continue this procedure until modified soil PRGs are developed for all Inactive Flyash Pile, South Field, and Active Flyash Pile COCs.

D.1.2 SOLID WASTE LANDFILL

The Solid Waste Landfill occupies an approximate area of 1.5 acres and is located northwest of the former Production Area near the center of the FEMP property (see Figure D.1-5). The Solid Waste Landfill was capped with soil and currently has a grassy vegetation cover. The following sections describe the fate and transport modeling conducted for the Solid Waste Landfill to develop modified soil PRGs and summarizes the results.

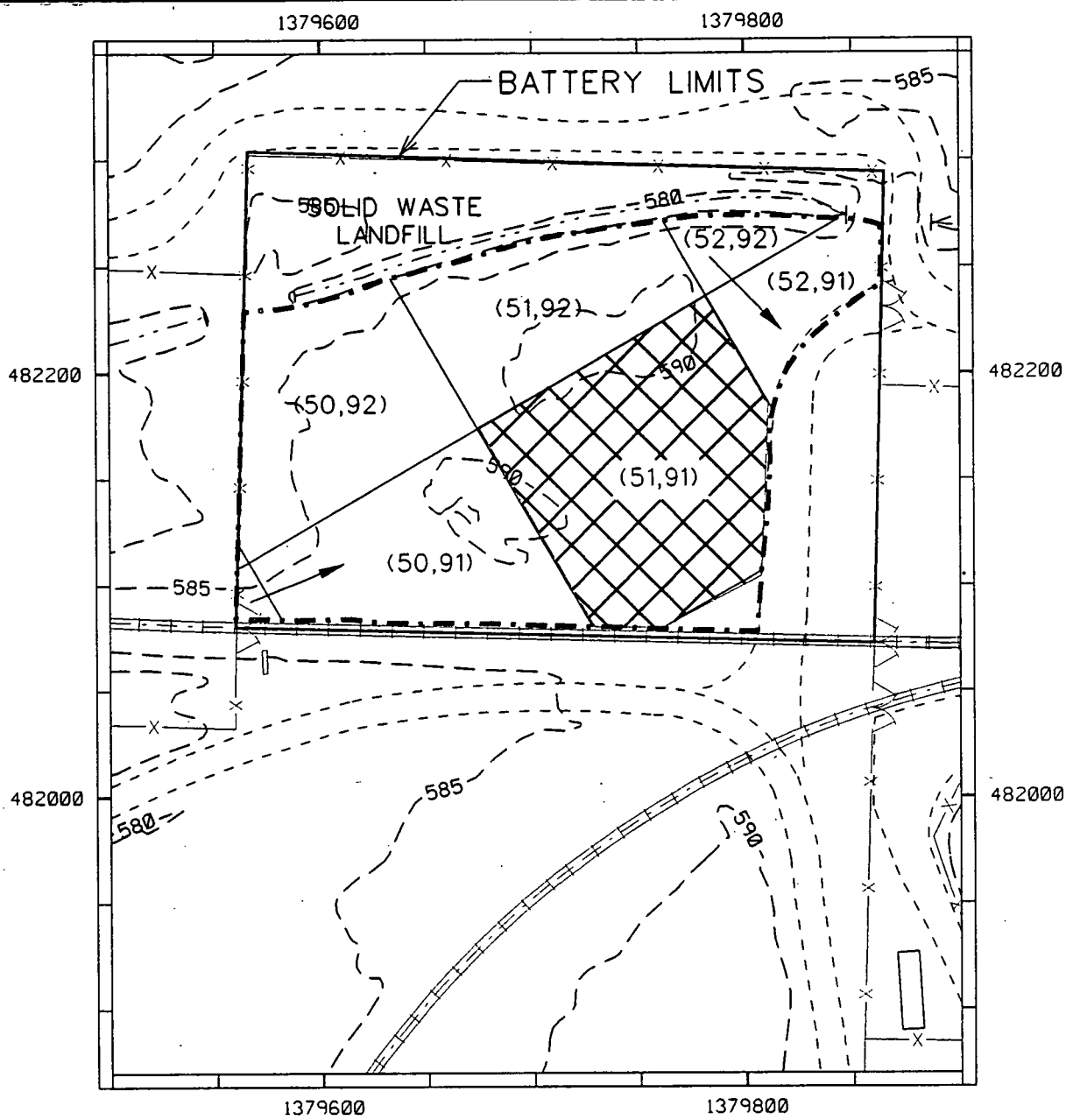
D.1.2.1 Conceptual Model

The conceptual model used to describe the Solid Waste Landfill for modified soil PRG development identifies and incorporates the key hydrogeologic characteristics of the waste unit and the underlying geologic units, COC source information, and factors that control transport of the COCs to be modeled. The following sections describe the conceptual model used for Solid Waste Landfill PRG modeling.

Hydrogeologic Conditions

For the Solid Waste Landfill, the conceptualized conditions can be summarized as follows: rainfall and surface water infiltrate through the surface of the Solid Waste Landfill, leaching of constituents from the source material into the dissolved phase occurs, and the contaminated leachate then percolates through the till/glacial overburden (gray clay) to the perched water aquifer. The perched groundwater is typically discontinuous under the Solid Waste Landfill and downgradient transport of contaminants was not considered. For PRG development this is a conservative approach since the closest exposure point, the perched groundwater under the source, will result in the lowest modified soil PRGs. Figure D.1-6 shows the conceptual model for the migration of infiltration from the source to the perched groundwater zone at the Solid Waste Landfill.

Vertical migration of infiltration was the only applicable type of flow for the Solid Waste Landfill. Hydrogeologic and geologic data from a SWIFT grid block, which is a three-dimensional finite difference cell in SWIFT which has its own hydrogeologic and contaminant transport parameters assigned to it, was used to represent the Solid Waste Landfill. The actual Solid Waste Landfill source area was used for PRG modeling. Grid block 51,91 was selected to depict the Solid Waste Landfill area for modified soil PRG development. The infiltration rates for all SWIFT grid blocks for the Solid Waste Landfill area were the same. Block 51,91 was selected since it has average till and unsaturated sand and gravel layer thicknesses. This block is highlighted in Figure D.1-5.



LEGEND

- 575 ELEVATION CONTOURS
- ROADS
- DRAINAGE
- FENCE
- RAILROAD
- EXTENT OF WASTE
- WASTE FROM CELL IS INCLUDED IN OTHER CELL
- (51,91) SWIFT MODEL CELL (COLUMN, ROW)

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)

0 40 80 160

FIGURE D.1-5
LOCATION MAP AND MODELED SWIFT GRID BLOCKS, SOLID WASTE LANDFILL

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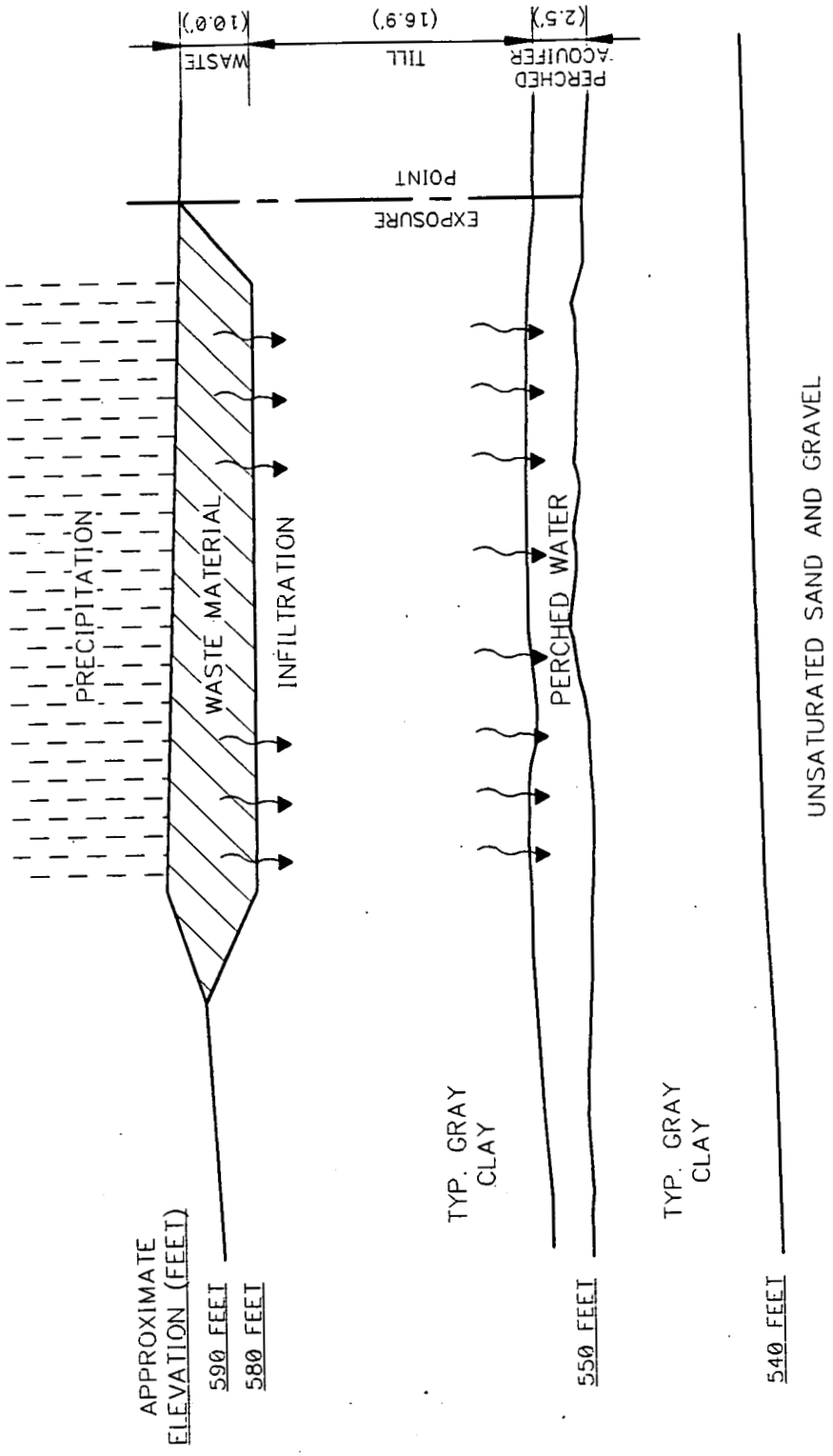

FIGURE D.1-6
CROSS SECTION WITH TYPICAL WASTE UNIT GEOLOGY AND INFILTRATION PATTERNS
SOLID WASTE LANDFILL
NOT TO SCALE

CAD: C:\NG96\CRU2\CONMODEL.DWG 3/17/94 MB P-SOLID, SOLID

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COCs

Modified soil PRGs were developed for all Operable Unit 2 COCs which pose a risk through the perched groundwater exposure pathway. The Solid Waste Landfill had two COCs which could potentially impact perched groundwater, technetium-99 and carbazole.

Potential Exposure Points

Due to the discontinuous nature of the perched groundwater zone, the only applicable perched water exposure point for modified soil PRG development was the perched water directly below the site (See Figure D.1-6). The potential receptor for the perched water was the on-property resident farmer.

D.1.2.2 Remedial Scenarios Evaluated

For private ownership land use, one potential Operable Unit 2 remedial alternative for the Solid Waste Landfill was investigated for modified soil PRG development. The alternative includes removal of all contaminated soil above the modified soil PRL concentrations, replacement with clean soil, and no capping (i.e., clean closure).

D.1.2.3 Model Input

The following sections summarize the data used as input to the ECTran model for Solid Waste Landfill modified soil PRG development. A majority of the input was taken directly from the Operable Unit 2 RI fate and transport modeling sections. Other input was calculated from data presented in the Operable Unit 2 RI or previous reports.

Hydrogeologic Conditions

Table D.1-1 shows the general hydraulic parameters and physical dimensions of the Solid Waste Landfill. The physical dimensions of the site were taken from the Operable Unit 2 RI and the layer thicknesses presented are for the appropriate SWIFT grid block. Table D.1-2 displays the soil media parameters used for the Solid Waste Landfill. All of these soil parameters were taken directly from the Operable Unit 2 RI. The Solid Waste Landfill infiltration rates for the No Cap scenario are presented in Table D.1-1. The no capping infiltration rates were estimated in the Operable Unit 2 RI using the HELP model.

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TABLE D.1-1

HYDRAULIC PARAMETERS AND PHYSICAL DIMENSIONS OF SOLID WASTE LANDFILL MODIFIED PRG DEVELOPMENT

Parameter	Input Value
Length	261 ft
Width	175 ft
Waste Thickness	10.0 ft
Till Thickness (Source)	16.9 ft
Perched Groundwater Zone Thickness	2.5 ft
Infiltration Rate for No Capping Scenario	9.03 in/yr

Note: Swift Grid Block - (51, 91)

TABLE D.1-2

SUMMARY OF SOIL MEDIA PARAMETERS FOR THE SOLID WASTE LANDFILL MODIFIED PRG DEVELOPMENT

Soil Media Parameter	Till	Perched Aquifer
Porosity (%)	41	39
Bulk Density (g/cc)	1.85	1.60
Organic Content (%)	1.43	0.87
Moisture Content (%)	37	39
Saturation	0.90	1.00

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Chemical Characteristics

The target risk-based water criteria level (1×10^{-6}) was used for the development of modified soil PRGs for the Solid Waste Landfill. The chemical-specific criteria were developed as part of the Operable Unit 2 RI Baseline Risk Assessment. The criteria represents a chemical-specific groundwater concentration which presents 1×10^{-6} cancer risk due to the perched groundwater exposure pathway. Table D.1-3 presents a summary of the chemical/geochemical data for the two Solid Waste Landfill COCs. Also shown in the table are the target 1×10^{-6} risk-based water criteria used for modified soil PRG development.

Current COC Concentrations

Current Solid Waste Landfill soil COC concentrations included concentrations in the source and till. Table D.1-4 shows the current COC soil concentrations for the source and till. These concentrations were estimated as part of the Operable Unit 2 FS and a description of how the concentrations were estimated is presented in Appendix A, Sampling Results for COCs.

D.1.2.4 Model Verification With Measured Conditions

The ECTran model was not used to estimate current contaminant concentrations in the perched water for the Solid Waste Landfill. From the available measurements, technetium-99 and carbazole have not been detected in the perched water below the site. Therefore, a comparison of the ECTran model results with measurements could not be made.

D.1.2.5 Modified Soil PRGs

Modified soil PRG modeling results for the Solid Waste Landfill include modified soil PRGs which are COC, layer-specific and remedial alternative specific. All of the modified soil PRG results are presented in Table D.1-5.

No Controls

The modified soil PRGs developed for the private ownership (i.e.,no capping, source removal, clean closure) scenario with the target 1×10^{-6} risk-based water criteria are presented in Table D.1-5. The exposure point for these modified soil PRGs was the perched groundwater zone.

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TABLE D.1-3

SUMMARY OF CHEMICAL/GEOCHEMICAL DATA FOR THE SOLID WASTE LANDFILL MODIFIED PRG DEVELOPMENT

COC	K_d (L/kg)			Specific Activity (Ci/g)	Half-Life (years)	Risk-Based Water Criteria (μg/L)
	Waste	Layer 1	Layer 2			
Technetium-99	1.18×10^{-1}	1.18×10^{-1}	7.00×10^{-2}	1.70×10^{-2}	2.13×10^{5}	9.24×10^{-4}
Carbazole	1.34×10^{1}	1.34×10^{1}	3.55×10^{0}	NA	NA	1.80×10^{0}

NA = Not Applicable

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TABLE D.1-4

CURRENT CONTAMINANT CONCENTRATIONS FOR THE SOLID WASTE LANDFILL MODIFIED PRG DEVELOPMENT

COC	Source		Till (Layer 1)	
	(pCi/g)	(mg/kg)	(pCi/g)	(mg/kg)
Technetium-99	7.54×10^{-1}	4.44×10^{-5}	ND	ND
Carbazole	NA	4.20×10^{1}	NA	2.10×10^{-1}

ND = No Data Available
NA = Not Applicable

TABLE D.1-5

SOIL PRGs WHICH ARE PROTECTIVE OF PERCHED WATER
SOLID WASTE LANDFILL

OU2 AREA: SOLID WASTE LANDFILL		RECEPTOR = PROPERTY RESIDENT FARMER EXPOSURE POINT = PERCHED WATER		
COC	Layer	Current Concentrations	10^{-6} Risk Based No Cap PRG	10^{-6} Risk Based Cap PRG
Radionuclides (pCi/g)				
Technetium-99	Source	7.54×10^{-1}	5.38×10^{-6}	8.45×10^{-5}
	Layer 1	ND	2.55×10^{-3}	2.50×10^{-3}
Organics (mg/kg)				
Carbazole	Source	4.2×10^{0}	9.02×10^{-4}	9.10×10^{-4}
	Layer 1	2.1×10^{-1}	2.72×10^{-2}	2.72×10^{-2}

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Summary

Table D.1-5 summarizes the modified soil PRGs for the Solid Waste Landfill which were developed using the 1 x 10^{-6} criteria. For technetium-99, vertical source modified soil PRGs range from a minimum of 5.38 x 10^{-6} pCi/g (perched water, no cap) to a maximum of 8.45 x 10^{-5} pCi/g (perched water, cap). Layer 1 (till) modified soil PRGs for technetium-99 range from a minimum of 2.50 x 10^{-3} pCi/g (perched water, cap) to a maximum of 2.55 x 10^{-3} pCi/g (perched water, no cap). For carbazole, vertical source modified soil PRGs range from a minimum of 9.02 x 10^{-4} mg/kg (perched water, no cap) to a maximum of 9.10 x 10^{-4} mg/kg (perched water, cap). The Layer 1 (till) modified soil PRG for carbazole is 2.72 x 10^{-2} mg/kg in both cases. These modified soil PRGs suggest that remediation of the waste is necessary because their values are significantly below the current conditions.

D.1.3 INACTIVE FLYASH PILE

The Inactive Flyash Pile is located approximately 2,000 feet southwest of the former Production Area. The pile covers roughly two acres with Paddys Run as the western boundary (Figure D.1-7). The Inactive Flyash Pile and the South Field are contiguous without a clearly defined boundary between the two subunits. The following sections describe the fate and transport modeling conducted for the Inactive Flyash Pile to develop modified soil PRGs and summarize the results.

D.1.3.1 Conceptual Model

The conceptual model used to describe the Inactive Flyash Pile for modified soil PRG development identifies and incorporates the key hydrogeologic characteristics of the vadose and saturated zones of the Inactive Flyash Pile, COC source information, and factors that control transport of the COCs to be modeled. The following sections describe the conceptual model used for Inactive Flyash Pile modified soil PRG modeling.

Hydrogeologic Conditions

For the Inactive Flyash Pile, the conceptualized conditions can be summarized as follows: rainfall and surface water infiltrate through the surface of the Inactive Flyash Pile, leaching of constituents from the source material into the dissolved phase occurs, the contaminated leachate migrates laterally or percolates vertically to the underlying GMA, lateral infiltration travels horizontally across the till or in the perched water zone and eventually discharges into areas with no till and percolates vertically to the GMA, and once in the GMA, the contaminants are then transported down-gradient. In addition to

the infiltration in the area of the waste unit there is also vertical infiltration in downgradient areas which affects the contaminant concentrations in the GMA. Vertical infiltration from areas downgradient of the waste unit were considered during modeling of transport of COCs to the FEMP fence line. This additional infiltration was considered in the ECTran model by increasing the effective decay rate in the downgradient area.

The conceptual model for vadose zone transport is highly dependent upon the available vertical drainage pathways through each waste unit. Figure D.1-8 shows the conceptual model for lateral and vertical drainage to the unsaturated GMA at the Inactive Flyash Pile.

As described in the technical approach, three cases were used to investigate the variety of hydrogeologic conditions at the Inactive Flyash Pile. Cases 1 and 2 (i.e., Case 1 area) considered the areas without till which have substantial lateral infiltration and perched water inflow rates from Case 3 areas. Case 3 considers the area which has till and provides the lateral infiltration and perched water to the Case 1 area. Figure D.1-9 shows the lateral drainage patterns for the SWIFT grid blocks used to depict the Inactive Flyash Pile. A SWIFT grid block is a three-dimensional finite difference cell in SWIFT which has its own hydrogeological and contaminant transport parameters assigned to it. Grid block 29,65 was used to depict Cases 1 and 2 for modified soil PRG development with no controls. Grid block 30,62 was selected to depict Cases 1 and 2 for modified soil PRG development with perched water controls. Grid block 29,66 was used for the Case 3 area. These blocks were selected since they have the maximum total infiltration rate (i.e., lateral and vertical) to the GMA for their particular case.

COCs

Modified soil PRGs were developed for all Inactive Flyash Pile COCs which pose a risk through the GMA groundwater exposure pathway. Three Inactive Flyash Pile COCs had the potential to impact groundwater. The Inactive Flyash Pile COCs include uranium-234, uranium-235/236 and uranium-238.

Potential Exposure Points

Two exposure points were used for modified soil PRG development at the Inactive Flyash Pile. Both the GMA under the waste unit and the GMA at the FEMP fence line were used as exposure points

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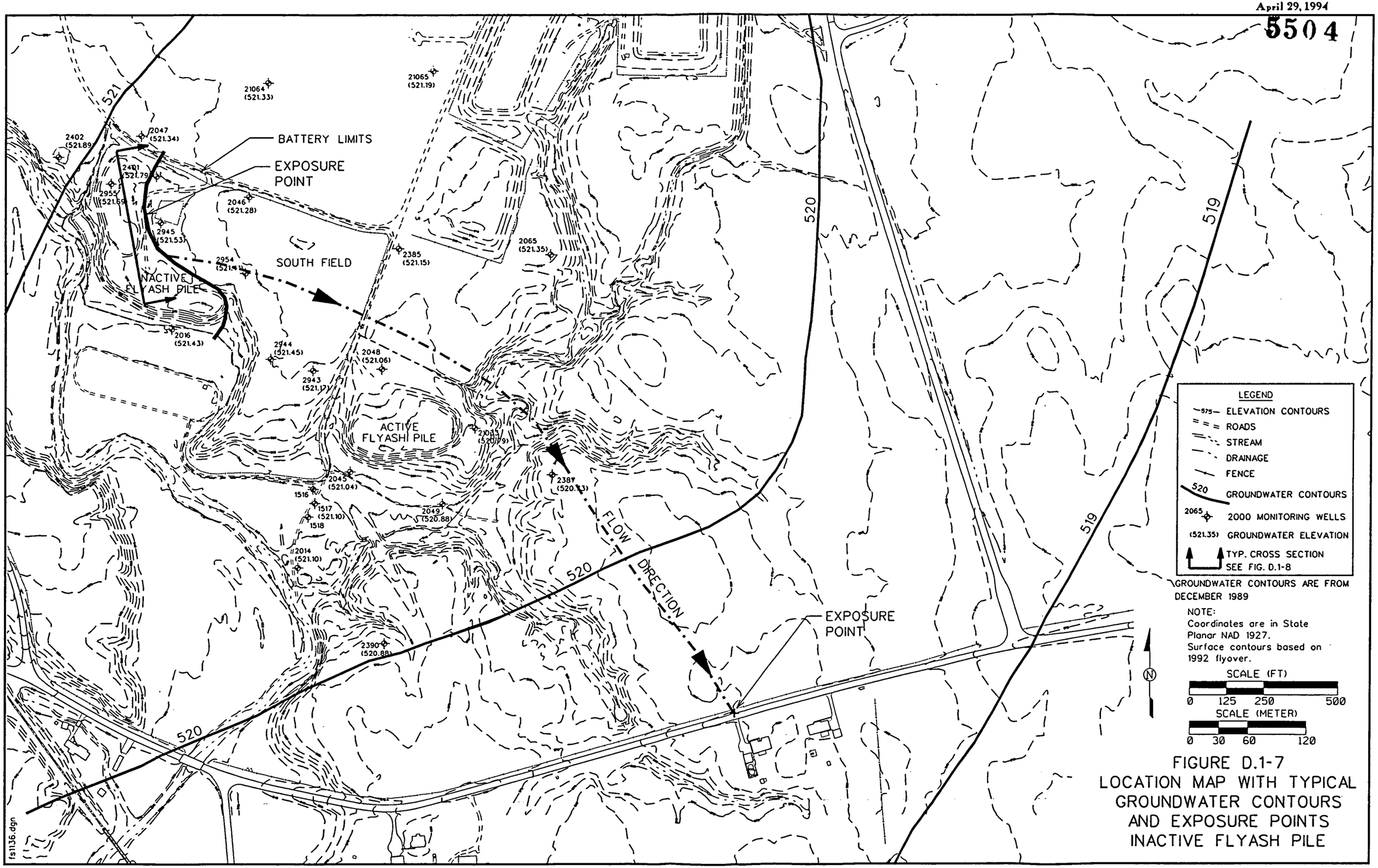

FIGURE D.1-7
LOCATION MAP WITH TYPICAL GROUNDWATER CONTOURS AND EXPOSURE POINTS INACTIVE FLYASH PILE

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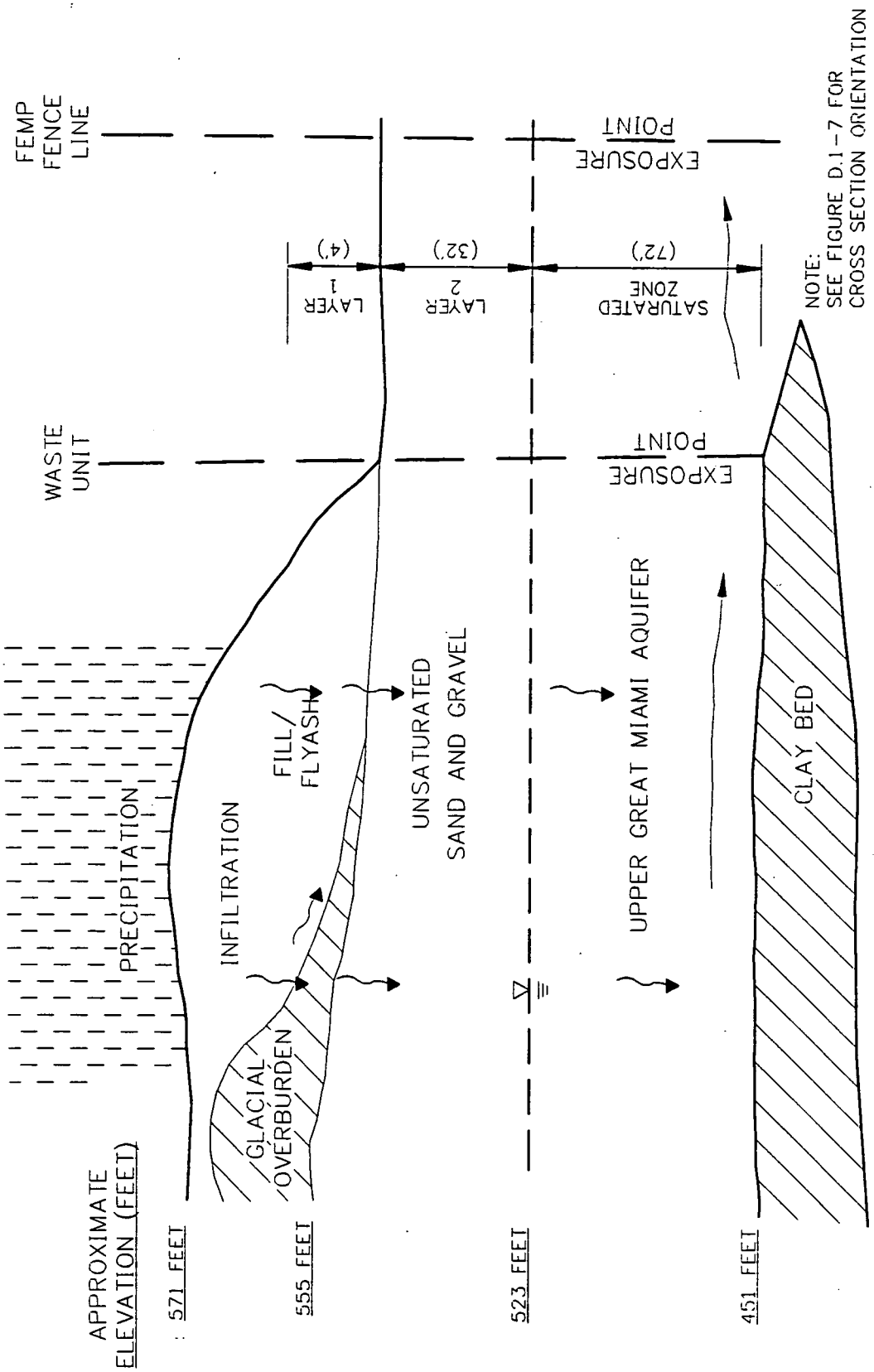

FIGURE D.1-8
CROSS SECTION WITH TYPICAL WASTE UNIT GEOLOGY AND INFILTRATION PATTERNS
INACTIVE FLYASH PILE
NOT TO SCALE

ACAD: C:\NG96\CRU5\CONMODEL.DWG 3/17/94 MB P-INFA1, INFA1

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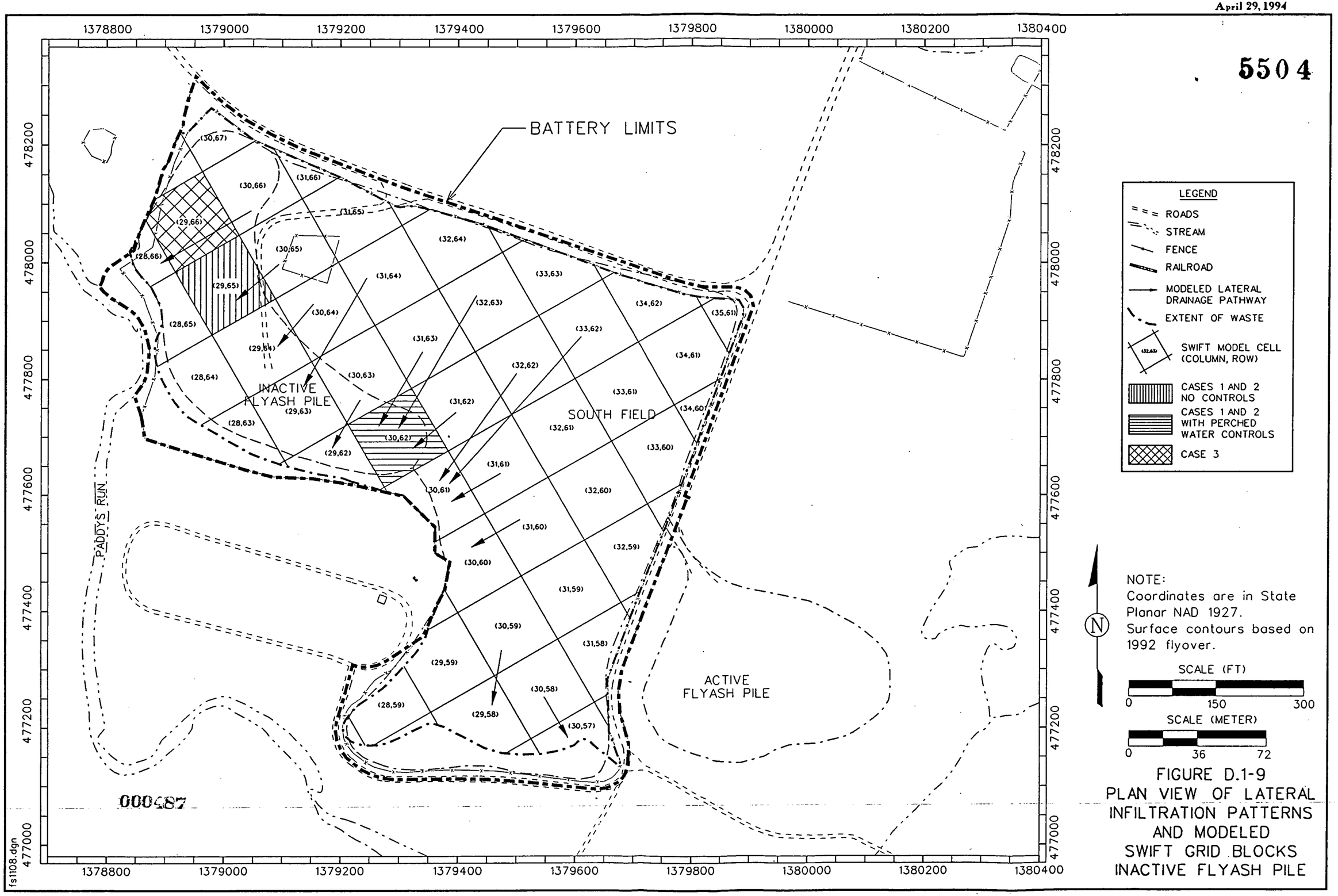

FIGURE D.1-9
PLAN VIEW OF LATERAL INFILTRATION PATTERNS AND MODELED SWIFT GRID BLOCKS INACTIVE FLYASH PILE

Figures D.1-7 and D.1-8 show the Inactive Flyash Pile exposure points in plan view and cross-sectional view, respectively.

The selection of groundwater exposure points for modified soil PRG development was based on the two potential future land use scenarios for the site, namely a private or federal owner. Under private ownership there are two potential receptors, the on-property and off-property resident farmers, and it is assumed that no administrative or source controls exist to limit access to the GMA. The exposure points for these two receptors would be the GMA groundwater under the waste units (GMA under waste unit) and the GMA groundwater at the FEMP fence/property line (GMA at FEMP fence line). For the federal owner there is one potential receptor, the off-property resident farmer. However, unlike private ownership, with federal ownership, administrative or source controls would be implemented to limit access to the GMA under the waste units and the only groundwater exposure point for this receptor is the GMA at FEMP fence line.

D.1.3.2 Remedial Scenarios Evaluated

For federal ownership, all contaminated material above PRLs will also be remediated, however, controls will be used to increase PRL levels which will allow higher levels of contaminated materials to be left on-site. Four potential remedial alternatives for the Inactive Flyash Pile were investigated for modified soil PRG development. For private ownership, all contaminated material above the modified soil PRL concentrations will be replaced with clean soil, and no controls will be implemented (i.e., clean closure). The potential controls include: 1) administrative controls to limit access to the site, 2) administrative controls, as well as source controls to control perched water, and 3) administrative controls and perched water controls as well as capping to limit vertical infiltration. An in situ, composite type cap is proposed for the Inactive Flyash Pile. The design details for this type of cap are presented in Appendix E.

D.1.3.3 Model Input

The following sections summarize the data used as input to the ECTran model for Inactive Flyash Pile modified soil PRG development. A majority of the input was taken directly from the Operable Unit 2 RI fate and transport modeling sections. Other input was calculated from data presented in the Operable Unit 2 RI or previous reports.

Hydrogeologic Conditions

Table D.1-6 shows the general hydraulic parameters and physical dimensions of the Inactive Flyash Pile. The physical dimensions of the site and the layer thicknesses are presented separately for the three appropriate SWIFT grid blocks. The hydraulic gradient and flow distance along the pathline to the FEMP fence line were calculated using groundwater contours from 2000-series monitoring wells for the months of April 1988 to December 1989. Table D.1-7 displays the soil media parameters used for the Inactive Flyash Pile. All of these soil parameters were taken directly from the Operable Unit 2 RI. The Inactive Flyash Pile infiltration rates and mixing depth information for the No Cap and Composite Cap scenarios are presented in Table D.1-8. The no capping infiltration rates were estimated in the Operable Unit 2 RI using the HELP model. The capping infiltration rates were estimated specifically for the Operable Unit 2 FS and they were also calculated using the HELP model. Perched water flow rates were estimated from average hydraulic gradients and hydraulic conductivities for the perched water zone. These flow rates were added to the lateral infiltration rates to determine the total lateral flow rate under no controls. The mixing depth was calculated based on an equation presented in the ECTran model development report (Halliburton NUS, 1993) which is presented in Attachment D.1.I.

TABLE D.1-6

HYDRAULIC PARAMETERS AND PHYSICAL DIMENSIONS OF INACTIVE FLYASH PILE MODIFIED SOIL PRG DEVELOPMENT

Parameter	Input Value		
	Cases 1 and 2 (29,65)	Cases 1 and 2 (30,62)	Case 3 (29,66)
Length	125 ft	125 ft	125 ft
Width	125 ft	125 ft	125 ft
Till Thickness (Layer 1)	0.0 ft	0.0 ft	2.0 ft
Unsaturated GMA Thickness (Layer 2)	24.1 ft	24.1 ft	32.0 ft
Saturated GMA Thickness	72 ft	72 ft	72 ft
Hydraulic Gradient	6.1×10^{-4} ft/ft		
Horizontal Hydraulic Conductivity	638 ft/day		
Darcy's Velocity	142.1 ft/yr		
Horizontal Seepage Velocity	473.5 ft/yr		
Distance to FEMP Fenceline	1650 ft		
Downgradient Infiltration Rate	0.698 ft/yr		

Note: SWIFT Grid Block - Case 1 and 2 (29,65) - No Controls
Case 1 and 2 (30,62) - Perched Water Controls
Case 3 (29,66)

TABLE D.1-7

SUMMARY OF SOIL MEDIA PARAMETERS FOR THE INACTIVE FLYASH PILE MODIFIED PRG DEVELOPMENT

Soil Media Parameter	Till (Layer 1)	Unsaturated Sand & Gravel (Layer 2)	Great Miami Aquifer
Porosity (%)	41	39	30
Bulk Density (g/cc)	1.85	1.60	1.70
Organic Content (%)	1.69	0.87	0.87
Moisture Content (%)	37	13.1	30
Saturation	0.902	0.336	1.00
Vertical Hydraulic Conductivty (ft/day)	3.97×10^{-4}	45	NA
Horizontal Hydraulic Conductivity (ft/day)	NA	NA	638

NA = Not Applicable

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TABLE D.1-8

INFILTRATION RATE AND MIXING DEPTH INFORMATION FOR THE INACTIVE FLYASH PILE MODIFIED SOIL PRG DEVELOPMENT

Capping Scenario (Case)	Waste Unit Infiltration Rate (in/yr)			Vertical Hydraulic Conductivity Kv (ft/day)	Empirical Soil[a] Parameter Layer 2 (1/2b+3)	Vertical Seepage[b] Velocity V_{zo} (ft/yr)	Dispersion[b] Coefficient (ft^2/yr)	Dispersivity[c] α_v (ft)	Mixing Depth[d] H (ft)
	Vertical	Lateral	Total						
No Controls (1 and 2)	7.01	102.31	109.32	45	0.09	45.87	5.362	0.117	16.6
Perched Water Controls (1 and2)	7.01	8.71	15.72	45	0.09	7.853	0.956	0.122	7.562
Perched Water Controls (3)	7.01	0	7.01	45	0.09	3.766	0.555	0.147	7.054
Composite Cap (1,2,4)	1.22	0	1.22	45	0.09	0.769	0.290	0.377	9.911
Composite Cap (3)	1.22	0	1.22	45	0.09	0.769	0.290	0.377	9.911

[a]United States Environmental Protection Agency, April 1988, "Superfund Exposure Assesment Manual", EPA/540/1-88/001, Washington, D.C.

[b]PARSONS, February 1993, "Fate and Transport Modeling Transition Report", Revision A, Fernald Environmental Management Project, Fernald, Ohio.

[c]Dispersion Coefficient / Vertical Seepage Velocity.

[d]Halliburton NUS, September 1993, "Development and Application of the ECTran Model to Support RI/FS at the FEMP", Fernald Environmental Management Project, Fernald, Ohio.

Chemical Characteristics and Risk-Based Criteria

Three different risk-based water criteria were used for the development of modified soil PRGs for Inactive Flyash Pile. The three individual, chemical-specific cancer risk levels investigated were 1 x 10^{-6}, 1 x 10^{-5} and 1 x 10^{-4}. The criteria were developed as part of the Operable Unit 2 RI Baseline Risk Assessment. These criteria represent chemical-specific groundwater concentrations which present 1 x 10^{-6}, 1 x 10^{-5} and 1 x 10^{-4} cancer risks due to the groundwater exposure pathway. Table D.1-9 presents a summary of the chemical/geochemical data for the three Inactive Flyash Pile COCs. Also shown in the table are the 1 x 10^{-6} risk-based water criteria used for modified soil PRG development. The 1 x 10^{-5} and 1 x 10^{-4} risk-based water criteria were calculated by taking 10 and 100 times, respectively, the 1 x 10^{-6} risk-based water criteria.

Current COC Concentrations

Current Inactive Flyash Pile COC concentrations, which were required for modified soil PRG development, included vadose zone soil concentrations. Table D.1-10 shows the current COC soil concentrations for the till and unsaturated sand and gravel. These concentrations were estimated as part of the Operable Unit 2 FS and a description of how the concentrations were estimated is presented in Appendix A, Sampling Results for Contaminants of Concern.

D.1.3.4 Model Verification With Measured Conditions

Once all input for the ECTran model was finalized, the model was used to estimate current groundwater conditions and maximum predicted concentrations for a 1000 year period at the Inactive Flyash Pile assuming no remediation. The estimated current and maximum conditions were then compared with measured groundwater concentrations presented in the Operable Unit 2 RI.

The current and maximum conditions were estimated by the ECTran model using the following procedure:

- Maximum COC leachate concentrations from the waste material, which were taken from the Operable Unit 2 RI, were assumed to be the initial contaminant leachate concentration when the waste was placed in the Inactive Flyash Pile approximately 40 years ago. The leachate concentrations were held constant for the 1000 year modeling period.

- The groundwater concentrations in Layer 1, Layer 2, GMA under the source, and GMA at the fence line due to these leachate concentrations were then calculated using the ECTran model. The current modeled conditions were ECTran concentrations for the particular layer at 40 years. The maximum modeled conditions were the maximum ECTran concentrations for the particular layer for a 1000 year period.

TABLE D.1-9

SUMMARY OF CHEMICAL/GEOCHEMICAL DATA FOR THE INACTIVE FLYASH PILE MODIFIED PRG DEVELOPMENT

COC	K_d (L/kg)				Specific Activity (Ci/g)	Half-Life (years)	1×10^{-6} Risk-Based Water Criteria (μg/L)
	Waste	Layer 1	Layer 2	GMA			
Uranium-234	37.5	200	1.78	1.78	6.22×10^{-3}	2.45×10^{5}	1.77×10^{-4}
Uranium-235/236	37.5	200	1.78	1.78	2.16×10^{-6}	7.04×10^{8}	5.09×10^{-1}
Uranium-238	37.5	200	1.78	1.78	3.36×10^{-7}	4.47×10^{9}	1.85×10^{0}

TABLE D.1-10

CURRENT CONTAMINANT CONCENTRATIONS FOR THE INACTIVE FLYASH PILE MODIFIED PRG DEVELOPMENT

COC	Till (Layer 1)		Unsaturated Sand & Gravel (Layer 2)	
	(pCi/g)	(mg/kg)	(pCi/g)	(mg/kg)
Uranium-234	7.7×10^{-1}	1.24×10^{-4}	1.29×10^{0}	2.07×10^{-4}
Uranium-235/236	5.20×10^{-2}	2.41×10^{-2}	8.00×10^{-2}	3.70×10^{-2}
Uranium-238	8.50×10^{-1}	2.53×10^{0}	1.44×10^{0}	4.29×10^{0}

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Three different comparisons of contaminant groundwater concentrations were made including the following:

- Layer 2 ECTran current and maximum modeled conditions versus measured 1000-series monitoring well concentrations;
- ECTran modeled current and maximum GMA conditions under the source versus 2000-series monitoring well concentrations; and
- ECTran modeled current versus maximum GMA conditions at the FEMP fence line.

The current contaminant measurements were taken from the Operable Unit 2 RI. Figures D.1-10 and D.1-11 show the locations of the 1000-series and 2000-series wells, respectively, where the minimum and maximum Inactive Flyash Pile current COC concentrations were measured. From Figure D.1-10 it can be seen that there were no 1000-series wells with COC measurements for the Inactive Flyash Pile. From Figure D.1-11 it can be seen that MW 2945 had the maximum COC measurement and MW 2401 had the minimum COC measurement. Both of these wells are in the Case 3 area.

Table D.1-11 shows the type (1) comparison, Table D.1-12 shows the type (2) comparison, and Table D.1-13 shows the type (3) comparison. From the comparisons it can be seen that the ECTran model's results are usually conservative but typically close to the range of groundwater measurements.

D.1.3.5 Modified Soil PRGs

Modified soil PRG modeling results for the Inactive Flyash Pile include modified soil PRGs which are layer specific, case specific, remedial alternative specific, and risk-based water criteria specific. All of the modified soil PRG results are presented in Attachment D.1.II. The following sections highlight the locations of particular modified soil PRGs in Attachment D.1.II.

No Controls

The modified soil PRGs developed for the no controls scenario with the 1×10^{-6}, 1×10^{-5} and 1×10^{-4} risk-based water criteria are presented in Tables D.1.II-1 and D.1.II-2 in Attachment D.1.II. As can be seen in the tables, the 1×10^{-6} modified soil PRGs are below background concentrations. When background is added to the modified PRGs to develop PRLs, the PRLs will essentially be at background concentrations. The modified PRGs for 1×10^{-5} and 1×10^{-4} risk levels increase proportionally.

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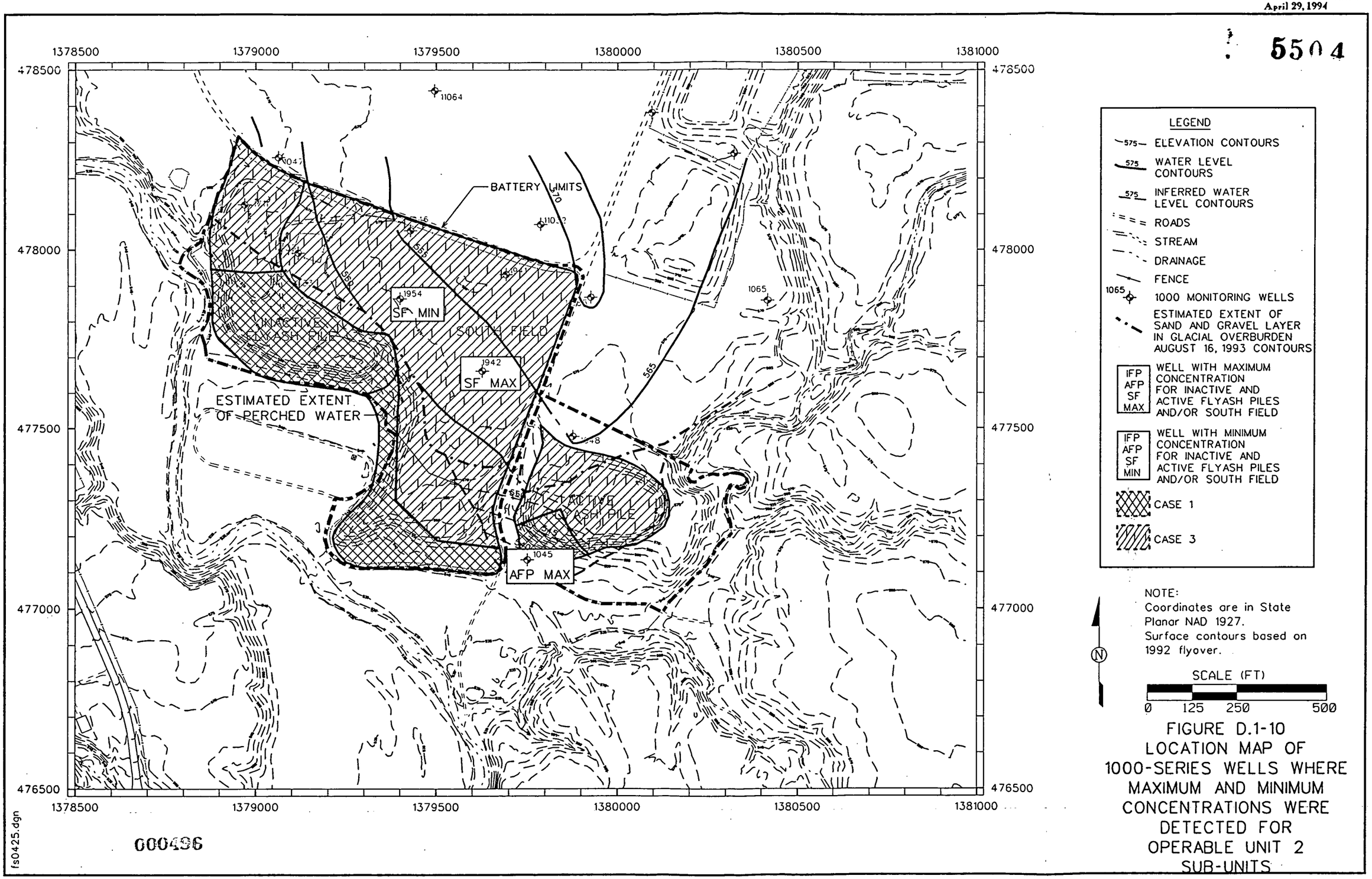

FIGURE D.1-10
LOCATION MAP OF 1000-SERIES WELLS WHERE MAXIMUM AND MINIMUM CONCENTRATIONS WERE DETECTED FOR OPERABLE UNIT 2 SUB-UNITS

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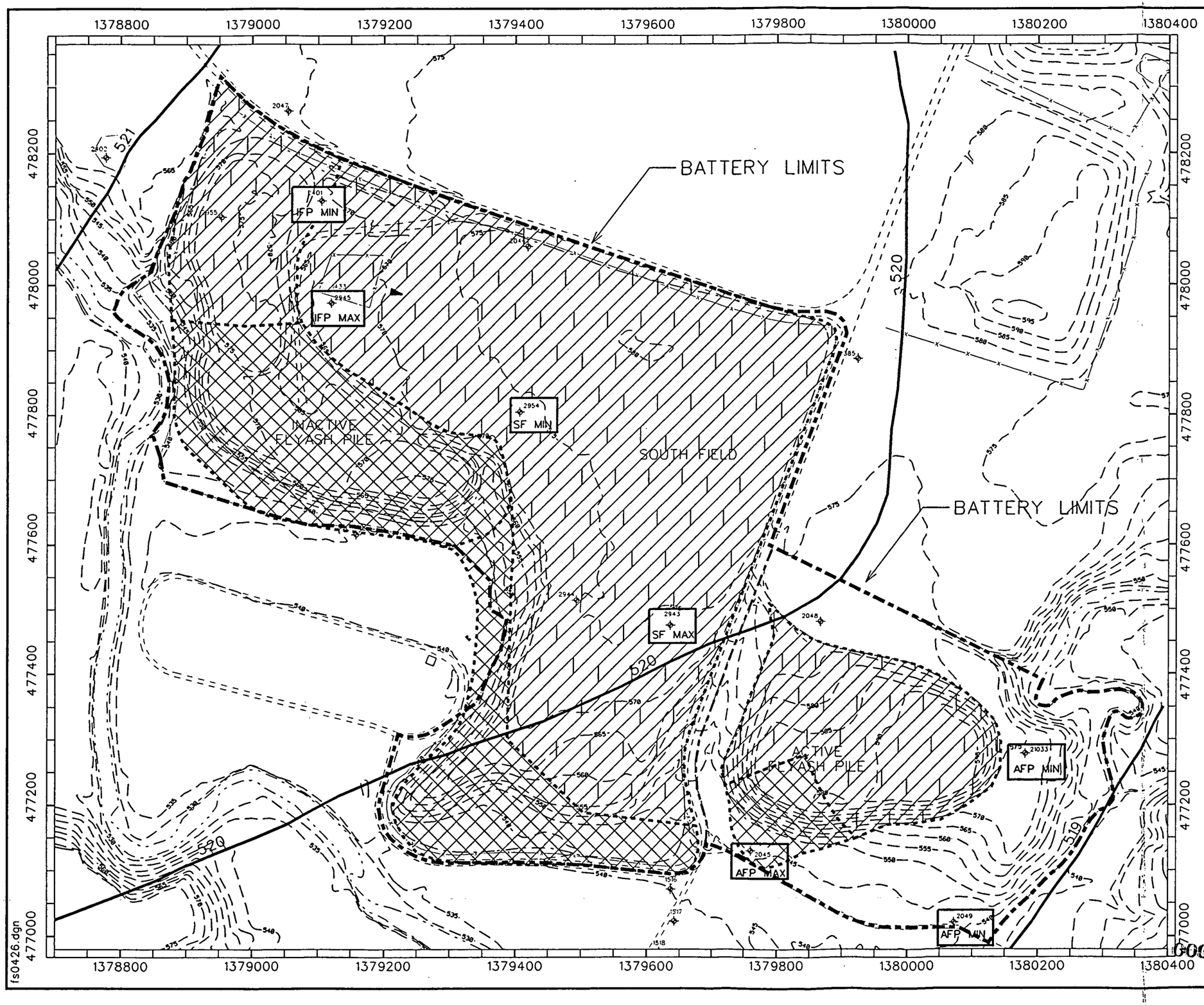

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- DRAINAGE
- FENCE
- 520 GROUNDWATER CONTOURS
- 2065 2000 MONITORING WELLS
- IFP AFP SF MAX — WELL WITH MAXIMUM CONCENTRATION FOR INACTIVE AND ACTIVE FLYASH PILES AND/OR SOUTH FIELD
- IFP AFP SF MIN — WELL WITH MINIMUM CONCENTRATION FOR INACTIVE AND ACTIVE FLYASH PILES AND/OR SOUTH FIELD
- CASE 1
- CASE 3

GROUNDWATER CONTOURS ARE FROM DECEMBER 1989

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

N

SCALE (FT)
0 150 300

SCALE (METER)
0 36 72

FIGURE D.1-11
LOCATION MAP OF 2000-SERIES WELLS WHERE MAXIMUM AND MINIMUM CONCENTRATIONS WERE DETECTED FOR OPERABLE UNIT 2 SUB-UNITS

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TABLE D.1-11

COMPARISON OF 1000 SERIES WELL MEASUREMENTS AND ECTran MODEL RESULTS
INACTIVE FLYASH PILE

(Units = μg/L)

COC	Range of 1000-Series[a] Well Measurements		Range of ECTran Simulated Current Layer 2 Concentration		Range of ECTran Simulated Max. Layer 2 Concentration	
	Minimum	Maximum	Case 3[c]	Case 1[b]	Case 3[c]	Case 1[b]
Uranium-234	NM	NM	1.71×10^{-2}	2.38×10^{0}	2.32×10^{0}	4.85×10^{0}
Uranium-235/236	NM	NM	3.47×10^{0}	4.81×10^{2}	4.70×10^{2}	9.81×10^{2}
Uranium-238	NM	NM	3.68×10^{2}	4.20×10^{3}	4.98×10^{4}	8.57×10^{3}

NM = No Measurements

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

TABLE D.1-12

COMPARISON OF 2000 SERIES WELL MEASUREMENTS AND ECTran MODEL RESULTS INACTIVE FLYASH PILE

(Units = μg/L)

COC	Range of 2000 Series[a] Well Measurements		Range of ECTran Simulated Current GMA Concentration		Range of ECTran Simulated Max. GMA Concentration	
	Minimum	Maximum	Case 3[c]	Case 1[b]	Case 3[c]	Case 1[b]
Uranium-234	2.56×10^{-4}	1.06×10^{-1}	1.25×10^{-3}	3.63×10^{-1}	1.69×10^{-1}	7.40×10^{-1}
Uranium-235/236	ND	1.47×10^{1}	2.53×10^{-1}	7.34×10^{1}	3.43×10^{1}	1.50×10^{2}
Uranium-238	4.29×10^{0}	2.10×10^{3}	2.68×10^{1}	6.41×10^{2}	3.63×10^{3}	1.31×10^{3}

ND = Non Detect

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

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TABLE D.1-13

COMPARISON OF ECTran MODELING RESULTS INACTIVE FLYASH PILE

(Units = μg/L)

COC	Range of ECTran Simulated Current Fenceline Concentration		Range of ECTran Simulated Max. Fenceline Concentration	
	Case 3[c]	Case 1[b]	Case 3[c]	Case 1[b]
Uranium-234	1.58×10^{-6}	9.61×10^{-4}	6.17×10^{-3}	2.81×10^{-2}
Uranium-235/236	3.20×10^{-4}	1.94×10^{-1}	1.25×10^{0}	5.68×10^{0}
Uranium-238	3.40×10^{-2}	1.70×10^{0}	1.33×10^{2}	4.96×10^{1}

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

Administrative Controls

The modified soil PRGs developed for the administrative controls only scenario with 1 x 10^{-6}, 1 x 10^{-5} and 1 x 10^{-4} risk-based water criteria are presented in Tables D.1.II-3 and D.1.II-4. As can be seen in the tables, the 1 x 10^{-6} modified PRGs for uranium-234 and uranium-238 are below background, while the uranium-235/236 modified PRGs are close to or slightly above background. The PRLs developed with these modified PRGs will be close to or slightly above background. The modified PRGs for 1 x 10^{-5} and 1 x 10^{-4} risk levels increase proportionally.

Administrative and Source Controls

The modified soil PRGs developed for the perched water controls scenario with the 1 x 10^{-6}, 1 x 10^{-5} and 1 x 10^{-4} risk-based water criteria are presented in Tables D.1.II-5 through Tables D.1.II-7 in Attachment D.1.II. As can be seen in the tables, the 1 x 10^{-6} modified PRGs for Cases 1 and 2 are generally below background, while the Case 3 modified PRGs are above background. The PRLs for Cases 1 and 2 will be approximately background while the PRLs for Case 3 will be higher than background. The modified PRGs for 1 x 10^{-5} and 1 x 10^{-4} risk levels increase proportionally.

Cap and Engineering Control

The modified soil PRGs developed for the in situ, composite cap with perched water controls scenario using the 1 x 10^{-6}, 1 x 10^{-5} and 1 x 10^{-4} risk-based water criteria are presented in Tables D.1.II-8 through Tables D.1.II-9 in Attachment D.1.II. As can be seen in the tables, the 1 x 10^{-6} modified PRGs for both Case 1 and Case 3 are significantly higher than background. PRLs developed from these numbers will be much higher than background. The modified PRGs for 1 x 10^{-5} and 1 x 10^{-4} risk levels increase proportionally.

D.1.4 SOUTH FIELD

The South Field is an 11-acre area that lies between the Active Flyash Pile and the Inactive Flyash Pile (Figure D.1-12). The actual boundary between the Inactive Flyash Pile and the South Field is not distinguishable. This area was reportedly used as a burial site for FEMP non-process wastes such as flyash, on-site construction/demolition rubble, and soils. The following sections will describe the fate and transport modeling conducted for the South Field to develop modified soil PRGs and summarize the results.

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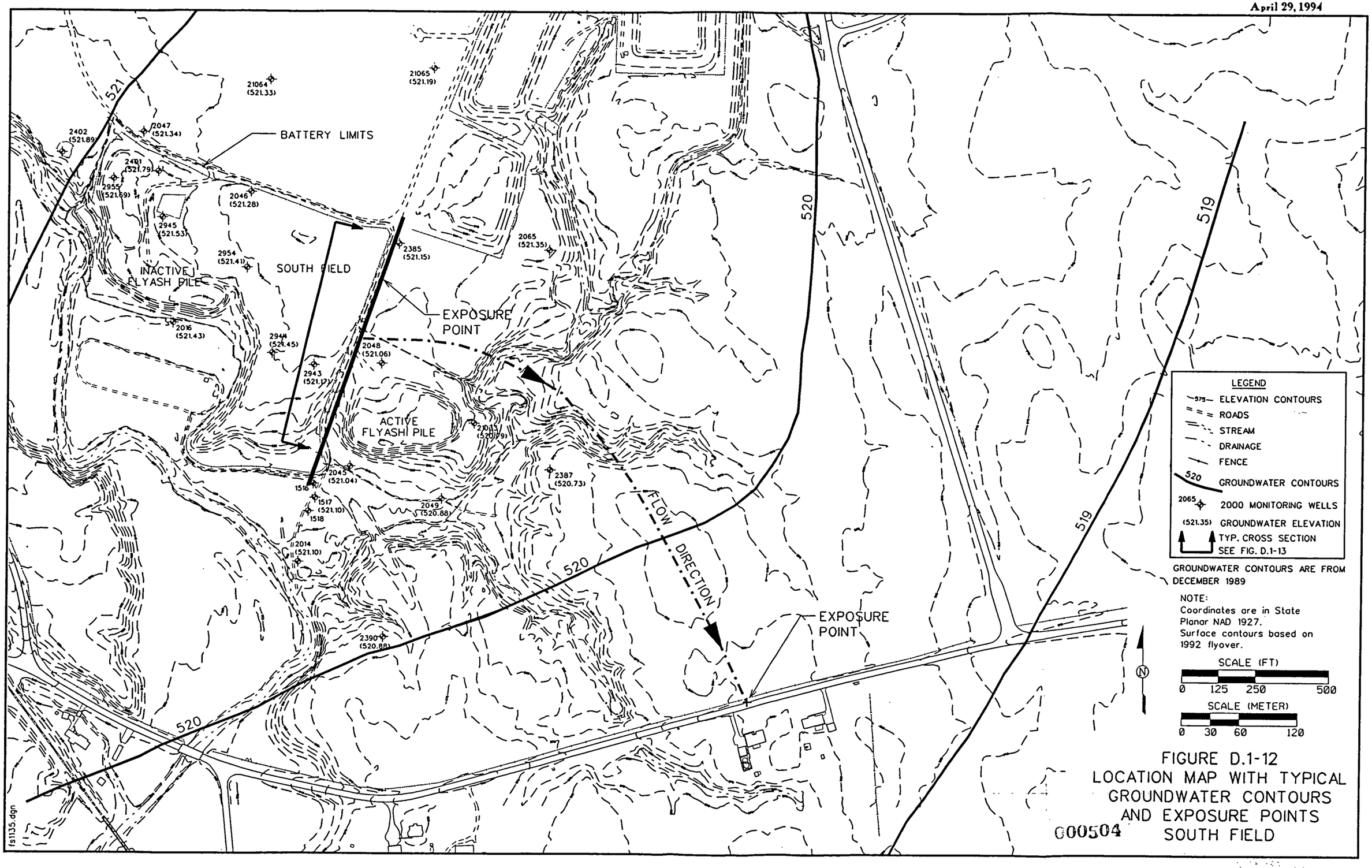

FIGURE D.1-12
LOCATION MAP WITH TYPICAL GROUNDWATER CONTOURS AND EXPOSURE POINTS SOUTH FIELD

D.1.4.1 Conceptual Model

The conceptual model used to describe the South Field for modified soil PRG development identifies and incorporates the key hydrogeologic characteristics of the vadose and saturated zones of the South Field, COC source information, and factors that control transport of the COCs to be modeled. The following sections will describe the conceptual model used for South Field modified soil PRG modeling.

Hydrogeologic Conditions

For the South Field the conceptualized conditions can be summarized as follows: rainfall and surface water infiltrate through the surface of the South Field, leaching of constituents from the source material into the dissolved phase occurs, the contaminated leachate migrates laterally or percolates vertically to the underlying GMA, lateral infiltration travels horizontally across the till or in the perched water zone and eventually discharges into areas with no till and percolates vertically to the GMA, and once in the GMA the contaminants are then transported down-gradient. In addition to the infiltration in the area of the waste unit there is also vertical infiltration in downgradient areas which affects the contaminant concentrations in the GMA. Vertical infiltration from areas downgradient of the waste unit were considered during modeling of transport of COCs to the FEMP fence line. This additional infiltration was considered in the ECTran model by increasing the effective decay rate in the downgradient area.

The conceptual model for vadose zone transport is highly dependent upon the available vertical drainage pathways through each waste unit. Figure D.1-13 shows the conceptual model for lateral and vertical drainage to the unsaturated GMA at the FEMP.

As described in the technical approach, three cases were used to investigate the variety of hydrogeologic conditions at the South Field. Cases 1 and 2 (i.e., Case 1 area) considered the areas without till which have substantial lateral infiltration and perched water inflow rates from Case 3 areas. Case 3 considers the area which has till and provides the lateral infiltration and perched water to the Case 1 area. Figure D.1-14 shows the lateral drainage patterns for the SWIFT grid blocks used to depict the South Field. A SWIFT grid block is a three-dimensional finite difference cell in SWIFT which has its own hydrogeological and contaminant transport parameters assigned to it. Grid block 30,61 was used to depict Cases 1 and 2 for modified soil PRG development under no controls. Grid block 30,57 was selected to depict Cases 1 and 2 area for modified soil PRG development under

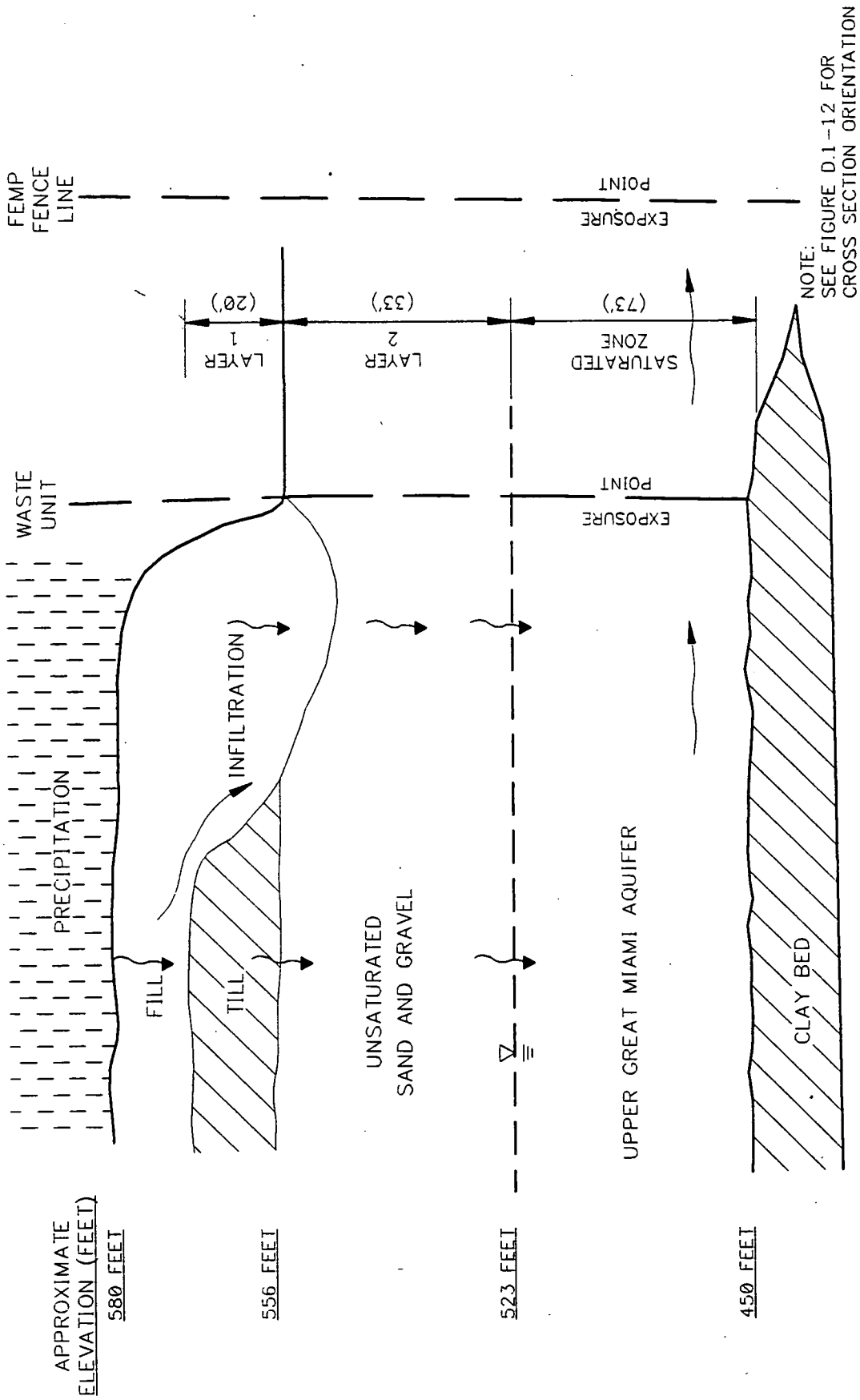

FIGURE D.1-13
CROSS SECTION WITH TYPICAL WASTE UNIT GEOLOGY
AND INFILTRATION PATTERNS
SOUTH FIELD
NOT TO SCALE

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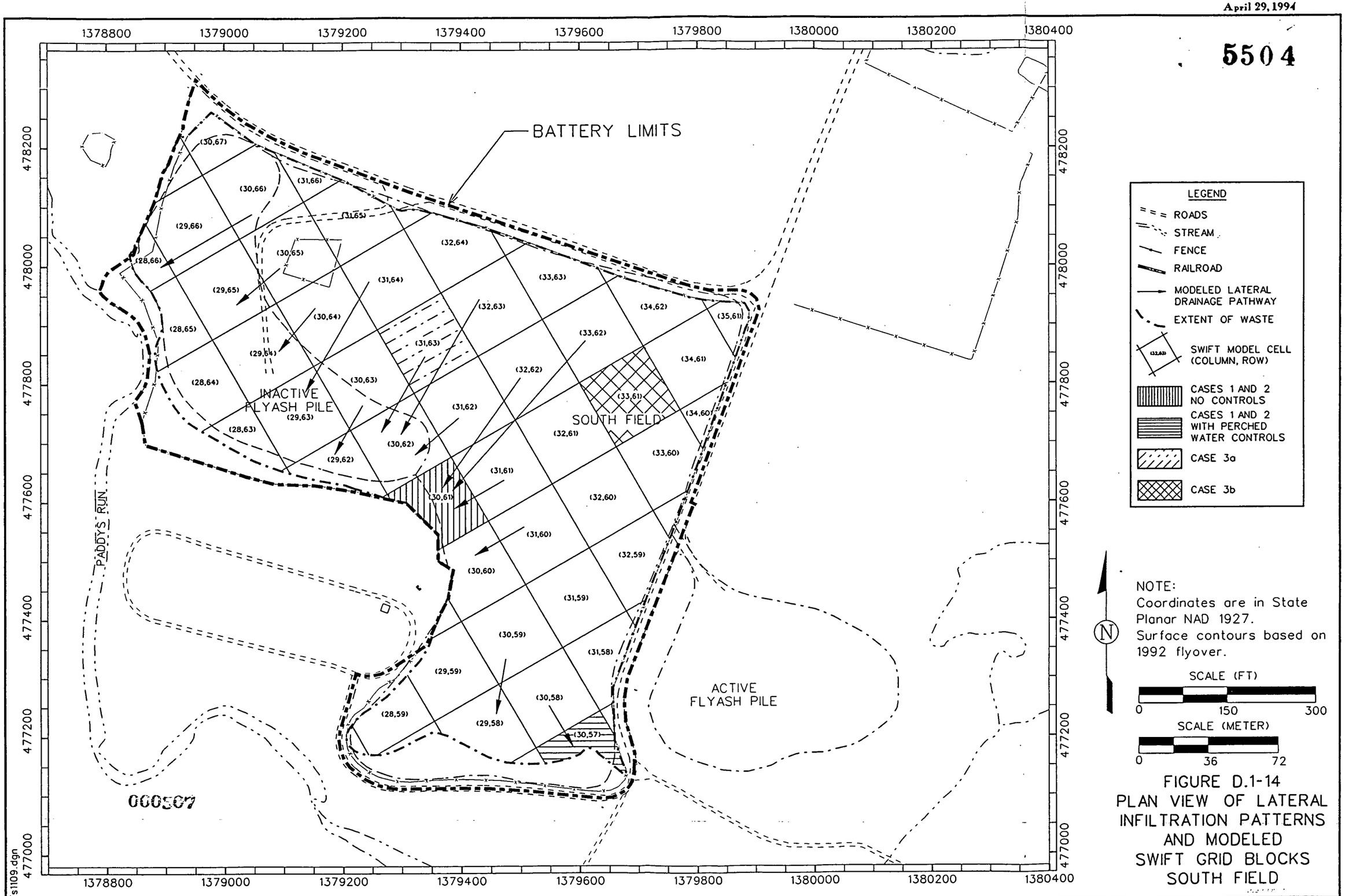

FIGURE D.1-14
PLAN VIEW OF LATERAL INFILTRATION PATTERNS AND MODELED SWIFT GRID BLOCKS SOUTH FIELD

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perched ground water controls. Grid blocks 31,63 (Case 3a) and 33,61 (Case 3b) were used for the Case 3 area. These blocks were selected since they have the maximum total infiltration rate (i.e., lateral and vertical) to the GMA for their particular case. Two blocks, 31,63 and 33,61, were chosen for the Case 3 area to better represent the varying till thickness in the South Field area. Block 31,63 has approximately 8 feet of till while block 33,61 has almost 18 feet of till.

COCs

Modified soil PRGs were developed for all South Field COCs which pose a risk through the GMA groundwater exposure pathway. Three South Field COCs had the potential to impact groundwater. The South Field COCs are uranium-234, uranium-235/236 and uranium-238.

Potential Exposure Points

Two potential exposure points were used for modified soil PRG development at the South Field. Both the GMA under the waste unit and the GMA at the FEMP fence line were used as exposure points. Figures D.1-12 and D.1-13 show the South Field exposure points in plan view and cross-sectional view, respectively.

The selection of groundwater exposure points for modified soil PRG development was based on the two potential future land use scenarios for the site, namely a private or federal owner. Under private ownership there are two potential receptors, the on-property and off-property resident farmers, and it is assumed that no administrative or source controls exist to limit access to the GMA. The exposure points for these two receptors would be the GMA groundwater under the waste units (GMA under waste unit) and the GMA groundwater at the FEMP fence/property line (GMA at FEMP fence line). For the federal owner there is one potential receptor, the off-property resident farmer. However, unlike private ownership, with federal ownership, administrative or source controls would be implemented to limit access to the GMA under the waste units and the only groundwater exposure point for this receptor is the GMA at FEMP fence line.

D.1.4.2 Remedial Scenarios Evaluated

Four potential remedial alternatives for the South Field were investigated for modified soil PRG development. For private ownership, all contaminated soil above the modified soil PRL concentrations will be removed and replaced with clean soil, and no controls will be implemented (i.e., clean closure). For federal ownership, all contaminated material above PRLs will also be

remediated, however, controls will be used to increase PRL levels which will allow higher levels of contaminated material to be left on-site. The potential controls include: 1) administrative controls to limit access to the site; 2) administrative controls as well as source controls to control perched water; and 3) administrative controls, perched water controls, as well as capping to limit vertical infiltration. An in situ, composite type cap is proposed for the South Field. The design details for this type of cap are presented in Appendix E.

D.1.4.3 Model Input

The following sections summarize the data used as input to the ECTran model for South Field modified soil PRG development. A majority of the input was taken directly from the Operable Unit 2 RI fate and transport modeling sections. Other input was calculated from data presented in the Operable Unit 2 RI or previous reports.

Hydrogeologic Conditions

Table D.1-14 shows the general hydraulic parameters and physical dimensions of the South Field. The physical dimensions of the site and the layer thicknesses are presented separately for the four appropriate SWIFT grid blocks. The hydraulic gradient and flow distance along the pathline to the FEMP fence line were calculated using groundwater contours from 2000-series monitoring wells for the months of April 1988 to December 1989. Table D.1-15 displays the soil media parameters used for the South Field. All of these soil parameters were taken directly from the Operable Unit 2 RI. The South Field infiltration rates and mixing depth information for the No Cap and Composite Cap capping scenarios are presented in Table D.1-16. The no cap infiltration rates were estimated in the Operable Unit 2 RI using the HELP model. The capping infiltration rates were estimated specifically for the Operable Unit 2 FS and they were also calculated using the HELP model. Perched water flow rates were estimated from average hydraulic gradients and hydraulic conductivities for the perched water zone. These flow rates were added to the lateral infiltration rates to determine the total lateral flow rate under no controls. The mixing depth was calculated based on an equation presented in the ECTran model development report (Halliburton NUS, 1993) which is presented in Attachment D.1.I.

Chemical Characteristics and Risk-Based Criteria

Three different target risk-based water criteria were used for the development of modified soil PRGs for South Field. The three individual, chemical-specific cancer risk levels investigated were 1×10^{-6}, 1×10^{-5} and 1×10^{-4}. The criteria were developed as part of the Operable Unit 2 RI Baseline Risk

TABLE D.1-14

HYDRAULIC PARAMETERS AND PHYSICAL DIMENSIONS OF SOUTH FIELD MODIFIED SOIL PRG DEVELOPMENT

Parameter	Input Value			
	Case 1 and 2 (30,61)	Case 1 and 2 (30,57)	Case 3(a) (31,63)	Case 3 (b) (33,61)
Length	125 ft	125 ft	125 ft	125 ft
Width	125 ft	125 ft	125 ft	125 ft
Till Thickness (Layer 1)	0.0 ft	0.0 ft	8.2 ft	17.7 ft
Unsaturated GMA Thickness (Layer 2)	24.8 ft	21.3 ft	29.5 ft	31.8 ft
Saturated GMA Thickness	73 ft	73 ft	73 ft	
Hydraulic Gradient	5.7×10^{-4} ft/ft			
Horizontal Hydraulic Conductivity	638 ft/day			
Darcy's Velocity	132.7 ft/yr			
Horizontal Seepage Velocity	442.5 ft/yr			
Distance to FEMP Fenceline	1600 ft			
Downgradient Infiltration Rate	0.698 ft/yr			

Note: Swift Grid Block - Case 1 and 2 (30,61) - No Controls
Case 1 and 2 (30,57) - Perched Water Controls
Case 3A (31,63)
Case 3B (33,61)

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TABLE D.1-15

SUMMARY OF SOIL MEDIA PARAMETERS FOR THE SOUTH FIELD MODIFIED PRG DEVELOPMENT

Soil Media Parameter	Till (Layer 1)	Unsaturated Sand & Gravel (Layer 2)	Great Miami Aquifer
Porosity (%)	41	39	30
Bulk Density (g/cc)	1.85	1.60	1.70
Organic Content (%)	1.69	0.87	0.87
Moisture Content (%)	37	13.1	30
Saturation	0.902	0.336	1.00
Vertical Hydraulic Conductivty (ft/day)	3.97×10^{-4}	45	NA
Horizontal Hydraulic Conductivity (ft/day	NA	NA	638

NA = Not Applicable

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TABLE D.1-16

INFILTRATION RATE AND MIXING DEPTH INFORMATION FOR THE SOUTH FIELD MODIFIED SOIL PRG DEVELOPMENT

Capping Scenario (Case)	Waste Unit Infiltration Rate (in/yr)			Vertical Hydraulic Conductivity Kv (ft/day)	Empirical Soil[a] Parameter Layer 2 (1/2b+3)	Vertical Seepage[b] Velocity V_{zo} (ft/yr)	Dispersion[b] Coefficient (ft^2/yr)	Dispersivity[c] α_v (ft)	Mixing Depth[d] H (ft)
	Vertical	Lateral	Total						
No Controls (1 and 2)	9.28	25.78	35.06	45	0.09	12.31	1.42	0.116	8.780
Perched Water Controls (1 and 2)	9.28	4.08	13.36	45	0.09	6.771	0.847	0.125	7.480
Perched Water Controls (3a)	3.00	0	3.00	45	0.09	1.740	0.371	0.213	7.791
Perched Water Controls (3b)	1.86	0	1.86	45	0.09	1.126	0.319	0.283	8.736
Composite Cap (1 and 2)	1.22	0	1.22	45	0.09	0.769	0.290	0.377	9.925
Composite Cap (3 a,b)	1.22	0	1.22	45	0.09	0.769	0.290	0.377	9.925

[a]United States Environmental Protection Agency, April 1988, "Superfund Exposure Assesment Manual", EPA/540/1-88/001, Washington, D.C.

[b]PARSONS, February 1993, "Fate and Transport Modeling Transition Report", Revision A, Fernald Environmental Management Project, Fernald, Ohio.

[c]Dispersion Coefficient / Vertical Seepage Velocity.

[d]Halliburton NUS, September 1993, "Development and Application of the ECTran Model to Support RI/FS at the FEMP", Fernald Environmental Management Project, Fernald, Ohio.

Assessment. These criteria represent chemical-specific groundwater concentrations which present 1 x 10^{-6}, 1 x 10^{-5} and 1 x 10^{-4} cancer risks due to the groundwater exposure pathway. Table D.1-17 presents a summary of the chemical/geochemical data for the three South Field COCs. Also shown in the table are the 1 x 10^{-6} risk-based water criteria used for modified soil PRG development. The 1 x 10^{-5} and 1 x 10^{-4} risk-based water criteria were calculated by taking 10 and 100 times, respectively, the 1 x 10^{-6} risk-based water criteria.

Current COC Concentrations

Current South Field COC concentrations required for modified soil PRG development included source leachate concentrations and vadose zone soil concentrations. Table D.1-18 shows the current COC soil concentrations for the till and unsaturated sand and gravel. These concentrations were estimated as part of the Operable Unit 2 FS and a description of how the concentrations were estimated is presented in Appendix A, Sampling Results for Contaminants of Concern.

D.1.4.4 Model Verification With Measured Conditions

Once all input for the ECTran model was finalized, the model was used to estimate current groundwater conditions and maximum predicted concentrations for a 1000 year period at the South Field assuming no remediation. The estimated current and maximum conditions were then compared with measured groundwater concentrations presented in the Operable Unit 2 RI.

The current and maximum conditions were estimated by the ECTran model using the following procedure:

- Maximum COC leachate concentrations from the waste material, which were taken from the Operable Unit 2 RI, were assumed to be the initial contaminant leachate concentration when the waste was placed in the South Field approximately 40 years ago. The leachate concentrations were held constant for the 1000 year modeling period.

- The groundwater concentrations in Layer 1, Layer 2, GMA under the source, and GMA at the fence line due to these leachate concentrations were then calculated using the ECTran model. The current modeled conditions were ECTran concentrations for the particular layer at 40 years. The maximum modeled conditions were the maximum ECTran concentrations for the particular layer for a 1000 year period.

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TABLE D.1-17

SUMMARY OF CHEMICAL/GEOCHEMICAL DATA FOR THE SOUTH FIELD MODIFIED PRG DEVELOPMENT

COC	K_d (L/kg)				Specific Activity (Ci/g)	Half-Life (years)	1×10^{-6} Risk-Based Water Criteria (μg/L)
	Waste	Layer 1	Layer 2	Great Miami Aquifer			
Uranium-234	177	200	1.78	1.78	6.22×10^{-3}	2.45×10^{5}	1.77×10^{-4}
Uranium-235/236	177	200	1.78	1.78	2.16×10^{-6}	7.04×10^{8}	5.09×10^{-1}
Uranium-238	177	200	1.78	1.78	3.36×10^{-7}	4.47×10^{9}	1.85×10^{0}

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TABLE D.1-18

CURRENT CONTAMINANT CONCENTRATIONS FOR THE SOUTH FIELD MODIFIED PRG DEVELOPMENT

COC	Till (Layer 1)		Unsaturated Sand & Gravel (Layer 2)	
	(pCi/g)	(mg/kg)	(pCi/g)	(mg/kg)
Uranium-234	3.51×10^{0}	5.64×10^{-4}	5.85×10^{-1}	9.41×10^{-5}
Uranium-235/236	2.19×10^{-1}	1.01×10^{-1}	2.00×10^{-2}	9.26×10^{-3}
Uranium-238	4.55×10^{0}	1.35×10^{1}	6.60×10^{-1}	1.96×10^{0}

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Three different comparisons of contaminant groundwater concentrations were made including the following:

- Layer 2 ECTran current and maximum modeled conditions versus measured 1000-series monitoring well concentrations;
- ECTran modeled current and maximum GMA conditions under the source versus 2000-series monitoring well concentrations; and
- ECTran modeled current versus maximum GMA conditions at the FEMP fence line.

The current contaminant measurements were taken from the Operable Unit 2 RI. Figures D.1-10 and D.1-11 show the locations of the 1000-series and 2000-series wells, respectively, where the minimum and maximum South Field current COC concentrations were measured. From Figure D.1-10 it can be seen that MW 1942 had the maximum COC measurement and MW 1954 had the minimum COC measurement for the Inactive Flyash Pile. From Figure D.1-11 it can be seen that MW 2954 had the maximum COC measurement and MW 2943 had the minimum COC measurement. All of these wells are in the Case 3 area.

Table D.1-19 shows the type (1) comparison, Table D.1-20 shows the type (2) comparison, and Table D.1-21 shows the type (3) comparison. From the comparisons it can be seen that the ECTran model's results are usually conservative but typically close to the range of groundwater measurements.

D.1.4.5 Modified Soil PRGs

Modified soil PRG modeling results for the South Field include modified soil PRGs which are layer specific, case specific, remedial alternative specific, and risk-based water criteria specific. All of the modified soil PRG results are presented in Attachment D.1.III. The following sections highlight the locations of particular modified PRGs in Attachment D.1.III.

No Controls

The modified PRGs developed for the no controls scenario with 1×10^{-6}, 1×10^{-5}, and 1×10^{-4} risk-based water criteria are presented in Tables D.1.III-1 and D.1.III-2 in Attachment D.1.III. As can be seen in the tables, the modified 1×10^{-6} PRGs are below background concentrations. When background is added to the modified PRGs to develop PRLs, the PRLs will essentially be at background levels. The modified PRGs for 1×10^{-5} and 1×10^{-4} risk levels increase proportionally.

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TABLE D.1-19

COMPARISON OF 1000 SERIES WELL MEASUREMENTS AND ECTran MODEL RESULTS SOUTH FIELD

(Units = μg/L)

COC	Range of 1000 Series[a] Well Measurements		Range of ECTran Simulated Current Layer 2 Concentration		Range of ECTran Simulated Max. Layer 2 Concentration	
	Minimum	Maximum	Case 3b[c]	Case 1[b]	Case 3b[c]	Case 1[b]
Uranium-234	4.49×10^{-3}	3.59×10^{-2}	1.47×10^{-4}	2.29×10^{0}	5.76×10^{-2}	4.84×10^{0}
Uranium-235/236	7.96×10^{-1}	7.27×10^{0}	2.97×10^{-2}	4.64×10^{2}	1.17×10^{1}	9.81×10^{2}
Uranium-238	8.78×10^{1}	6.82×10^{2}	4.09×10^{-1}	2.12×10^{2}	1.61×10^{2}	4.49×10^{2}

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

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TABLE D.1-20

COMPARISON OF 2000 SERIES WELL MEASUREMENTS AND ECTran MODEL RESULTS SOUTH FIELD

(Units = μg/L)

COC	Range of 2000 Series[a] Well Measurements		Range of ECTran Simulated Current GMA Concentration		Range of ECTran Simulated Max. GMA Concentration	
	Minimum	Maximum	Case 3b[c]	Case 1[b]	Case 3b[c]	Case 1[b]
Uranium-234	1.98×10^{-4}	5.98×10^{-2}	2.45×10^{-6}	3.21×10^{-1}	9.62×10^{-4}	6.79×10^{-1}
Uranium-235/236	3.29×10^{-1}	7.27×10^{0}	4.97×10^{-4}	6.51×10^{1}	1.95×10^{-1}	1.38×10^{2}
Uranium-238	3.72×10^{0}	1.14×10^{3}	6.84×10^{-3}	2.98×10^{1}	2.69×10^{0}	6.30×10^{1}

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

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TABLE D.1-21

COMPARISON OF ECTran MODELING RESULTS SOUTH FIELD

(Units = $\mu g/L$)

SITE	COC	Range of ECTran Simulated Current Fenceline Concentration		Range of ECTran Simulated Max. Fenceline Concentration	
		Case 3b[c]	Case 1[b]	Case 3b[c]	Case 1[b]
SF	U234	2.62×10^{-9}	7.23×10^{-4}	3.42×10^{-5}	2.59×10^{-2}
	U235/236	5.30×10^{-7}	1.46×10^{-1}	6.94×10^{-3}	5.26×10^{0}
	U238	7.30×10^{-6}	6.70×10^{-2}	9.55×10^{-2}	2.41×10^{0}

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

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Administrative Controls

The modified PRGs developed for the administrative controls only scenario with 1 x 10^{-6}, 1 x 10^{-5}, and 1 x 10^{-4} risk-based water criteria are presented in Tables D.1.III-3 and D.1.III-4 in Attachment D.1.III. As can be seen in the tables, the 1 x 10^{-6} modified PRGs for uranium-234 and uranium-238 are below background concentrations while the uranium-235/236 modified PRGs are above background concentrations. The PRLs developed with these modified PRGs will be close to or above background levels. The modified PRGs for 1 x 10^{-5} and 1 x 10^{-4} increase proportionally.

Administrative and Source Controls

The modified PRGs developed for the administrative and source controls scenario with 1 x 10^{-6}, 1 x 10^{-5}, and 1 x 10^{-4} risk-based water criteria are presented in Tables D.1.III-5 through D.1.III-7 . As can be seen in the tables, the 1 x 10^{-6} modified PRGs for Cases 1 and 2 are generally below background, while the Case 3 modified PRGs are above background. The PRLs for Cases 1 and 2 will be approximately background while the PRLs for Case 3 will be higher than background. The modified PRGs for 1 x 10^{-5} and 1 x 10^{-4} risk levels increase proportionally.

Cap and Source Controls

The modified PRGs developed for the cap and source controls scenario with 1 x 10^{-6}, 1 x 10^{-5}, and 1 x 10^{-4} risk-based water criteria are presented in Tables D.1.III-8 and D.1.III-9 . As can be seen in the tables, the 1 x 10^{-6} modified PRGs for Cases 1 and 3 are significantly higher than background. PRLs developed for the numbers will be much higher than background. The modified PRGs for 1 x 10^{-5} and 1 x 10^{-4} risk levels increase proportionally.

D.1.5 ACTIVE FLYASH PILE

The Active Flyash Pile is a Operable Unit 2 waste unit which is located just east of the South Field and is bounded on the east by the Storm Sewer Outfall Ditch (Figure D.1-15). The Active Flyash Pile has a surface area of approximately three acres and has received flyash waste since the mid-1960s. The following sections will describe the fate and transport modeling conducted for the Active Flyash Pile to develop modified soil PRGs and summarize the results.

D.1.5.1 Conceptual Model

The conceptual model used to describe the Active Flyash Pile for modified soil PRG development identifies and incorporates the key hydrogeologic characteristics of the vadose and saturated zones of

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the Active Flyash Pile, COC source information, and factors that control transport of the COCs to be modeled. The following sections present the details of the conceptual model used for modified soil PRG modeling at the Active Flyash Pile.

Hydrogeologic Conditions

For the Active Flyash Pile the conceptualized conditions can be summarized as follows: rainfall and surface water infiltrate through the surface of the Active Flyash Pile, leaching of constituents from the source material into the dissolved phase occurs, the contaminated leachate migrates laterally or percolates vertically to the underlying GMA, lateral infiltration travels horizontally across the till and eventually discharges into areas with no till and percolates vertically to the GMA, and once in the GMA, the contaminants are then transported down-gradient. There are no significant amounts of perched water in the Active Flyash Pile area. In addition to the infiltration of the waste unit there is also vertical infiltration in downgradient areas which affects the contaminant concentrations in the GMA. Vertical infiltration from areas downgradient of the waste unit were considered during modeling of transport of COCs to the FEMP fence line. This additional infiltration was considered in the ECTran model by increasing the effective decay rate in the downgradient area.

The conceptual model for vadose zone transport is highly dependent upon the available vertical drainage pathways through each waste unit. Figure D.1-16 shows the conceptual model for lateral and vertical drainage to the unsaturated GMA at the Active Flyash Pile. The model shows that there are two pathways available depending upon the presence or absence of till/glacial overburden.

As described in the technical approach, three cases were used to investigate the variety of hydrogeological conditions at the Active Flyash Pile. Cases 1 and 2 (i.e., Case 1 area) considered the areas without till which have substantial lateral infiltration inflow rates from Case 3 areas. Case 3 considers the area which has till and provides the lateral infiltration to the Case 1 areas. Figure D.1-17 shows the lateral drainage patterns for the SWIFT grid blocks used to depict the Active Flyash Pile. A SWIFT grid block is a three-dimensional finite difference cell in SWIFT which has its own hydrogeological and contaminant transport parameters assigned to it. Grid block 32,56 was selected to depict the Case 1 area for modified soil PRG development while block 33,57 was used for the Case 3 area. These blocks were selected since they have the maximum total infiltration rate (i.e., lateral and vertical) to the GMA for their particular case.

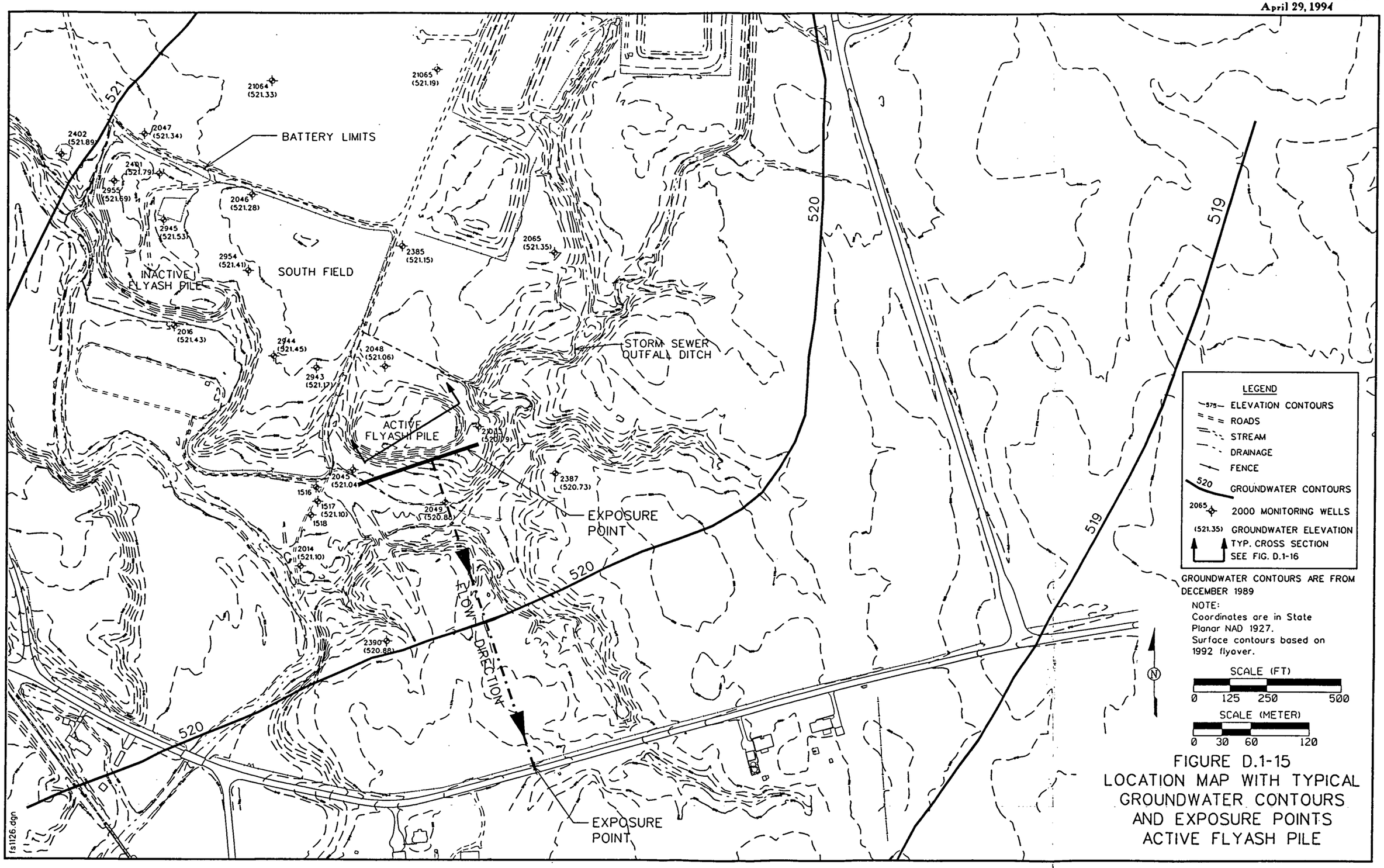

FIGURE D.1-15
LOCATION MAP WITH TYPICAL GROUNDWATER CONTOURS AND EXPOSURE POINTS ACTIVE FLYASH PILE

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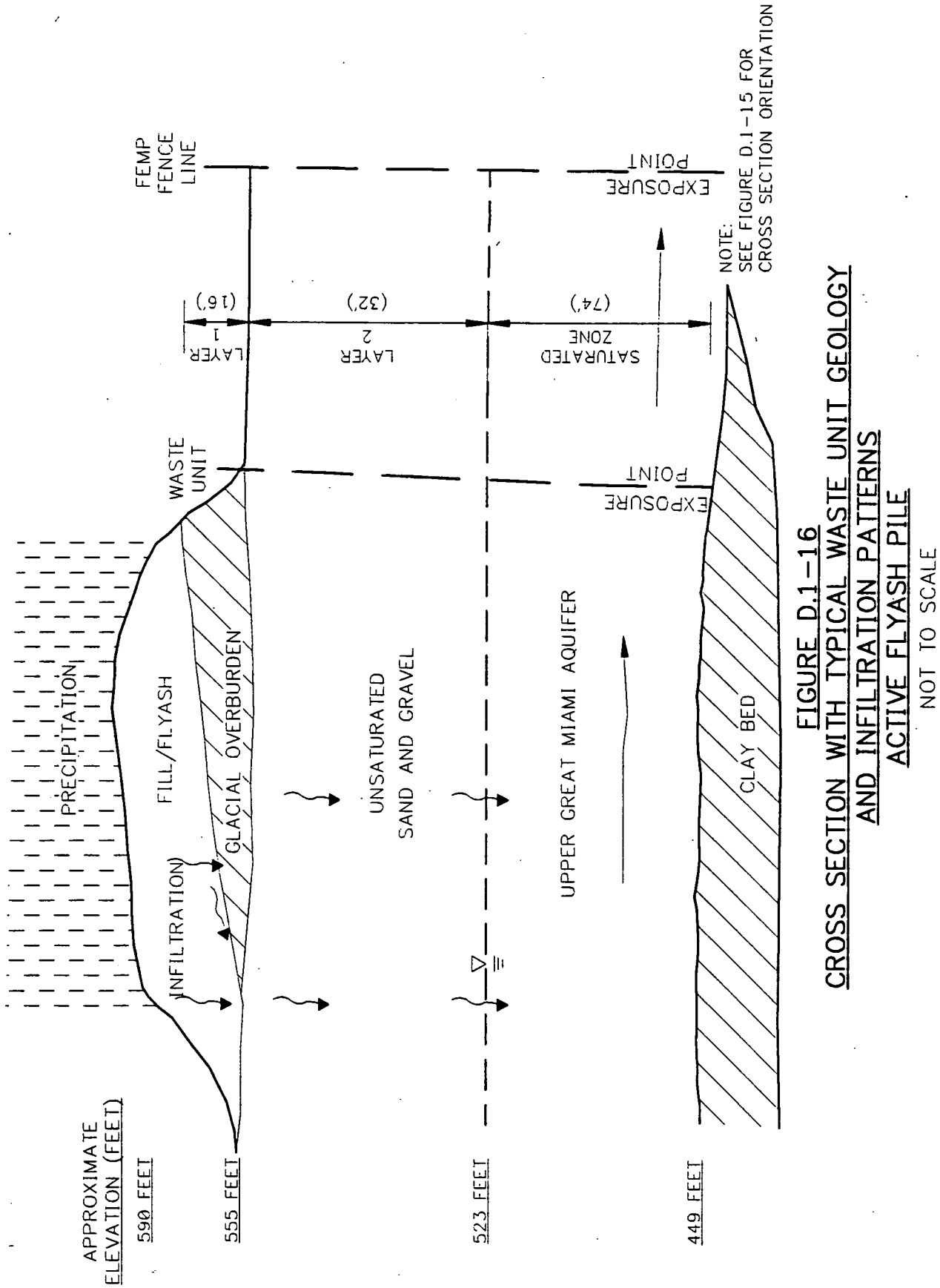

FIGURE D.1-16
CROSS SECTION WITH TYPICAL WASTE UNIT GEOLOGY
AND INFILTRATION PATTERNS
ACTIVE FLYASH PILE
NOT TO SCALE

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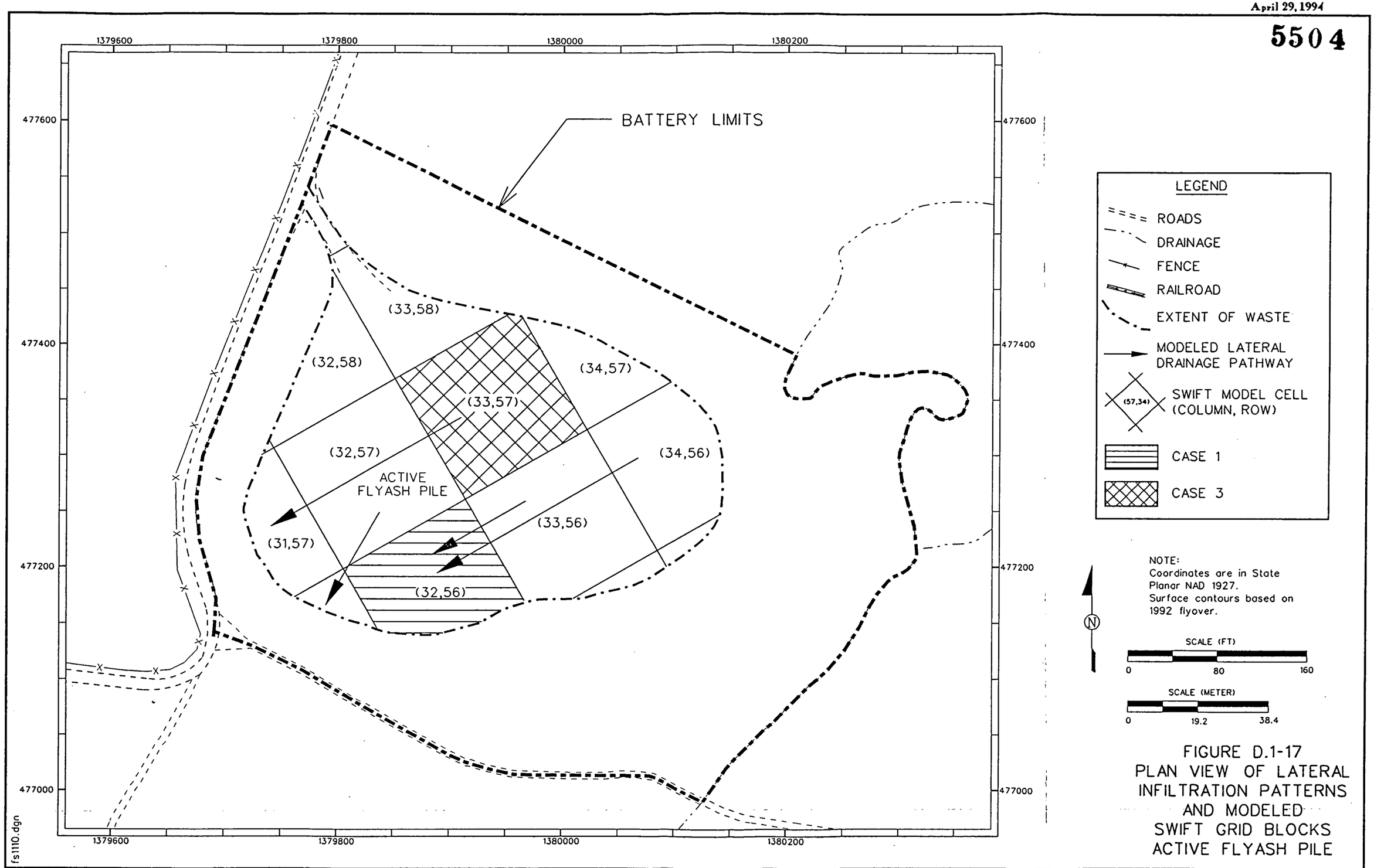

FIGURE D.1-17
PLAN VIEW OF LATERAL INFILTRATION PATTERNS AND MODELED SWIFT GRID BLOCKS ACTIVE FLYASH PILE

COCs

Modified soil PRGs were developed for all Active Flyash Pile COCs which pose a risk through the GMA groundwater exposure pathway. Two Active Flyash Pile COCs had the potential to impact groundwater, uranium-234 and uranium-238.

Potential Exposure Points

Two potential exposure points were used for modified soil PRG development at the Active Flyash Pile. Both the GMA under the waste unit and the GMA at the FEMP fence line were used as exposure points. Figures D.1-15 and D.1-16 show the Active Flyash Pile exposure points in plan view and cross-sectional view, respectively. The selection of groundwater exposure points for modified soil PRG development was based on the two potential future land use scenarios for the site, namely a private or federal owner. Under private ownership there are two potential receptors, the on-property and off-property resident farmer, and it is assumed that no administrative or source controls exist to limit access to the GMA. The exposure points for these two receptors would be the GMA groundwater under the waste units (GMA under waste unit) and the GMA groundwater at the FEMP fence/property line (GMA at FEMP fence line). For the federal owner there is one potential receptor, the off-property resident farmer. However, unlike private ownership, with federal ownership, administrative or source controls would be implemented to limit access to the GMA under the waste units and the only groundwater exposure point for this receptor is the GMA at FEMP fence line.

D.1.5.2 Remedial Scenarios

Three potential Operable Unit 2 remedial alternatives for the Active Flyash Pile were investigated for modified soil PRG development. For private ownership, all contaminated soil above the modified soil PRL concentrations will be removed, replaced with clean soil, and no controls will be implemented (i.e., clean closure). For federal ownership, all contaminated material above PRLs will also be remediated, however, controls will be used to increase PRL levels which will allow higher levels of contaminated material to be left on-site. The potential controls include: 1) administrative controls to limit access to the site; and 2) administrative controls as well as capping to limit vertical infiltration. An in-situ, clay type cap is proposed for the Active Flyash Pile.

D.1.5.3 Model Input

The following sections summarize the data used as input to the ECTran model for Active Flyash Pile modified soil PRG development. A majority of the input was taken directly from the Operable Unit 2 RI fate and transport modeling sections. Other input was calculated from data presented in the Operable Unit 2 RI or previous reports.

Hydrogeologic Conditions

Table D.1-22 shows the hydraulic parameters and physical dimensions of the Active Flyash Pile. The physical dimensions of the site and the layer thicknesses are presented separately for the two appropriate SWIFT grid blocks. The hydraulic gradient and flow distance along the pathline to the FEMP fence line were calculated using groundwater contours from 2000-series monitoring wells for the months of April 1988 to December of 1989. Table D.1-23 displays the soil media parameters used for the Active Flyash Pile. All of these soil parameters were taken directly from the Operable Unit 2 RI. The Active Flyash Pile infiltration rates and mixing depth information for the No Cap and Clay Cap capping scenarios are presented in Table D.1-24. The no cap infiltration rates were estimated in the Operable Unit 2 RI using the HELP model. The capping infiltration rates were estimated specifically for the Operable Unit 2 FS and they were also calculated using the HELP model. The mixing depth was calculated based on an equation presented in the ECTran model development report (Halliburton NUS, 1993) which is presented in Attachment D.1.I.

Chemical Characteristics and Risk-Based Criteria

Three different target risk-based water criteria were used for the development of modified soil PRGs for Active Flyash Pile. The three individual, chemical-specific cancer risk levels investigated were 1×10^{-6}, 1×10^{-5} and 1×10^{-4}. The criteria were developed as part of the Operable Unit 2 RI Baseline Risk Assessment. These criteria represent chemical-specific groundwater concentrations which present 1×10^{-6}, 1×10^{-5} and 1×10^{-4} cancer risks due to the groundwater exposure pathway.

Table D.1-25 presents a summary of the chemical/geochemical data for the two Active Flyash Pile COCs. Also shown in the table are the 1×10^{-6} risk-based water criteria used for modified soil PRG development. The 1×10^{-5} and 1×10^{-4} risk-based water criteria were calculated by taking 10 and 100 times, respectively, the 1×10^{-6} risk-based water criteria.

TABLE D.1-22

HYDRAULIC PARAMETERS AND PHYSICAL DIMENSIONS OF ACTIVE FLYASH PILE MODIFIED SOIL PRG DEVELOPMENT

Parameter	Input Value	
	Case 1 and 2	Case 3
Length	125 ft	125 ft
Width	125 ft	125 ft
Waste Thickness	20.7 ft	17.7 ft
Till Thickness (Layer 1)	0.0 ft	5.0 ft
Unsaturated GMA Thickness (Layer 2)	28.3 ft	31.6 ft
Saturated GMA Thickness	74 ft	74 ft
Hydraulic Gradient	6.1×10^{-4} ft/ft	
Horizontal Hydraulic Conductivity	638 ft/day	
Darcy's Velocity	142.1 ft/yr	
Horizontal Seepage Velocity	473.5 ft/yr	
Distance to FEMP Fenceline	1200 ft	
Downgradient Infiltration Rate	0.698 ft/yr	

Note : Swift Grid Block -Case 1 (32,56)
Case 3 (33,57)

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TABLE D.1-23

SUMMARY OF SOIL MEDIA PARAMETERS FOR THE ACTIVE FLYASH PILE MODIFIED PRG DEVELOPMENT

Soil Media Parameter	Till (Layer 1)	Unsaturated Sand & Gravel (Layer 2)	Great Miami Aquifer
Porosity (%)	41	39	30
Bulk Density (g/cc)	1.85	1.60	1.70
Organic Content (%)	1.89	0.87	0.87
Moisture Content (%)	41	13.1	30
Saturation	0.902	0.336	1.00
Vertical Hydraulic Conductivty (ft/day)	3.97×10^{-4}	45	NA
Horizontal Hydraulic Conductivity (ft/day)	NA	NA	638

NA = Not Applicable

TABLE D.1-24

INFILTRATION RATE AND MIXING DEPTH INFORMATION FOR THE ACTIVE FLYASH PILE MODIFIED SOIL PRG DEVELOPMENT

Capping Scenario (Case)	Waste Unit Infiltration Rate (in/yr)			Vertical Hydraulic Conductivity Kv (ft/day)	Empirical Soil[a] Parameter Layer 2 (1/2b+3)	Vertical Seepage[b] Velocity V_{zo} (ft/yr)	Dispersion[b] Coefficient (ft^2/yr)	Dispersivity[c] α_v (ft)	Mixing Depth[d] H (ft)
	Vertical	Lateral	Total						
With or Without Administrative Controls (1,2,4)	11.57	16.82	28.38	45	0.09	13.444	1.545	0.115	8.825
With or Without Administrative Controls (3)	3.16	0	3.16	45	0.09	1.821	0.378	0.208	7.682
Clay Cap (1,2,4)	1.14	0	1.14	45	0.09	0.721	0.287	0.398	10.17
Clay Cap (3)	1.14	0	1.14	45	0.09	0.721	0.287	0.398	10.17

[a]United States Environmental Protection Agency, April 1988, "Superfund Exposure Assesment Manual", EPA/540/1-88/001, Washington, D.C.

[b]PARSONS, February 1993, "Fate and Transport Modeling Transition Report", Revision A, Fernald Environmental Management Project, Fernald, Ohio.

[c]Dispersion Coefficient / Vertical Seepage Velocity.

[d]Halliburton NUS, September 1993, "Development and Application of the ECTran Model to Support RI/FS at the FEMP", Fernald Environmental Management Project, Fernald, Ohio.

TABLE D.1-25

SUMMARY OF CHEMICAL/GEOCHEMICAL DATA FOR THE ACTIVE FLYASH PILE

COC	K_d (L/kg)				Specific Activity (Ci/g)	Half-Life (years)	Risk-Based Water Criteria (μg/L)
	Waste	Layer 1	Layer 2	GMA			
Uranium-234	37.5	200	1.78	1.78	6.22×10^{-3}	2.45×10^{5}	1.77×10^{-4}
Uranium-238	37.5	200	1.78	1.78	3.36×10^{-7}	4.47×10^{9}	1.85×10^{0}

Current COC Concentrations

Current Active Flyash Pile COC concentrations, which were required for modified soil PRG development, included vadose zone soil concentrations. Table D.1-26 shows the current COC soil concentrations for the till and unsaturated sand and gravel.

These concentrations were estimated as part of the Operable Unit 2 FS and a description of how the concentrations were estimated is presented in Appendix A, Sampling Results for Contaminants of Concern.

D.1.5.4 Model Verification With Measured Conditions

Once all input for the ECTran model was finalized, the model was used to estimate current groundwater conditions and maximum predicted concentrations for a 1000 year period at the Active Flyash Pile assuming no remediation. The estimated current and maximum conditions were then compared with measured groundwater concentrations presented in the Operable Unit 2 RI.

The current and maximum conditions were estimated by the ECTran model using the following procedure:

- Maximum COC leachate concentrations from the waste material, which were taken from the Operable Unit 2 RI, were assumed to be the initial contaminant leachate concentration when the waste was placed in the Active Flyash Pile approximately 40 years ago. The leachate concentrations were held constant for the 1000 year modeling period.

- The groundwater concentrations in Layer 1, Layer 2, GMA under the source, and GMA at the fence line due to these maximum leachate concentrations were then calculated using the ECTran model. The current modeled conditions were ECTran concentrations for the particular layer at 40 years. The maximum modeled conditions were the maximum ECTran concentrations for the particular layer for a 1000 year period.

Three different comparisons of contaminant groundwater concentrations were made including the following:

- Layer 2 ECTran current and maximum modeled conditions versus current measured 1000-series monitoring well concentrations;

- ECTran modeled current and maximum GMA conditions under the source versus current 2000-series monitoring well concentrations; and

- ECTran modeled current versus maximum GMA conditions at the FEMP fence line.

TABLE D.1-26

CURRENT CONTAMINANT CONCENTRATIONS FOR THE ACTIVE FLYASH PILE MODIFIED PRG DEVELOPMENT

COC	Till (Layer 1)		Unsaturated Sand & Gravel (Layer 2)	
	(pCi/g)	(mg/kg)	(pCi/g)	(mg/kg)
Uranium-234	1.00×10^{0}	1.61×10^{-4}	9.21×10^{-1}	1.48×10^{-4}
Uranium-238	1.05×10^{0}	3.13×10^{0}	7.54×10^{-1}	2.24×10^{0}

The current contaminant measurements were taken from the Operable Unit 2 RI. Figures D.1-10 and D.1-11 show the locations of the 1000-series and 2000-series wells, respectively, where the minimum and maximum Active Flyash Pile current COC concentrations were measured. From Figure D.1-10 it can be seen that MW 1045 had the maximum COC measurement and no other wells were available to determine the minimum COC measurement for the Active Flyash Pile. From Figure D.1-11 it can be seen that MW 2045 had the maximum COC measurement and MW 2049 and MW 21033 had the minimum COC measurements, depending on the isotope. All of these wells are in the Case 1 area.

Table D.1-27 shows the type (1) comparison, Table D.1-28 shows the type (2) comparison, and Table D.1-29 shows the type (3) comparison. From the comparisons it can be seen that the ECTran model's results are usually conservative but typically close to the range of groundwater measurements.

D.1.5.5 Modified Soil PRGs

Modified soil PRG modeling results for the Active Flyash Pile include modified soil PRGs which are layer specific, case specific, remedial alternative specific, and risk-based water criteria specific. All of the modified soil PRG results are presented in Attachment D.1.IV. The following sections highlight the locations of particular modified soil PRGs in Attachment D.1.IV.

No Capping

The modified PRGs developed for the no controls scenario with 1×10^{-6}, 1×10^{-5}, and 1×10^{-4} risk-based water criteria are presented in Tables D.1.IV-1 and D.1.IV-2 in Attachment D.1.IV. As can be seen in the tables, the 1×10^{-6} modified PRGs are below background concentrations. When background is added to the modified PRGs to develop PRLs, the PRLs will essentially be at background levels. The modified PRGs for 1×10^{-5} and 1×10^{-4} risk levels increase proportionally.

Administrative Controls

The modified PRGs developed for the administrative and source controls scenario with 1×10^{-6}, 1×10^{-5}, and 1×10^{-4} risk-based water criteria are presented in Tables D.1.IV-3 through D.1.IV-5. As can be seen in the tables, the 1×10^{-6} modified PRGs for Cases 1 and 2 are generally below background, while the Case 3 modified PRGs are above background. The PRLs for Cases 1 and 2 will be approximately background while the PRLs for Case 3 will be higher than background. The modified PRGs for 1×10^{-5} and 1×10^{-4} risk levels increase proportionally.

TABLE D.1-27

COMPARISON OF 1000 SERIES WELL MEASUREMENTS AND ECTran MODEL RESULTS ACTIVE FLYASH PILE

(Units = μg/L)

COC	Range of 1000-Series[a] Well Measurements		Range of ECTran Simulated Current Layer 2 Concentration		Range of ECTran Simulated Max. Layer 2 Concentration	
	Minimum	Maximum	Case 3[c]	Case 1[b]	Case 3[c]	Case 1[b]
Uranium-234	ND	2.77×10^{-4}	3.36×10^{-4}	7.25×10^{-1}	9.80×10^{-2}	1.10×10^{0}
Uranium-238	ND	6.40×10^{0}	1.61×10^{0}	2.73×10^{3}	4.70×10^{2}	4.14×10^{3}

ND = Non Detect

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

TABLE D.1-28

COMPARISON OF 2000 SERIES WELL MEASUREMENTS AND ECTran MODEL RESULTS
ACTIVE FLYASH PILE

(Units = μg/L)

COC	Range of 2000 Series[a] Well Measurements		Range of ECTran Simulated Current GMA Concentration		Range of ECTran Simulated Max. GMA Concentration	
	Minimum	Maximum	Case 3[c]	Case 1[b]	Case 3[c]	Case 1[b]
Uranium-234	2.09×10^{-4}	2.11×10^{-2}	1.01×10^{-5}	1.71×10^{-1}	2.95×10^{-3}	2.60×10^{-1}
Uranium-238	6.25×10^{0}	4.29×10^{2}	4.85×10^{-2}	6.44×10^{2}	1.42×10^{1}	9.77×10^{2}

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

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TABLE D.1-29

COMPARISON OF ECTran MODELING RESULTS ACTIVE FLYASH PILE

(Units = μg/L)

COC	Range of ECTran Simulated Current Fenceline Concentration		Range of ECTran Simulated Max. Fenceline Concentration	
	Case 3[c]	Case 1[b]	Case 3[c]	Case 1[b]
Uranium-234	5.91×10^{-8}	2.39×10^{-3}	1.98×10^{-4}	1.83×10^{-2}
Uranium-238	2.83×10^{-4}	9.01×10^{0}	9.52×10^{-1}	6.91×10^{1}

[a]Information taken from CRU2 Remedial Investigation.

[b]Case 1 : Q_4, C_4; Q_3, C_2 (Lateral Infiltration and no till).

[c]Case 3 : Q_2, C_2 (No Lateral Infiltration but with till).

Administrative Controls and Capping

The modified PRGs developed for the cap and source controls scenario with 1 x 10^{-6}, 1 x 10^{-5}, and 1 x 10^{-4} risk-based water criteria are presented in Tables D.1.IV-6 and D.1.IV-7 . As can be seen in the tables, the modified 1 x 10^{-6} PRGs for Cases 1 and 3 are significantly higher than background. PRLs developed for the numbers will be much higher than background. The modified PRGs for 1 x 10^{-5} and 1 x 10^{-4} risk levels increase proportionally.

D.1.6 SUMMARY

The ECTran model was used to calculate modified soil PRGs for the Operable Unit 2 FS. Modified soil PRGs were estimated for the Solid Waste Landfill, Inactive Flyash Pile, South Field and Active Flyash Pile waste units for the appropriate COCs. The Solid Waste Landfill had COCs which impacted the perched groundwater zone, therefore modified soil PRGs were determined which were protective of the perched groundwater. The Inactive Flyash Pile, South Field, and Active Flyash Pile had COCs which impacted the GMA groundwater, and hence modified soil PRGs were determined for these waste units which were protective of the GMA groundwater.

Modified soil PRGs can be added to background soil concentrations to develop PRLs. The PRLs can be compared with current soil contaminant concentrations to determine the preliminary extent of remediation. All modified PRGs determined for the Operable Unit 2 FS are summarized in Table D.1-5 and tables presented in Attachments D.1.II to D.1.IV. The modified soil PRLs are presented in Section 2. Current contaminant soil concentrations are presented in Appendix A.

After comparing the modified soil PRLs with the current contaminant concentrations, Operable Unit 2 determined that remediation was necessary for the Operable Unit 2 waste units. Two remedial alternatives being investigated for the federal ownership land use scenario are the consolidation/ containment and the on-site disposal alternatives. Evaluation of the long-term residual risk associated with the consolidation/ containment alternative was considered and is presented in Appendix D.2. In addition, the necessity for an interceptor trench to collect perched water was also evaluated and is presented in Appendix D.2. The ECTran model was used to evaluate both of these modeling tasks.

A brief discussion on how the ODAST and improved SWIFT models were used to confirm the remedial alternatives, which were based on the modified PRGs, was presented within this appendix. The confirmation modeling results are included in Appendix D.3. The confirmation modeling was

performed to collectively evaluate the impact of the alternatives and to assure that the final design in compliance with health-based criteria.

ATTACHMENT D.1.I

DEVELOPMENT AND APPLICATION OF THE ECTran MODEL TO SUPPORT RI/FS AT THE FEMP

DEVELOPMENT AND APPLICATION OF THE ECTran MODEL TO SUPPORT RI/FS AT THE FEMP

U.S. DEPARTMENT OF ENERGY
FERNALD
CINCINNATI, OHIO

HALLIBURTON NUS PROJECT NUMBER 4P94

SEPTEMBER 1993

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FEMP-OU02-4 DRAFT
April 29, 1994

DEVELOPMENT AND APPLICATION OF THE ECTran MODEL TO SUPPORT RI/FS AT THE FEMP

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
SEPTEMBER 1993

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1.0 INTRODUCTION

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An efficient and robust groundwater contaminant fate and transport model implemented on Excel 4.0 and Crystal Ball 3.0 (ECTran) has been developed and is proposed to support the Remedial Investigation/Feasibility Study (RI/FS) processes at the Fernald Environmental Management Project (FEMP). This screening-level model can be utilized to supplement existing more complex fate and transport models during parameter estimation, risk assessment, cleanup goal development, Alternate Concentration Limit (ACL) determination, and stochastical sensitivity analysis. The ECTran (which stands for Excel-Crystal Ball Transport) model is based on straightforward mass-balances and advection/dispersion analytical equations, but can be used to simulate a variety of complex conditions. To date, Halliburton NUS has employed similar models to determine soil cleanup goals, ACLs, cleanup time estimations, and to support baseline risk assessments for both CERCLA and RCRA applications in U.S. EPA Regions III, VI, and X. This report presents the required capabilities, development processes, and proposed applications of the screening-level spreadsheet-based groundwater contaminant fate and transport model (i.e., ECTran) at the FEMP.

2.0 OBJECTIVE AND CAPABILITIES OF THE SCREENING MODEL

Groundwater fate and transport models, developed using ODAST and SWIFT codes, have been applied in various Removal Actions and RI reports at the FEMP. Based on the experiences of these modeling tasks, a screening-level contaminant fate and transport model was determined necessary to supplement the existing modeling tools. Due to their complexities, the current models are not efficient during model parameter estimation, model calibration, remedial alternative screening, long-term simulation, and stochastical sensitivity analysis. Because of this limitation, the usefulness of computer models in supporting RI/FS processes has not been fully utilized at the FEMP. The primary objective of the proposed screening model is to efficiently support the current models in tasks where larger numbers of long-term modeling runs are required. The screening model can be used to scope the necessary scenarios or final ranges of parameter values that the primary groundwater models need to simulate and verify. In order to achieve this objective, this auxiliary model should be robust and flexible. Desired capabilities of this model are summarized in the following subsections.

2.1 MODEL STRUCTURE

Figures 2-1 and 2-2 show the general hydrogeological conditions (setting) in the vicinity of FEMP. In order to support the existing models which simulate these conditions, the conceptual structure of the proposed screening model needs to:

- Include both the glacial overburden and sand and gravel aquifer underlying the FEMP.
- Use any specified groundwater flow conditions directly.
- Use a mixing-depth concept in the saturated zone instead of the fixed thickness of the entire saturated zone.
- Employ analytical solutions, so that no model grid is required.
- Be separately and flexibly applied in any localized source areas.

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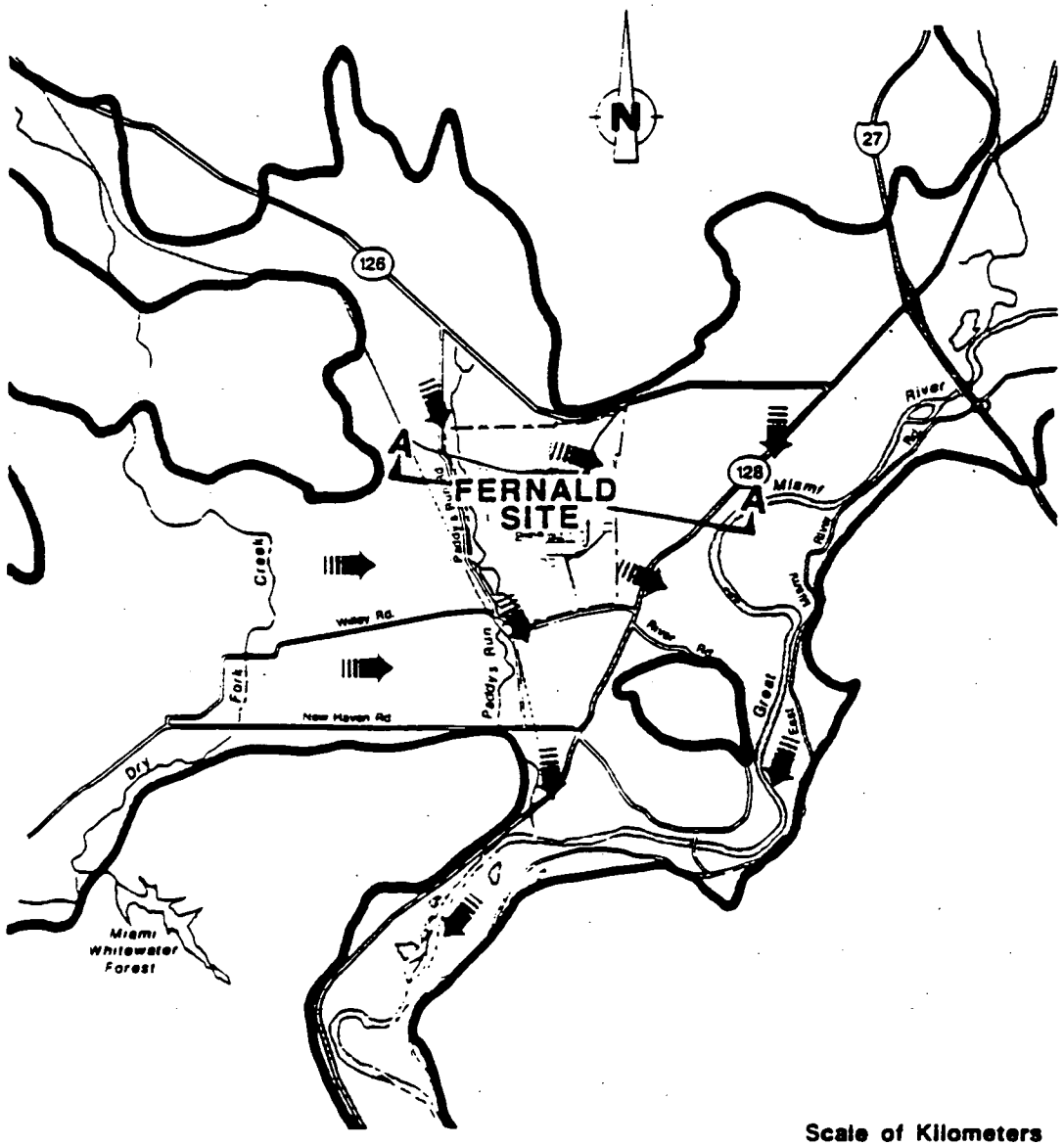
Figure 2-1 Buried Valley Aquifer Underlying the Fernald Site and Vicinity



Scale of Kilometers

0 1 2

1 Kilometer = 0.62 Mile

LEGEND

Buried Valley Aquifer	----- Plant Perimeter
General Direction of Groundwater Flow	A A Location of Cross-Section Shown in Figure 2-2

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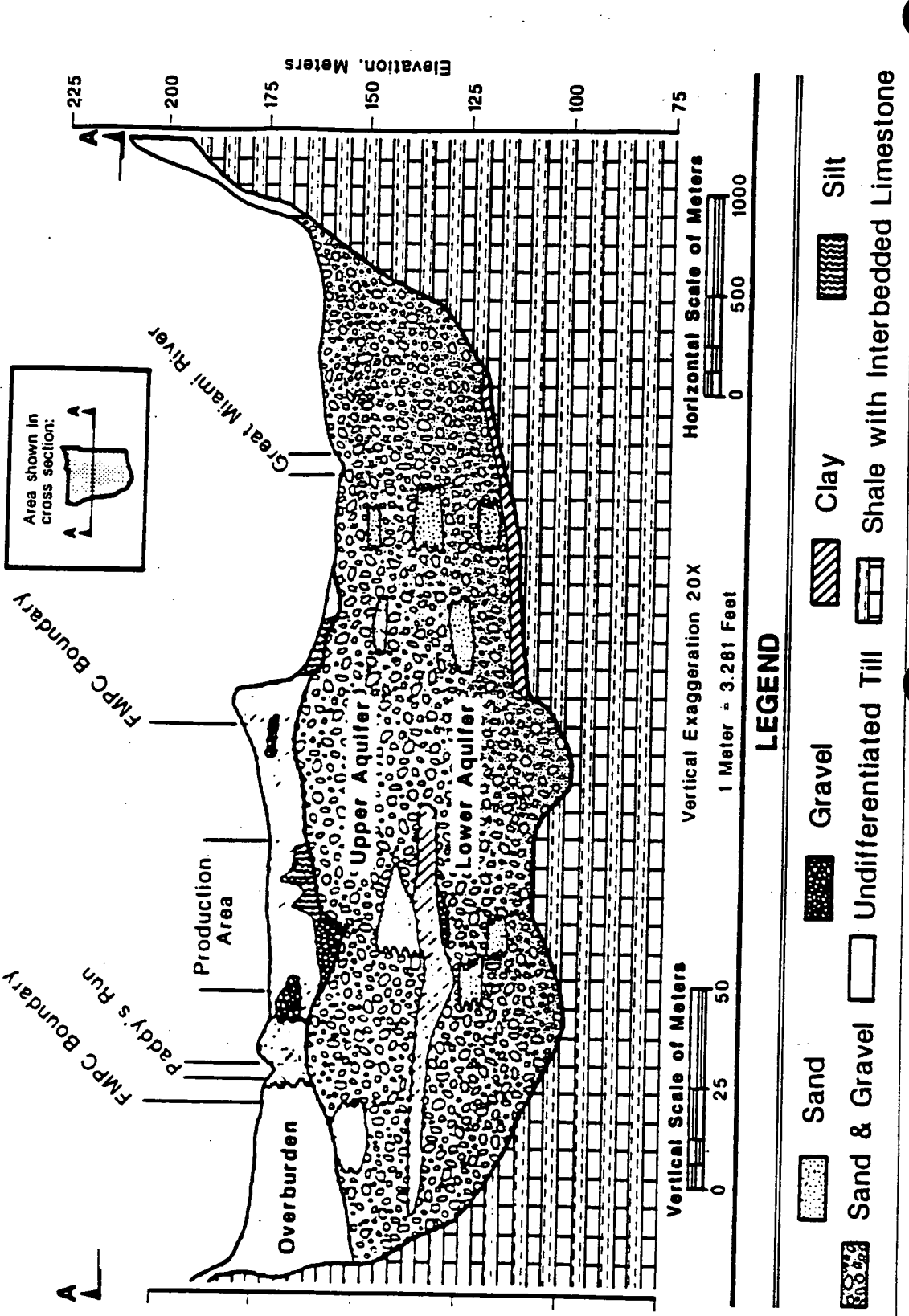

Figure 2-2: *Cross-Section of the New Haven Trough, Looking North*

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2.2 SOURCE LOADING AND ATTENUATION PROCESSES

Figure 2-3 shows the Operable Unit (OU) designations in the FEMP. Each of the five OUs presents different contaminant source loading characteristics and hydrogeological conditions that affect the attenuation of contaminants. Therefore, a realistic screening model for the FEMP should be able to:

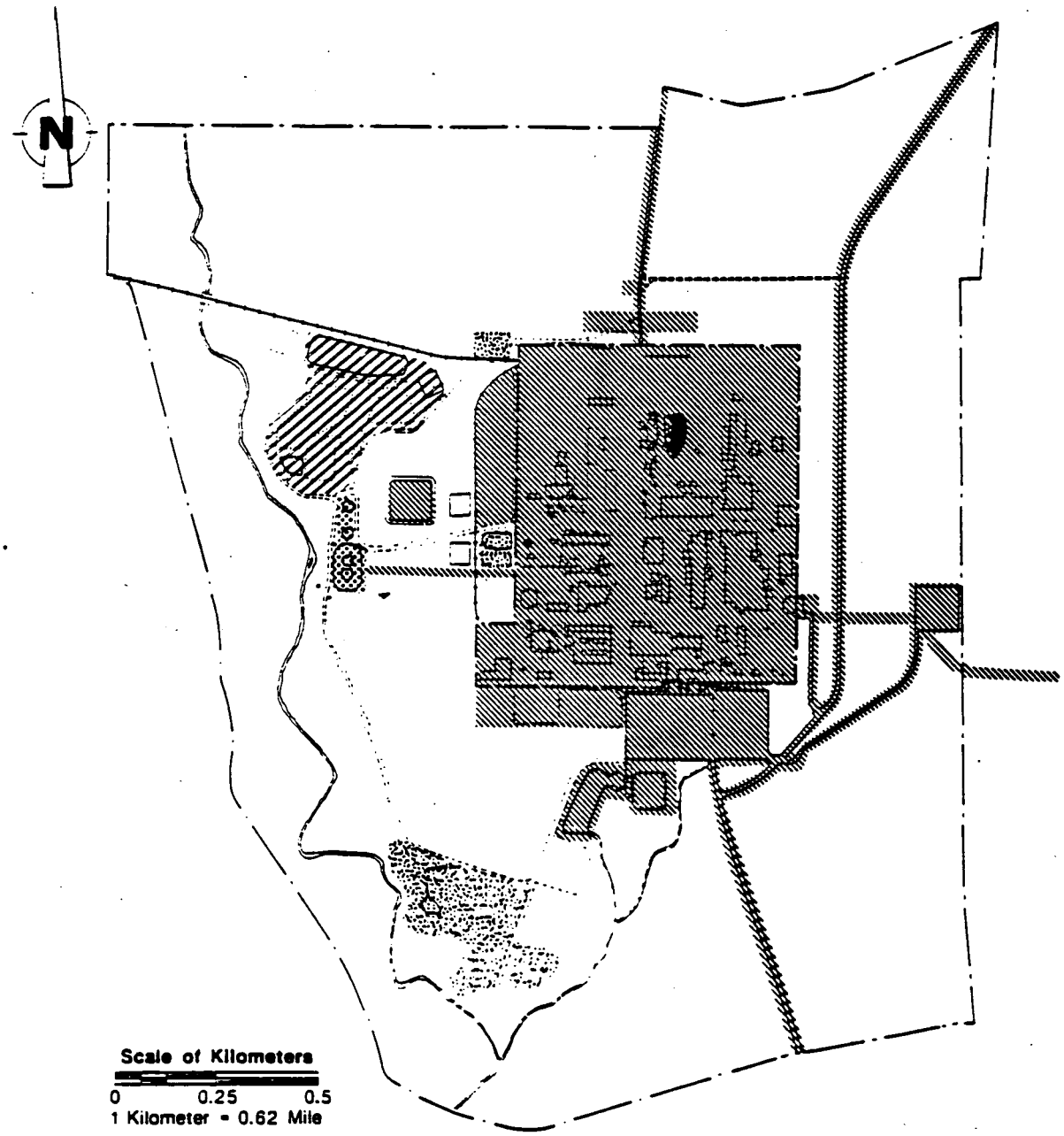
- Simulate all major physical and chemical processes that affect the contaminant fate and transport.
- Accept zone- and layer-specific initial contaminant concentrations, chemical decay rates and distribution coefficients.
- Include the source loading from the waste units.
- Include additional source loading in the glacial overburden.
- Consider contaminated or clean upgradient groundwater recharge.
- Consider impacts of pumping and/or containment in the source area on the exposure point concentrations.
- Consider age of the source to estimate the current downgradient concentrations.

2.3 MODEL OUTPUT

The modeling results need to be easily accessible and clearly understandable. Therefore, the screening model should be designed to:

- Present layer- and zone-specific contaminant concentrations vs. time.
- Present concentrations along the projected centerline of the contaminant plume at a downgradient location such as the FEMP property line.
- Present the output statistically and graphically without the need of post-processing.

Figure 2-3 : FEMP Operable Units



LEGEND

- Operable Unit 1
- Operable Unit 2
- Operable Unit 3
- Operable Unit 4
- Operable Unit 5 (Not Shown)

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2.4 MODEL PERFORMANCE

The most desired characteristic of the screening model is the capability to support fast, flexible, but realistic applications. Under these performance criteria, the screening model should:

- Apply and calibrate to field conditions easily.
- Support stochastical analysis.
- Have a very short run time that is not sensitive to contaminants being simulated.

3.0 ECTran MODEL DEVELOPMENT

Based on the required capabilities, a spreadsheet-based approach was selected to develop the screening fate and transport model. This section describes the development process of the ECTran model. Discussions on the development of the conceptual model, assumptions, governing equations, spreadsheet implementation (i.e., Excel 4.0), and Monte Carlo simulation capability (i.e., Crystal Ball) are all included within this section.

To develop a mathematical/computer model, the natural physical and chemical systems in question must first be characterized or conceptualized. This delineation of the natural systems on site with necessary assumptions and simplifications is usually called a conceptual model. Governing equations based on the conceptual model and assumptions are then derived. Next, suitable computer tools are utilized to implement the governing equations. The developed computer model with proper input data must then be applied to simulate a measured event and to verify the validity of the model development process. If the appropriate conceptual model, assumptions, and governing equations have been used for model development, the model will simulate the natural system properly.

Once the basic functions (i.e., deterministic simulations of the natural physical and chemical processes) of the model have been implemented and verified, auxiliary capabilities can be developed and incorporated to improve the overall usefulness of the model. Typical auxiliary functions can include: statistical calculations, Monte Carlo simulation, graphical presentation, and on-line user's guide.

3.1 CONCEPTUAL MODEL

Since the screening model will be independently applied in many localized source areas at the FEMP, the model should have sufficient flexibility and be easily customized to a specific source area during model applications. Therefore, a general conceptual model of fate and transport of a contaminant in the groundwater system underlying the FEMP should be determined. Information gathered during previous site and contaminant characterization tasks was utilized for this purpose. The general conceptual model for scoping the screening model development identified and incorporated the following information:

- General configuration of the water-bearing zones of interest.
- Possible hydrologic behavior of, and interconnections between, all major geologic formations.
- Ranges of velocities and directions of groundwater flow.
- Extent and configuration of potential contaminant sources.
- Chemical properties of major contaminants of concern.
- Geochemical properties of aquifer materials that affect contaminant transport.
- General contaminant migration pathways.
- Locations of potential exposure points to be considered in the risk assessment.

Detailed information on geology, hydrogeology, and contaminants has been collected at the FEMP during RI/FS and Removal Action activities. This information was used to develop a general conceptual model which could be applied over most of the site. Figure 3-1 depicts the general conceptual model determined for developing the proposed screening model. The following sections describe the rationale for the conceptual model.

3.1.1 Stratigraphy

In general, the geologic conditions at the FEMP site can be categorized into four general units. The uppermost unit consists of the waste unit and unsaturated weathered till. The next-lower unit consists of generally unweathered glacial overburden interbedded with glaciofluvial sand and gravel stringers. Some of the stringers are saturated and have been labeled as perched groundwater. The next-lower unit consists of unsaturated sand and gravel outwash deposits existing above the Great Miami Aquifer (GMA). The lowest geologic unit of interest is the GMA. This aquifer is a well-sorted sand and gravel water table system consisting of glacial outwash deposits located within a 2- to 3-mile-wide subterranean valley known as the New Haven Trough. This aquifer is divided by a 10- to 20-foot-thick clay aquitard at an approximate depth of 120 feet. The aquifer overlies limestone/shale bedrock at an approximate depth of 200 feet.

This information was used to determine that the screening model should have three potential layers (i.e., Layer 1, Layer 2, and Saturated Zone (GMA)). Layer 1 was used to represent the glacial overburden, Layer 2 was used to represent the unsaturated sand and gravel, and the bottom model layer represented the upper portion of the GMA. The conceptual model did not directly represent the waste unit and weathered till, but indirectly modeled it by using the leachate loadings from the waste unit as inflows to Layer 1. The reason for not considering the lower portion of the GMA is that the maximum contaminant

concentration will most likely occur in the upper portion of GMA. This approach seems reasonable for the ECTran model since the purpose of a screening model is to estimate the peak contaminant concentration.

3.1.2 Hydrogeology

The hydrogeology of the FEMP and the surrounding area is a textbook example of a glaciofluvial buried valley aquifer (Walton, 1970; Fetter, 1989; Freeze and Cherry, 1979). The primary aquifer in the region is the GMA, a well-sorted sand and gravel water table system consisting of glacial outwash deposits. As shown in Figure 2-1, groundwater in the aquifer enters the FEMP area via buried channels on the west, north, and east. Under natural conditions, the primary flow would be across the site to the south. However, large pumping wells east of the FEMP in the Big Bend area of the Great Miami River have created a pronounced cone of depression causing groundwater flow at the FEMP to have easterly, southeasterly, and southerly components.

Within the glacial overburden, there are numerous water-bearing zones (i.e., perched groundwater) that have limited interconnection. The majority of these zones are of glaciofluvial origin and consist of small beds of highly-sorted sands and gravels. These beds are probably the result of small meltwater streams that occurred along the ice margin and within the glacier itself. This information was used to determine that the screening model should allow potential subsurface perched water flow into and/or out of the model domain in the glacial overburden.

3.1.3 Contamination

The primary contaminant at the FEMP site is uranium. Other secondary contaminants at the site include radioactive contaminants such as radium and thorium and inorganic/organic contaminants such as lead, bis(2-ethylhexyl)phthalate and trichloroethene. The conceptual model was developed to be general enough to allow for modeling of each type of contaminant (i.e., radionuclide or inorganic/organic) and to take into consideration the contaminant geochemistry and transport at the site. The depositional characteristics and the hydrostratigraphic units present at the FEMP impart general contaminant transport characteristics on solutes migrating from the individual waste areas to receptor locations. These characteristics include:

- **Solute Migration Potential.** Solutes have a high migration potential through the upper weathered tills due to the fractured nature of the sediment. Solute migration can also occur through the unweathered till, however, at a much slower rate. Once the solute reaches the

glacial outwash, the solute migration potential is high, based on the hydraulic conductivity of the matrix.

- **Hydraulic Interconnection.** The intercommunication between perched water-bearing zones is limited in the glacial environment. Communication between the upper water-bearing zones within the glacial overburden and the GMA is likely over an extended period of time. Communication between the upper and lower zones within the GMA will be controlled by transverse (vertical) dispersion and will therefore be extremely limited.

- **Adsorption/Attenuation Characteristics.** Sediments found within the glacial overburden generally have sufficient organic carbon content (e.g., 0.5 percent to 1 percent) to cause retardation of organic constituents. The clay mineralogy would result in cation retardation for inorganic constituents. Given the till matrix, it is also unlikely that adsorption/attenuation breakthrough would occur. Adsorption/attenuation will occur at lower rates in the regional aquifer due to the lower organic carbon and clay content in the outwash.

This information was used to conclude that the screening model should allow zone- or layer-specific adsorption, attenuation, and decay parameters to be specified.

3.2 ASSUMPTIONS

In order to develop a spreadsheet-based analytical fate and transport model, the following simplified but conservative assumptions were incorporated into the proposed ECTran model:

- External source loadings and upgradient conditions are constant.

- Dispersion is negligible in the overburden

- Vertical dispersion is negligible in the Great Miami Aquifer.

- Downgradient aquifer can be approximated as homogeneous with uniform groundwater flow.

- Layer-averaged input conditions and model predictions are sufficient in the overburden for screening purposes.

- Zone-averaged contaminant concentrations in the mixing zone underlying the source area and concentrations at the fence line are sufficient in the GMA for screening purpose.

3.3 GOVERNING EQUATIONS

The differential equations which govern groundwater flow and transport of contaminants were used to develop analytical solutions in ECTran. The developed model relies on key information inside the waste units and uses simple and robust, but conservative, fate and transport equations to describe the relatively complex modeling domain and contaminant migration pathways encountered at the FEMP. Important parameters included in the ECTran model to describe each layer and zone in the conceptual model is shown in Figure 3-2. The following subsections discuss the development and rationale of the governing equations in each model layer or zone using these parameters (shown in Figure 3-2).

3.3.1 Model Layer 1

A mass-balance analysis with solid- and dissolved-phase partitioning for the contaminants from the source area, assuming that the infiltrating precipitation contains residual source leachate or background contamination and that dispersion in the Layer 1 is negligible, yields the following expression for the time-dependent leachate concentration in the Layer 1:

$$\frac{dC_A}{dt} = \left[\frac{Q_1}{S_A V_{wA} + K_{dA} W_{sA}}\right] [CU_1 - C_A] - \lambda_A C_A \qquad (1)$$

where:

CU_1 is the contaminant concentration in infiltrating precipitation (μg/L)

Q_1 is the infiltration rate (L/day)

C_A is the aqueous concentration in Layer 1 (μg/L)

S_A is the soil saturation fraction in Layer 1 (dimensionless)

V_{wA} is the void volume in Layer 1 (L)

K_{dA} is the aqueous/solid phase distribution coefficients in Layer 1 (L/kg)

W_{sA} is the dry weight of soil in Layer 1 (kg)

λ_A is the first-order chemical decay rate in Layer 1 (day^{-1})

For an initial condition of $C_A = C_{Ao}$, this equation may be solved via direct integration to yield the following solution:

$$C_A = \frac{CU_1 - \{CU_1 - [1 + (S_A V_{WA} + K_{dA} W_{sA})(\lambda_A / Q_1)] C_{Ao}\} \exp\left[- \frac{Q_1 + (S_A V_{WA} + K_{dA} W_{sA})\lambda_A}{S_A V_{WA} + K_{dA} W_{sA}} t \right]}{[1 + (S_A V_{WA} + K_{dA} W_{sA})(\lambda_A / Q_1)]} \quad (2)$$

3.3.2 Model Layer 2

Using a similar mass-balance/mass-partitioning approach, a general case for model Layer 2 which includes a time-dependent source loading term (C_A as described by Eq. (2)) and a secondary source may be written in the following differential equation:

$$\frac{dC_B}{dt} + \frac{K_2}{K_1} C_B = \frac{K_3}{K_1} + \frac{K_4}{K_1} \exp[-K_5 t] \quad (3)$$

In which:

$K_1 = S_B V_{wB} + K_{dB} W_{sB}$

$K_2 = Q_1 + Q_2 + (S_B V_{wB} + K_{dB} W_{sB}) \lambda_B$

$K_3 = Q_1 CU_1 / [1 + (S_A V_{wA} + K_{dA} W_{sA})(\lambda_A / Q_1)] + Q_2 CU_2$

$K_4 = Q_1 C_{Ao} - Q_1 CU_1 / [1 + (S_A V_{wA} + K_{dA} W_{sA})(\lambda_A / Q_1)]$

$K_5 = [Q_1 + (S_A V_{wA} + K_{dA} W_{sA})\lambda_A] / (S_A V_{wA} + K_{dA} W_{sA})$

And where:

CU_2 is the contaminant leachate concentration of the secondary source (μg/L)

C_B is the aqueous concentration in Layer 2 (μg/L)

Q_2 is the perched water inflow rate of the secondary source (L/day)

S_B is the soil saturation fraction in Layer 2 (dimensionless)

V_{wB} is the void volume in Layer 2 (L)

K_{dB} is the aqueous/solid phase distribution coefficients in Layer 2 (L/kg)

W_{sB} is the dry weight of soil in Layer 2 (kg)

λ_B is the first-order chemical decay rate in Layer 2 (day^{-1})

This equation is of the following general form:

$$C'_B + p(t)C_B = r(t)$$

where: $p(t) = K_2/K_1$

$$r(t) = \frac{k_3}{k_1} + \frac{k_4}{k_1}\exp[-k_5 t]$$

The above equation has a general solution as follows:

$$C_B = \exp[-h]\left[\int \exp(h)\, r(t)\, dt + K\right]$$

where: $h = \int p(t)dt$ and K is a constant of integration

This equation may be solved for the initial condition of $C_B = C_{Bo}$ using the preceding integrating factor approach or the method of undetermined coefficients to yield the following:

$$C_B = \frac{K_3}{K_2} + \frac{K_4}{K_2 - K_1 K_5}\exp(-K_5 t) + \left[C_{Bo} - \frac{K_3}{K_2} - \frac{K_4}{K_2 - K_1 K_5}\right]\exp\left(-\frac{K_2 t}{K_1}\right) \quad (4)$$

Special Cases

In addition to this standard form of the solution (i.e., Eq. (4)), the following two special cases were also considered and included in ECTran:

- For a constant-concentration in Layer 1 (i.e., $C_A = CU_1$), the equation for Layer 2 becomes:

$$C_B = \frac{Q_1 CU_1 + Q_2 CU_2 - \{Q_1 CU_1 + Q_2 CU_2 - K_2 C_{Bo}\}\exp\left(-\frac{K_2 t}{K_1}\right)}{K_2} \quad (5)$$

- In the case of $K_2 = K_1K_5$ (e.g., when both Layer 1 and Layer 2 are identical and $Q_2=0$), the solution of Eq. (3) and thus the equation for Layer 2 leachate concentration becomes:

$$C_B = \frac{K_3}{K_2} + \left[C_{Bo} - \frac{K_3}{K_2} + \frac{K_4}{K_1}t\right] \exp(-K_5 t) \tag{6}$$

3.3.3 Underlying Saturated Zone

Based on the mass balance in the underlying saturated zone, the following equation is derived:

$$C_C = \frac{CU_3Q_3 + C_B(Q_1+Q_2)}{Q_1+Q_2+Q_3} \tag{7}$$

Where: C_c is the aqueous concentration in underlying saturated zone (μg/L)
CU_3 is the contaminant concentration in upgradient groundwater flow (μg/L)
Q_3 is the upgradient groundwater flow rate through the saturated mixing zone underlying the source area (L/day).

This equation does not consider the portion of contaminant that can be adsorbed to soil and therefore gives a very conservative estimation of the dissolved phase concentrations. Equation (7) is also known as the Summer's model (from several sources including EPA, 1983).

In order to compute Q_3, the thickness of the mixing zone in the aquifer, which represents the vertical extent of the contamination in the model, must be determined. It is usually selected based on the minimum of the following three possible values:

- The thickness of the entire saturated zone.
- The lowest position of detected contaminants of concern.
- The mixing zone depth calculated by the following equation (Salhotra et al., 1990):

$$H = B[1 - \exp(-V_{zo}L / (BV_x))] + (2\alpha_v L)^{1/2} \tag{8}$$

where: H is the mixing zone thickness (ft)
B is the total saturated zone thickness (i.e., thickness of the upper GMA) (ft)

V_w is the vertical seepage velocity (ft/yr)

L is the length of the source area in the groundwater flow direction (ft)

V_x is the horizontal seepage velocity (ft/yr)

α_v is the vertical dispersivity (ft)

Since H is usually less than B, the mixing zone depth concept was found to be the most appropriate to be used for the FEMP site. This approach is also more conservative than the fixed top layer thickness used in the current SWIFT groundwater fate and transport model.

3.3.4 Downgradient Transport

A simplified version of a general solution to a three-dimensional contaminant advection/dispersion/sorption/decay equation was used to simulate solute transport. It provides an estimate of the contaminant concentration at a receptor location or discharge area downgradient of the source area under different source-loading conditions.

The basic equation, a modified version of a general constant-source equation developed by Domenico (1987), for the plume centerline is as follows:

$$C(X, t, Co) = \frac{Co}{2} \exp\left\{\left(\frac{X}{2\,(D_x/V)}\right)\left[1 - \left(1 + \frac{4\lambda_c D_x}{V_2}\right)^{1/2}\right]\right\}$$

$$erfc\left[\frac{X - Vt\left(1 + \frac{4\lambda_c D_x}{V^2}\right)^{1/2}}{2(D_x t)^{1/2}}\right] erf\left[\frac{Y}{4\left(\frac{D_y}{V} X\right)^{1/2}}\right] \qquad (9)$$

where: C is the downgradient concentration along the plume centerline caused by C_o (μg/L)

C_o is the constant groundwater concentration at/below the source (μg/L)

X is the distance downgradient from the source(ft)

V is the retarded contaminant velocity (ft/year)

t is the elapsed time since the beginning of the constant source loading (years)

D_x is the principle value of the dispersion tensor in the x (longitudinal) direction (ft^2/year)

Y is the source dimension in the y (lateral) direction (ft)

D_y is the principle value of the dispersion tensor in the y (lateral) direction (ft^2/year)

λ_c is the chemical decay rate ($years^{-1}$)

In the preceding expression, erf and erfc are the error function and the complimentary error function, respectively. Vertical dispersion was not considered in equation (9) in order to provide a more conservative estimate of the exposure point concentration. The contaminant velocity is determined as the groundwater interstitial pore velocity divided by the retardation factor. The retardation factor (R_d) can be estimated using the distribution coefficient (K_{dc}), the soil bulk density (ρ), and porosity or volumetric water content (θ) of the soil as:

$$R_d = 1 + \frac{\rho K_{dc}}{\theta}$$

In cases where the net recharge, outside the source area (i.e., recharge that directly percolates into and dilutes the downgradient contaminant plume), is significant, the effective decay rate in the downgradient area can be increased to λ_c^*, as follows

$$\lambda_c^* = \lambda_c \cdot \frac{q}{B\theta}$$

Where q is the annual infiltration rate in the downgradient area (ft/year); and θ is the volumetric water content in the underlying saturated zone.

Although derived for a constant source loading condition, Equation (9) can be applied using superposition to simulate the time-dependent source loading For a time-dependent source, the concentration at a downgradient location at a given time T can be estimated using the following procedure. First the continuous function of the time-dependent source concentration C_c [i.e., Eq. (7)] is approximated by a series of step impulses which simplifies the solution and is usually also more conservative than the original function as shown in Figure 3-3. In Figure 3-3, it is also assumed that the source area has been contaminated with a concentration S_0 for a time period ("Age") before the initial time t_0. This contaminant concentration has convected to the area downgradient of the source area by dispersion/sorption/decay. Therefore, the contaminant concentration S_0 in this time period is also treated as an impulse.

The concentration at X feet downgradient of the source at time T can therefore be estimated by superposition of constant source solutions [Eq. (9)] for all impulses prior to time T as follows:

$$
\begin{aligned}
C_D(x, T) &= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) + \sum_{i=0}^{n} \left[C(X, T-t_i, S_i) - C(X, T-t_i-\Delta t_i, S_i)\right] \\
&= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) \\
&\quad + C(X, T-t_0, S_0) - C(X, T-t_0 - \Delta t_0, S_0) \\
&\quad + \ldots + C(X, T-t_n, S_n) - C(X, T-t_n - \Delta t_n, S_n)
\end{aligned}
\tag{10}
$$

where:

S_i is the source concentration of the ith impulse

t_i is the starting time of the ith impulse

Δt_i is the time interval for the ith impulse

$T-t_n-\Delta t_n = 0$

C_D (X, T) is the combined effects of n + 1 impulses

In the preceding equation (i.e., Eq. (9)), C (X, t, S) is the concentration at X caused by a constant source with concentration S for a duration of t. Therefore, C(X,t,S) needs to be applied twice to determine each single impulse's net lasting effect at time T. This approach is similar to the procedure used in the Expert ROKEY Computer System (McClymont and Schivarte, 1987). The Expert ROKEY Computer System is a saturated-zone contaminant fate and transport model with an expert system that assists the user to estimate necessary hydrogeological and chemical parameters for the model. The source loading from the unsaturated zone must be specified by the user in the Expert ROKEY.

If a groundwater pumping system is designed to prevent the movement of contaminated groundwater to the downgradient area, the Eq. (10) may be modified. For instance, if the pumping starts at t_0 and stops at t_j as shown in Figure 3-4, the S_i, i from 0 to j-1 , will have no impact on the downgradient area. Therefore, Eq. (10) will be rewritten as:

$$
\begin{aligned}
C_D(x, T) &= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) + \sum_{i=j}^{n} \left[C(X, T-t_i, S_i) - C(X, T-t_i-\Delta t_i, S_i)\right] \\
&= C(X, T-t_o+Age, S_o) - C(X, T-t_o, S_o) + C(X, T-t_j, S_j) - C(X, T-t_j - \Delta t_j, S_j) \\
&\quad + C(X, T-t_{j-1}, S_{j-1}) - C(X, T-t_{j-1} - \Delta t_{j-1}, S_{j-1}) \\
&\quad + \ldots + C(X, T-t_m, S_n) - C(X, T-t_n - \Delta t_m, S_n)
\end{aligned}
\tag{11}
$$

3.4 SPREADSHEET IMPLEMENTATION

Several advantages of a spreadsheet-based model over a traditional "pre/post-processors and stand-alone program approach" are apparent. Because the simulation is implemented by a spreadsheet, the model input and output data are contained in the same file. It is extremely easy for the user to change values of any specific input parameters, and the effects of various input values can be seen on the computer screen. The graphical and statistical capability provided by the spreadsheet makes presentation of the model results very efficient and flexible. A spreadsheet in Excel (i.e., ECTran) was developed to code the equations described in Section 3.3. This section describes the spreadsheet coding, input/output format, and example output of the ECTran model.

3.4.1 Coding

The coding for equations in Layer 1 and underlying saturated zone was straightforward, (i.e., the Eqs (2) and (7) are directly coded in Excel). For layer 2, the **IF** function in Excel was used to take care of the special cases specified in Section 3.3.2. The Excel functions, such as **ERF**, **ERFC** and **SUMPRODUCT**, were used to code equations (9), (10) and (11) for downgradient transport calculations. The **ERF** and **ERFC** functions compute the error function and the complimentary error function, respectively. The **SUMPRODUCT** function returns the sum of the products of the specified arrays.

It is important for the ECTran model to maintain consistency among all the inter-related model parameters. Therefore, some of the model parameters are automatically calculated and protected in the spreadsheet. Other intermediate calculations are performed in spreadsheet cells outside the main table as shown in Table 3-1. These cells were also protected and hidden from the user. For example, a column in the spreadsheet was specified to compute the following term in Eq. (8):

$$F(t_i) = erfc\left[\frac{X - V\,t_i\left(1 + \frac{4\lambda_c D_x}{V^2}\right)^{1/2}}{2(D_x t_i)^{1/2}}\right]$$

The value of each cell in the column varies with t_i (elapsed time) and t_i ranges from 0 to the T with a increment Δt_i. The product, between each of S_i (i.e., S_0, S_1,....,S_n), $F(t_i)$ and a constant will give $C(X,t,S_i)$. The constant is the following remaining terms in Eq.(8):

$$\frac{1}{2}\exp\left\{\left(\frac{X}{2(D_x/V)}\right)\left[1-\left(1+\frac{4\lambda_c D_x}{V^2}\right)^{1/2}\right]\right\} erf\left[\frac{Y}{4\left(\frac{D_y}{V}X\right)^{1/2}}\right]$$

Finally, the Excel function **SUMPRODUCT** computes the $C_0(x,T)$ in Eq. (10) through summation of the products from t_0 to T or computes the $C_0(x,T)$ in Eq. (11) through summation of the products from t_i to T when the pump system exists.

In a previous version of this model (Chiou and Hubbard, 1992), which was implemented on SuperCalc5, a separate FORTRAN program (Appendix B) was required to perform calculations described in Eqs (9), (10), and (11). The linkage between the main spreadsheet and the external executable file was accomplished using macro commands in the spreadsheet. With Excel this external FORTRAN program was no longer necessary due the unique functions available within the spreadsheet.

3.4.2 Input/Output Format

Table 3-1 shows the format of the input/output table used by ECTran. This table is designed for both easy data input/revision processes and clear/complete output presentations. Table 3-1 also briefly explains the types of information included and the purpose of each portion of the format. The necessary input parameters used to calculate all the other information in the table are identified. These parameters will be discussed in Section 4.

3.4.3 Example Output

Three examples are presented here to demonstrate the capabilities and possible uses of the ECTran model during a typical RI/FS process for a hypothetical hazardous waste site.

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Concentrations calculated by ECTran model in Layer 1, Layer 2, underlying saturated zone and downgradient transport under a constant source loading at a initially clean site are shown in Table 3-2 and Figure 3-5. This example presents the baseline conditions that need to be studied during the RI process. On the other hand, the next two examples will present the effect of remedial actions studied during the FS.

Model predicted concentrations for the same site used in the previous example, with the source loading being removed after 10 years, are shown in Table 3-3 and Figure 3-6. In this case the model parameter "Age" was specified as 10 years. In order to determine long-term residual impact at the downgradient exposure point, a longer time interval (i.e., 250 years) was simulated in this example.

Source loading removal and pumping of contaminated groundwater around the source area are both simulated in the third example. Model results are shown in Table 3-4 and Figure 3-7. In this case the model parameter "Age" was still specified as 10 years while the parameter "P&T" was specified as 20 years. The same time interval as in the second example was simulated in this example. As indicated by the last two examples, both source removal and pumping are required for the hypothetical site to ensure that the groundwater contaminant concentrations will be less than the given water criteria at the fence line.

3.5 MONTE CARLO SIMULATION

Unavoidably, uncertainties in the model input parameters will create uncertainties in the model outputs. Monte Carlo simulations can be used to assess the uncertainties of model predictions, based on the probability distributions of the model input parameters. The concept of a Monte Carlo simulation is to run a predicting model repeatedly with varying sets of possible input parameters. All the individual results can then be statistically analyzed to generate probability distributions of the "true" result. For performing Monte Carlo simulations, the uncertainties of input parameters may best be expressed in terms of probability density functions. These functions of input parameters should be statistically analyzed individually and be consistent with available observed data. Values of every model parameter to be studied in the Monte Carlo simulation should then be randomly generated according to these probability density functions before each individual simulation run.

Monte Carlo simulation requires a sufficiently large number of runs to achieve accuracy, which means that the ECTran model can typically be run numerous times. All the governing analytical transport equations implemented in ECTran are very efficient. Each individual run of ECTran can be completed within just a

TABLE 3-2

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTrans) MODEL

SITE: HYPOTHETICAL, FEMP, FERNALD, OH
BASELINE

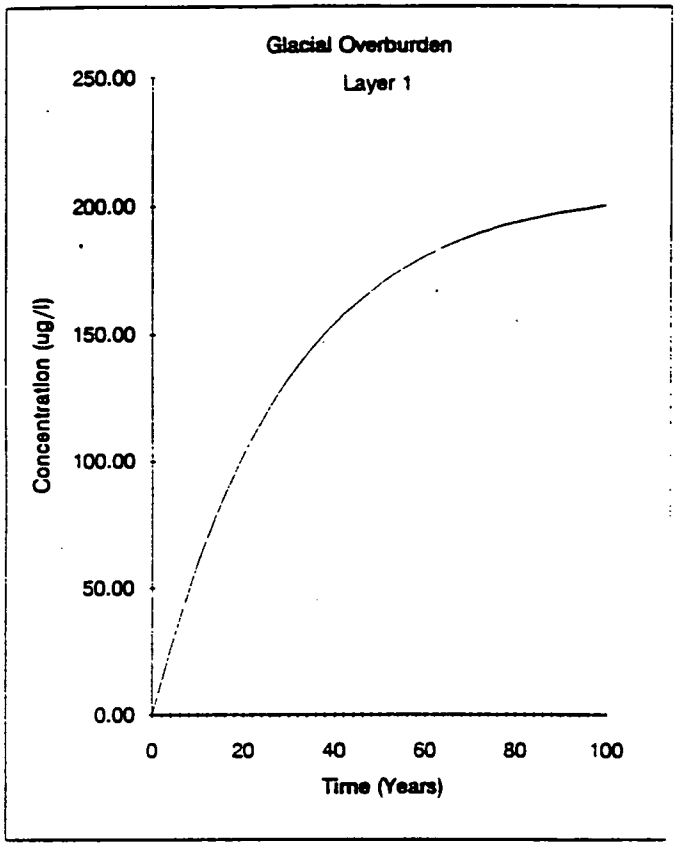
INVESTIGATOR: CAR
DATE: 8/7/93

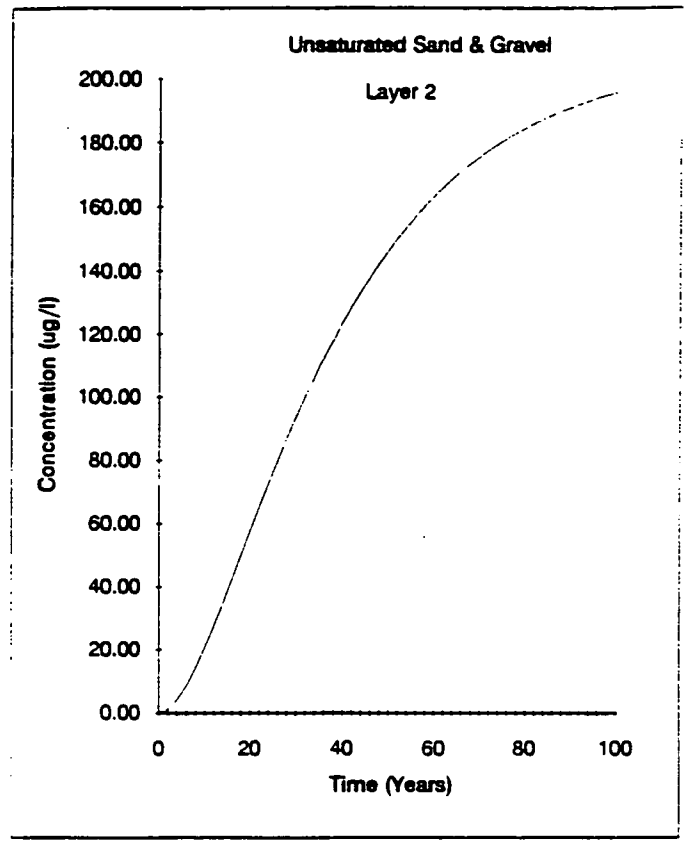
CONTAMINANT:		CHEMICAL X	
KOC (L/KG):	45.00	WATER CRITERIA (UG/L):	3.00E+00
HALF LIFE (YRS):		CONSTANT SOURCE LEACHATE (UG/L):	2.07E+02
LAYER 1:	4.47E+09	INITIAL LAYER 1 SOIL CONC. (MG/KG):	0.00E+00
LAYER 2:	4.47E+09	INITIAL LAYER 2 SOIL CONC. (MG/KG):	0.00E+00
GMA:	4.47E+09		

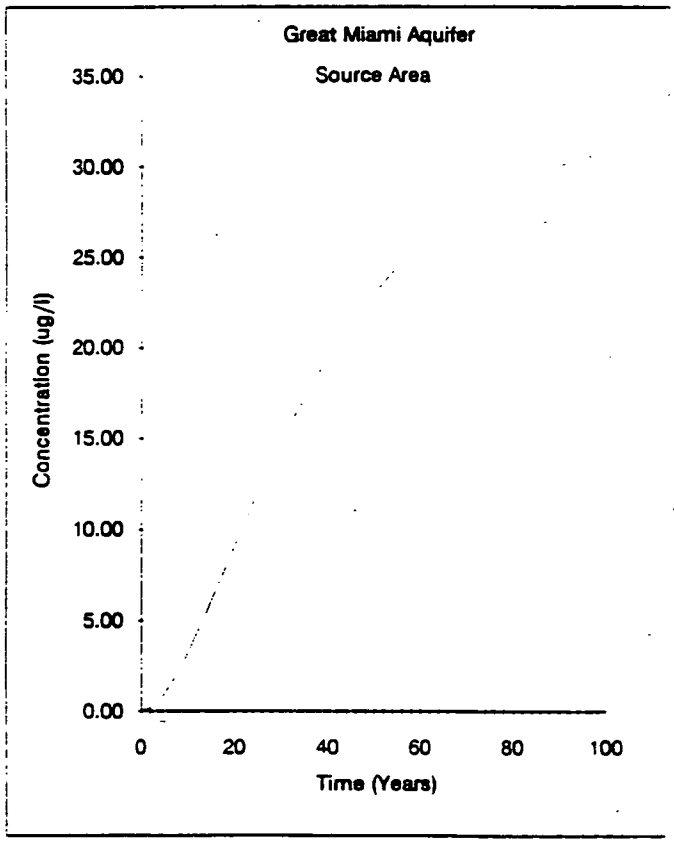
UNSAT. SOURCE	AREA:	LAYER 1 (GLACIAL OVERBURDEN)		LAYER 2 (SAND & GRAVEL)		GREAT MIAMI AQUIFER (SAT. S. & G.)			
						B (FT):	67	Vzo (FT/YR):	11.5445
LENGTH (FT):	250	FOC (KG/KG):	0.04	FOC (KG/KG)	0.0329	GW Q3 (L/DAY)	3.26E+04	FOC (KG/KG)	0.0329
WIDTH (FT):	230	Kd (L/KG):	1.8	Kd (L/KG):	1.481	GW V.(FT/YR):	575.00	Kd (L/KG):	1.4805
		SATURATION:	0.45	SATURATION:	0.25	H (FT):	12.7100	RETARDATION:	11.5412
POROSITY:	0.34	THICKNESS (FT):	10.00	THICKNESS (FT):	5.00	EFF. POROSITY	0.25	q (FT/YR)	0
DENSITY (G/CM3):	1.78	DECAY (1/DAY):	4.25E-13	DECAY (1/DAY)	4.25E-13	DISPERSIVITY:		DECAY (1/YR):	1.6E-10
INFILT. (FT/YR):	1.15	CAo (UG/L):	0.00E+00	CBo (PPB)	0.00E+00	Az(FT):	0.12	CU3 (PPB):	0
		CU1 (PPB):	207	CU2 (PPB):	0.00E+00	Ax (FT):	100.00	P&T(YEARS)	0
AGE (YEARS):	0	Q1 (L/DAY):	5.13E+03	Q2 (L/DAY)	0.00E+00	Ay (FT):	33.33	DISTANCE TO F.L.(FT).	275

TIME INTERVAL (YRS)	2	LAYER 1 LEACHATE CONC.	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.	FENCE LINE CONC.
ELAPSED TIME - YRS	DAYS	(UG/L)	(UG/L)	(UG/L)	(UG/L)
0	0	0.00	0.00	0.00	0.00
2	730	13.71	1.11	0.17	0.00
4	1460	26.52	4.11	0.65	0.01
6	2190	38.48	8.56	1.35	0.07
8	2920	49.64	14.12	2.22	0.20
10	3650	60.07	20.50	3.23	0.43
12	4380	69.80	27.44	4.32	0.75
14	5110	78.89	34.77	5.47	1.16
16	5840	87.38	42.33	6.66	1.64
18	6570	95.31	49.98	7.86	2.18
20	7300	102.71	57.63	9.07	2.77
22	8030	109.62	65.21	10.26	3.40
24	8760	116.07	72.64	11.43	4.05
26	9490	122.09	79.89	12.57	4.72
28	10220	127.72	86.91	13.68	5.40
30	10950	132.97	93.69	14.74	6.08
32	11680	137.88	100.20	15.77	6.75
34	12410	142.46	106.44	16.75	7.41
36	13140	146.73	112.39	17.69	8.05
38	13870	150.72	118.06	18.58	8.68
40	14600	154.45	123.44	19.42	9.29
42	15330	157.93	128.55	20.23	9.87
44	16060	161.19	133.39	20.99	10.43
46	16790	164.22	137.96	21.71	10.97
48	17520	167.06	142.28	22.39	11.49
50	18250	169.70	146.35	23.03	11.98
52	18980	172.17	150.18	23.63	12.44
54	19710	174.48	153.79	24.20	12.88
56	20440	176.63	157.19	24.73	13.30
58	21170	178.65	160.38	25.24	13.69
60	21900	180.53	163.37	25.71	14.07
62	22630	182.28	166.18	26.15	14.42
64	23360	183.92	168.82	26.57	14.75
66	24090	185.45	171.34	26.95	15.06
68	24820	186.87	173.61	27.32	15.36
70	25550	188.21	175.79	27.66	15.63
72	26280	189.45	177.82	27.98	15.89
74	27010	190.62	179.72	28.28	16.14
76	27740	191.70	181.51	28.56	16.37
78	28470	192.71	183.18	28.82	16.58
80	29200	193.66	184.74	29.07	16.78
82	29930	194.54	186.20	29.30	16.97
84	30660	195.37	187.56	29.51	17.15
86	31390	196.14	188.84	29.72	17.31
88	32120	196.86	190.04	29.90	17.47
90	32850	197.53	191.15	30.08	17.61
92	33580	198.16	192.20	30.24	17.75
94	34310	198.74	193.17	30.40	17.88
96	35040	199.29	194.08	30.54	17.99
98	35770	199.80	194.94	30.67	18.10
100	36500	200.28	195.73	30.80	18.21
MAXIMUM		200.28	195.73	30.80	18.21

FIGURE 3-5


Glacial Overburden
Layer 1
Concentration (ug/l)
250.00
200.00
150.00
100.00
50.00
0.00
0
20
40
60
80
100
Time (Years)


Unsaturated Sand & Gravel
Layer 2
Concentration (ug/l)
200.00
180.00
160.00
140.00
120.00
100.00
80.00
60.00
40.00
20.00
0.00
0
20
40
60
80
100
Time (Years)


Great Miami Aquifer
Source Area
Concentration (ug/l)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
20
40
60
80
100
Time (Years)

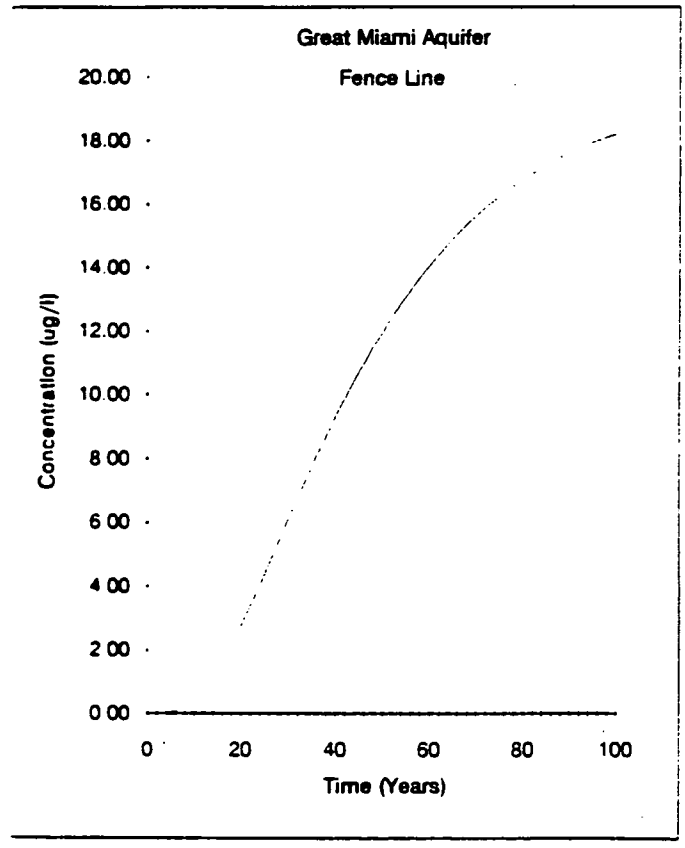

Great Miami Aquifer
Fence Line
Concentration (ug/l)
20.00
18.00
16.00
14.00
12.00
10.00
8 00
6 00
4 00
2 00
0 00
0
20
40
60
80
100
Time (Years)

TABLE 3-3

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTran) MODEL

TE:	HYPOTHETICAL, FEMP, FERNALD, OH
	AGE = 10 YRS; SOURCE REMOVED
	RESIDUAL CONTAMINATION IN LAYER 1 & 2
	PUMPING = 0 YRS
INVESTIGATOR:	CAR
DATE:	8/7/93

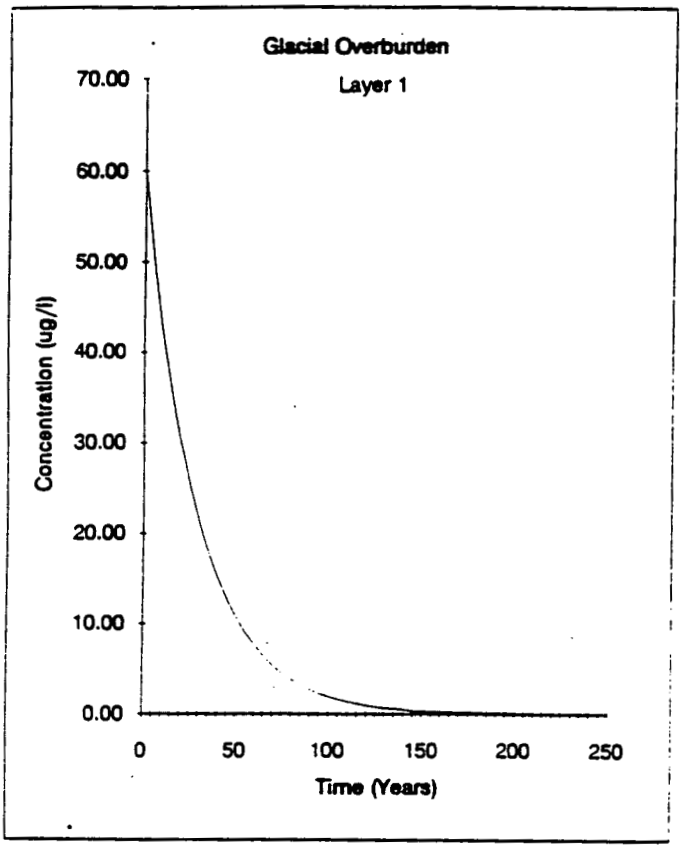
CONTAMINANT:		CHEMICAL X	
KOC (L/KG):	45.00	WATER CRITERIA (UG/L):	3.00E+00
HALF LIFE (YRS):		CONSTANT SOURCE LEACHATE (UG/L):	0.00E+00
LAYER 1:	4.47E+09	INITIAL LAYER 1 SOIL CONC. (MG/KG):	1.08E-01
LAYER 2:	4.47E+09	INITIAL LAYER 2 SOIL CONC. (MG/KG):	3.03E-02
GMA:	4.47E+09		

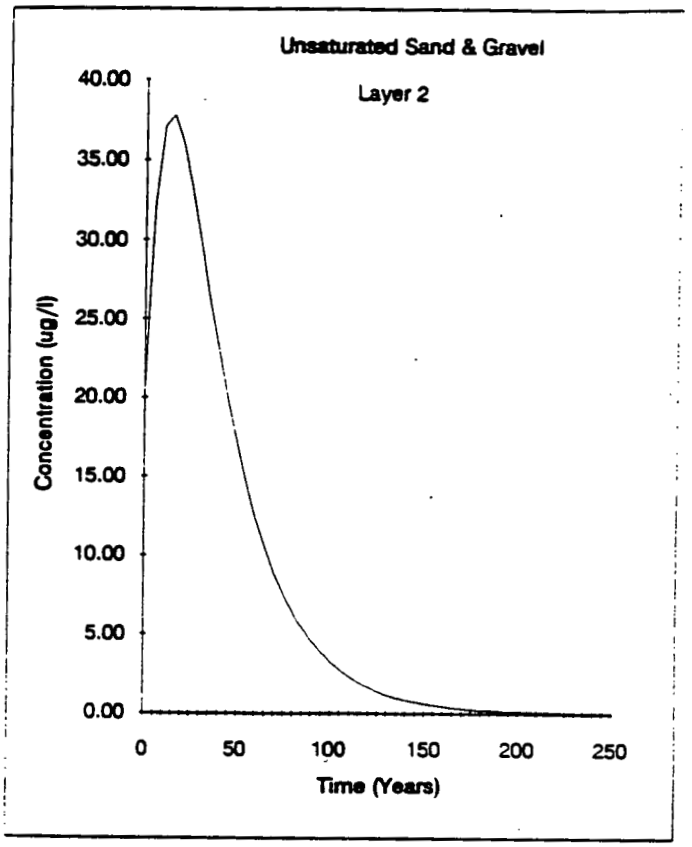
UNSAT. SOURCE	AREA:	LAYER 1 (GLACIAL OVERBURDEN)		LAYER 2 (SAND & GRAVEL)		GREAT MIAMI AQUIFER (SAT. S. & G.)			
						B (FT):	67	Vzo (FT/YR):	11.5445
LENGTH (FT):	250	FOC (KG/KG):	0.04	FOC (KG/KG)	0.0329	GW Q3 (L/DAY)	3.26E+04	FOC (KG/KG):	0.0329
WIDTH (FT):	230	Kd (L/KG):	1.8	Kd (L/KG)	1.481	GW V.(FT/YR):	575.00	Kd (L/KG)	1.4805
		SATURATION:	0.45	SATURATION	0.25	H (FT):	12.7100	RETARDATION	11.5412
POROSITY:	0.34	THICKNESS (FT):	10.00	THICKNESS (FT)	5.00	EFF. POROSITY	0.25	q (FT/YR)	0
DENSITY (G/CM3):	1.78	DECAY (1/DAY):	4.25E-13	DECAY (1/DAY)	4.25E-13	DISPERSIVITY:		DECAY (1/YR)	1.6E-10
INFILT. (FT/YR):	1.15	CAo (UG/L):	6.01E+01	CBo (PPB)	2.05E+01	Az(FT):	0.12	CU3 (PPB):	0
		CU1 (PPB):	0	CU2 (PPB)	0.00E+00	Ax (FT):	100.00	P&T(YEARS).	0
AGE (YEARS):	10	Q1 (L/DAY):	5.13E+03	Q2 (L/DAY)	0.00E+00	Ay (FT):	33.33	DISTANCE TO F.L.(FT)	275

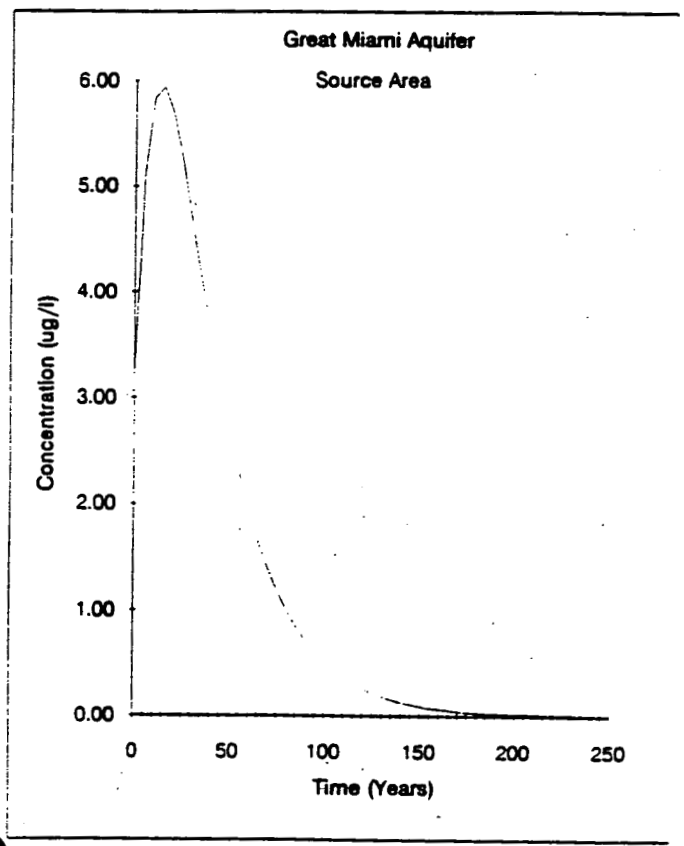
TIME INTERVAL (YRS)	5	LAYER 1 LEACHATE CONC.	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.	FENCE LINE CONC
ELAPSED TIME - YRS	DAYS	(UG/L)	(UG/L)	(UG/L)	(UG/L)
0	0	60.06	20.49	3.22	1.48
5	1825	50.60	32.34	5.09	1.73
10	3650	42.63	37.13	5.84	2.36
15	5475	35.91	37.75	5.94	2.96
20	7300	30.26	36.05	5.67	3.30
25	9125	25.49	33.15	5.22	3.38
30	10950	21.48	29.75	4.68	3.28
35	12775	18.09	26.25	4.13	3.06
40	14600	15.25	22.90	3.60	2.78
45	16425	12.84	19.80	3.12	2.48
50	18250	10.82	17.02	2.68	2.18
55	20075	9.12	14.56	2.29	1.90
60	21900	7.68	12.41	1.95	1.64
65	23725	6.47	10.55	1.66	1.41
70	25550	5.45	8.95	1.41	1.20
75	27375	4.59	[illegible]	1.19	1.03
80	29200	3.87	6.41	1.01	0.87
85	31025	3.26	[illegible]	0.85	0.74
90	32850	2.75	[illegible]	0.72	0.63
95	34675	2.31	[illegible]	0.61	0.53
100	36500	1.95	[illegible]	0.51	0.45
105	38325	1.64	[illegible]	0.43	0.38
110	40150	1.38	[illegible]	0.36	0.32
115	41975	1.17	[illegible]	0.31	0.27
120	43800	0.98	[illegible]	0.26	0.23
125	45625	0.83	[illegible]	0.22	0.19
130	47450	0.70	[illegible]	0.18	0.16
135	49275	0.59	[illegible]	0.16	0.14
140	51100	0.49	[illegible]	0.13	0.11
145	52925	0.42	[illegible]	0.11	0.10
150	54750	0.35	[illegible]	0.09	0.08
155	56575	0.30	[illegible]	0.08	0.07
160	58400	0.25	[illegible]	0.07	0.06
165	60225	0.21	[illegible]	0.06	0.05
170	62050	0.18	[illegible]	0.05	0.04
175	63875	0.15	[illegible]	0.04	0.03
180	65700	0.13	[illegible]	0.03	0.03
185	67525	0.11	[illegible]	0.03	0.02
190	69350	0.09	[illegible]	0.02	0.02
195	71175	0.08	[illegible]	0.02	0.02
200	73000	0.06	[illegible]	0.02	0.01
205	74825	0.05	[illegible]	0.01	0.01
210	76650	0.04	[illegible]	0.01	0.01
215	78475	0.04	[illegible]	0.01	0.01
220	80300	0.03	[illegible]	0.01	0.01
225	82125	0.03	[illegible]	0.01	0.01
230	83950	0.02	[illegible]	0.01	0.01
235	85775	0.02	[illegible]	0.01	0.00
240	87600	0.02	[illegible]	0.00	0.00
245	89425	0.01	0.02	0.00	0.00
250	91250	0.01	0.02	0.00	0.00
MAXIMUM		60.06	37.75	5.94	3.38

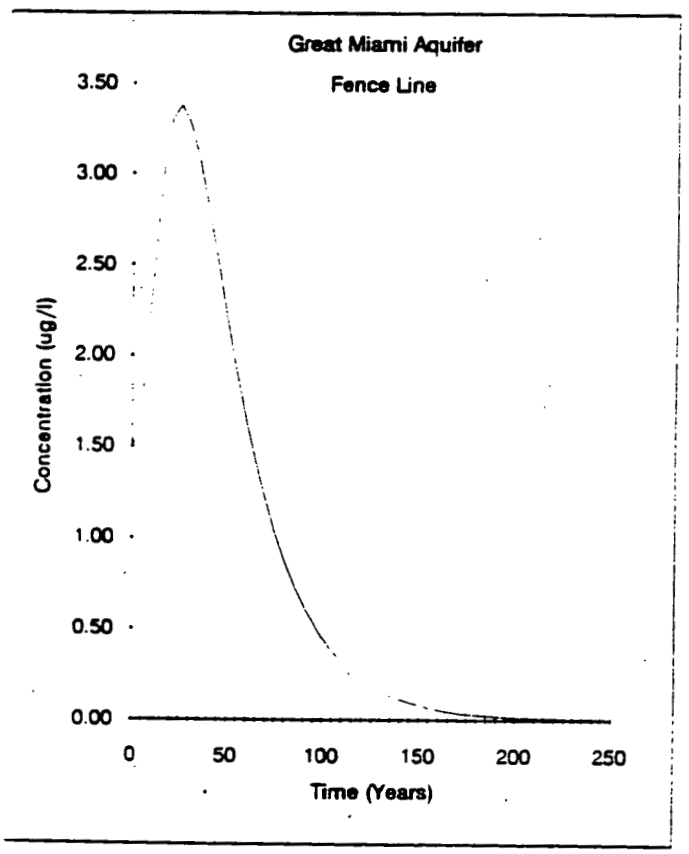
000570

FIGURE 3-6


Glacial Overburden
Layer 1
Concentration (ug/l)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
50
100
150
200
250
Time (Years)


Unsaturated Sand & Gravel
Layer 2
Concentration (ug/l)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
50
100
150
200
250
Time (Years)


Great Miami Aquifer
Source Area
Concentration (ug/l)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
50
100
150
200
250
Time (Years)


Great Miami Aquifer
Fence Line
Concentration (ug/l)
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0
50
100
150
200
250
Time (Years)

few seconds. Therefore, Monte Carlo simulation can be very efficiently performed with ECTran. On the other hand, SWIFT and ODAST, which require more than 30 hours for a typical application at FEMP, are not suggested to be used in a Monte Carlo simulation.

3.5.1 Implementation

For a spreadsheet without specially designed capabilities, it is very difficult to repeat and summarize computations with automatically changing parameters. Fortunately, a software package called Crystal Ball is available which can work within Excel to facilitate Monte Carlo simulation. Crystal Ball allows different probability distributions, such as normal, Poisson, binomial and exponential, to be defined for each uncertain cell in the Excel spreadsheet and then generates random numbers from the given probability distributions. Crystal Ball uses these random numbers to compute the formulas in the forecast cells. This process continues with the forecast formulas being recalculated over and over until the required number of individual simulations is reached. Also, while the simulation is running, Crystal Ball charts the forecast results in an easy-to-understand graphical format. Finally, Crystal Ball will give the statistics that describe the forecast results. As described, Crystal Ball significantly extends the forecasting capability of Excel.

ECTran utilizes Crystal Ball during the Monte Carlo simulation applications. For example, selected stratigraphy, hydrogeology, and contaminant parameters can be analyzed separately or simultaneously to quantify the probability of groundwater concentrations at an exposure point exceeding given criteria.

The sensitivity of the groundwater concentrations to the input parameters may also be approximated in terms of the correlation coefficients between the outputs and inputs.

3.5.2 Examples

A Monte Carlo simulation in ECTran based on the third example presented in Section 3.4.3 (i.e., remediation with source removal and pumping) was performed. The infiltration rate, saturation rates, foc values, and groundwater velocity in the model were treated as random variables simultaneously with specific probability functions. For this demonstrative example, 500 simulations were automatically run by ECTran. The resulting maximum groundwater contaminant concentrations at the source area and the fence line in the GMA were statistically analyzed and a summary report was generated by the model.

Although the previously predicted maximum concentration at the fence line was acceptable, the Monte Carlo simulation concluded that, with about 40 percent possibility, this maximum groundwater contaminant

concentration may actually exceed the water criteria given the uncertainties in model parameters. Therefore, it was determined necessary to extend the pumping time in the source area to 30 years. A second Monte Carlo simulation was conducted for this new pumping time with the same uncertainties associated with the model parameters. Results of this analysis indicate that there is less than a 5 percent possibility that the maximum fence line groundwater contaminant concentration will exceed the water criteria.

Complete summary reports of the first and second Monte Carlo simulations are included in Appendices A.1 and A.2, respectively.

4.0 DATA REQUIREMENT

As a screening model, several types of data are still required for the ECTran model to realistically simulate a site. Necessary data includes contaminant, geochemical and hydrogeological information at the study area. Preferably, site-specific data is determined by field tests or laboratory analyses and used as input for the model. In some cases, when site-specific values are not available when the model is applied, the input data can be estimated from literature values. Other information such as the risk assessment scenario and remedial alternative can also be incorporated and analyzed by the ECTran model.

4.1 CONTAMINANT AND GEOCHEMICAL INFORMATION

Radionuclides, inorganic and organic contaminants are all present at the FEMP. The data necessary to model radionuclides includes radioactive decay half-lives and soil- and contaminant-specific distribution coefficients (K_d). For the organic contaminants, soil and groundwater biodegradation and chemical decay half-lives and the contaminant-specific organic carbon partition coefficient (K_{oc}) or octanol-water partition coefficient (K_{ow}) are necessary model input. For the inorganic contaminants, soil- and contaminant-specific K_ds are required.

Information regarding the initial/current levels of contamination in each model layer and future source loading rates should also be defined. Chemical-specific acceptable concentration levels are also provided in cleanup goal development applications.

4.2 HYDROGEOLOGICAL INFORMATION

Several aquifer and soil parameters are necessary in the ECTran model. They include porosity, bulk density, saturation rate, fraction of organic content (FOC), hydraulic conductivity, hydraulic gradient, travel distance to downgradient exposure points, groundwater velocity, infiltration rate, dispersion coefficient, and vertical seepage velocity.

A majority of these parameters have been estimated by field measurements at the FEMP. For instance, hydraulic conductivity values were estimated by a pump test in the South Plume and numerous slug tests throughout the facility. Hydraulic gradients can be calculated from groundwater contour maps which were

developed from monthly field measurements. Porosity, bulk density, saturation rate, and foc can be acquired from the results of geotechnical and laboratory analyses.

Other input parameters can be estimated using other hydrological models. For example, the HELP model can be used to estimate the infiltration rate and the degree of saturation or moisture content of the unsaturated zones.

4.3 RISK ASSESSMENT SCENARIO INFORMATION

For many fate and transport modeling tasks the results of the modeling are used to determine the potential risk of the contaminants in the groundwater to humans, wildlife, and the environment. To assess the effects of the groundwater contaminants on the potential receptors, the model must be flexible enough to calculate the contaminant concentrations at each potential exposure point defined in the risk assessment scenario. A risk assessment scenario is the combination of the potential migration and exposure pathways and the protocol for risk calculations. Usually an acceptable chemical-specific groundwater concentration for a receptor are defined in the scenario. These criteria are usually either the Maximum Concentration Limits (MCLs) or the incremental cancer risk-based concentrations which can be calculated based on chemical-specific cancer slope factors.

For model applications at the FEMP to support risk assessment, there are three potential groundwater exposure scenarios. They include using perched groundwater, GMA groundwater under the contaminant source area, or GMA groundwater downgradient at the FEMP property line as drinking or irrigation water. The criteria used for the modeling will usually be the incremental cancer risk-based concentrations. These values can be more conservative than the MCLs and account for the combined effect of contaminants.

4.4 REMEDIAL ALTERNATIVE INFORMATION

Remedial alternatives constitute the proposed actions to be performed on contaminant source areas to mitigate potential impacts on human health, wildlife, and environment. Several alternatives which are currently evaluated at the FEMP include capping, source reduction and removal, soil washing, and hydraulic recovery and barrier. All of these alternatives' effectiveness can be investigated with the ECTran model. The capping alternative can be simulated in the ECTran model by reducing the infiltration rate. Source removal can be accomplished with the model by reducing the source leachate concentration or initial

concentrations in soil layers. The impact of saturated zone containment or pumping on the downgradient groundwater concentrations can be investigated by using the pumping option of the ECTran model.

5.0 COMPARISON AND VERIFICATION WITH SWIFT AND ODAST

5504

As described in Sections 2.0 and 3.0, the ECTran model can simulate contaminant transport through both the vadose and saturated zones. In previous modeling at the FEMP site two separate models were used to estimate the contaminant migration through these zones and they are ODAST and SWIFT (DOE, 1993a), respectively. The following sections compare results from these two different modeling approaches. Also the advantages and disadvantages of using the two different modeling schemes are described.

It is important to note that the overall purpose of the model comparsions discussed in this section is to demonstrate the relative conservativeness between the two modeling approaches (i.e., ECTran and current ODAST/SWIFT). Because the current groundwater flow and transport model developed with SWIFT code is under improvements (DOE, 1993b), the accuracy or correctness of either model are not the main focus of this section.

5.1 MODEL RESOLUTION

A model's accuracy and usefulness is highly dependent on the resolution of the model. The resolution of a model is dependent upon the characteristics of the natural system to be modeled and the required modeling results. Vertical and areal coverages allowed in the model are the two most important resolution characteristics. For instance an aquifer's vertical resolution may be represented in the model using either a general single-layer structure or a detailed multi-layer structure. The model using the general single-layer structure would estimate only a single contaminant result for the entire depth of the aquifer. This type of model would be best suited for a homogeneous aquifer system. In comparison the model which uses the detailed multi-layer structure could simulate layer-specific contaminant concentrations which would be more comparable to the natural aquifer system. This type of model would be better suited for a heterogeneous aquifer system.

The goal during the screening model development was to create a single flexible model which could adequately estimate the maximum contaminant concentrations in the vadose and saturated zones underlying any given source area in the FEMP. To accommodate this goal, the model was created so that concentrations could be calculated in two separate vadose zone layers and at two separate saturated zone locations (i.e., under the source area and a down gradient location which is usually at the fence line). The

saturated thickness used in the ECTran model was the mixing depth. This thickness is usually smaller than the thickness used for the top layer in the current SWIFT model. The current SWIFT model has two model layers in the Upper Great Miami Aquifer which has an about 65 to 75 feet saturated thickness. The current top SWIFT model layer is 40 feet (in which about 35 feet is saturated). Using Equation (8) in Section 3, calculated groundwater mixing depths at the FEMP are usually between 10 and 20 feet. Therefore, with the mixing depth approach, the ECTran model provides higher resolution than the current SWIFT model in the saturated zone. ECTran, thus, gives more conservative estimations of the maximum groundwater contaminant concentrations. Due to the differences between the mixing depth used in ECTran and the fixed top layer thickness in current SWIFT model alone, the maximum groundwater concentrations estimated by ECTran are expected to be at least 2 to 4 times higher than corresponding concentrations by the current SWIFT model.

There are also limitations to having a simple model as compared to a very rigid, detailed model. The ECTran model uses uniform flow equations, considers only one source at a time, areal coverage limited to one specific region, and the model represents the aquifer as a single, continuous, homogeneous layer. In comparison the SWIFT model uses nonuniform flow equations, can consider multiple sources at one time, the areal coverage of the model is almost limitless, and the aquifer can be separated into discrete grid blocks each having its own properties to account for the heterogeneities in the aquifer.

5.2 MODEL RESULT

In general, different models may simulate the same system slightly differently. The differences are usually due to the simplifications and assumptions in the conceptual models, governing equations, numerical methods, and amount of detail used by each model. A comparison can be made to quantify the differences between the ECTran model results and the ODAST and SWIFT models results. So that the comparison is equal, the same input should be used for each of the models. Table 5-1 summarizes site characteristics for comparing two OU2 waste units that were used for the three models of interest. It is re-emphasized that significant differences between the two modeling approaches are expected. Therefore, the purpose of these comparsions is to demonstrate and quantify the relative conservativeness. The accuracy or correctness of either model are not the main focus of the comparsions.

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TABLE 5-1

SUMMARY OF MODELING CHARACTERISTICS
FOR TWO OU2 WASTE UNITS

Parameter	Solid Waste Landfill	Inactive Fly Ash Pile
Source Leachate Conc.[1] (ug/L)	57,000	502
Source Area (ft^2)	42,400	130,800
Porosity	0.34	0.34
Layer 1 K_d[2] (L/kg)	1.80	1.80
Layer 2 K_d[2] (L/kg)	1.48	1.48
Aquifer K_d[2] (L/kg)	1.48	1.48
Infiltration Rate (ft/yr)	1.06	1.06
Layer 1 Thickness (ft)	20	5
Layer 2 Thickness (ft)	30	25
Aquifer Thickness[3] (ft)	65 (9.03)	72 (18.87)

(1) Uranium concentration estimated in the previous RI report (DOE, 1992).

(2) K_d value used in the previous RI report. The area-specific K_d values are currently under laboratory study.

(3) The aquifer thickness presented is an approximation of the Upper Great Miami Aquifer thickness. The values in parentheses are the calculated mixing depths used in the ECTran model. Thickness of the top layer in the current SWIFT model is 40 ft.

The data summarized in Table 5-1 was used in the ECTran, ODAST, and SWIFT models. A comparison of the ECTran and ODAST model's results is presented in Figures 5-1 and 5-2. From Figures 5-1 and 5-2 it can be seen that the ECTran and ODAST models compare fairly well for Inactive Flyash Pile Waste Site and not as well for the Solid Waste Landfill Site. The reason for the difference is that the two waste units have different source characteristics. The Inactive Flyash Pile has a very long depletion time for the source due to the presence of a large amount of contaminant mass, small α (decay constant), and long T_e (time for complete depletion of source). With these characteristics, the source of the Inactive Flyash Pile waste unit acts like as a constant source, which is the same way ECTran models the source loading. In contrast, the Solid Waste Landfill has a very short depletion time for the source due to a limited amount of contaminant mass, large α (decay constant), and short T_e (time for complete depletion of the source). A source with these characteristics will deplete quickly and is not directly comparable to a constant source.

A comparison of the ECTran and SWIFT model's results is presented in Figures 5-3 and 5-4. From the figures it is obvious that the ECTran model is more conservative than the SWIFT model. For the Inactive Flyash Pile the ECTran concentrations are approximately five (5) times greater than the SWIFT predicted concentrations. In comparison the ECTran results for the Solid Waste Landfill vary from approximately 5 to 155 times greater than the SWIFT results. The differences between the results are due to both the thicknesses of model layers and the source depletion characteristics. After reviewing the comparison between the ECTran model and the current ODAST and SWIFT models it is obvious that the ECTran model is more conservative than the other models. Therefore, the ECTran model can be used safely as a screening model but the model may over estimate the final (e.g., after 1,000 years from the current time) contaminant concentrations in the aquifer. These final concentrations should be estimated using the more complex ODAST/SWIFT model combination which considers depletion of the source term.

Although not directly related to ECTran model development and application, it is also important to note that the current SWIFT groundwater fate and transport model is currently under improvement activities (DOE, 1993b). One of the improvement tasks is to increase the vertical resolution by dividing the current top layer into two (2) separated model layers. After this improvement, it is expected that maximum concentrations estimated by SWIFT model will increase by two (2) to four (4) times. The difference between ECTran and ODAST/SWIFT model will then be insignificant within a five-hundred-year time frame for the major contaminant (i.e., uranium) in most of the source areas at the FEMP because of the existing amount of contaminant.

5.3 MODEL RUN TIME

The model run times for the ODAST/SWIFT model combination are very lengthy, approximately 30 hours using a 486/50 PC to simulate a single Uranium transport scenario for 1,000 years. The required run time for some other contaminants are even longer (e.g., 3 days for technetium). Because of this lengthy run time, a screening model (i.e., the ECTran model) was developed. The run times for the ECTran model vary depending on the particular case scenario but are independent of chemicals simulated. Generally ECTran requires between 4 seconds (for single simulations) to 30 minutes (for automatic Monte Carlo simulations and interactive simulations for model calibrations or cleanup goal developments) to run. This run time range is far less than ODAST/SWIFT model combination run time. Therefore, by using the ECTran model a greater amount of runs can be made and many more case scenarios and chemicals of concern can be investigated.

6.0 APPLICATION

This section discusses potential uses of the ECTran as a screening model during the RI/FS processes at the FEMP. As stated earlier, the primary objective of the proposed screening model is to efficiently support the current ODAST and SWIFT models in tasks where large numbers of long-term modeling runs are required. These tasks may include: transport model calibrations for specific contaminants and source areas; initial contaminants of concern (COC) screening; working cleanup goal developments; preliminary comparisons between remedial alternatives; and parameter sensitivity analyses. ECTran can also be utilized to perform stochastical modeling which ODAST and SWIFT were not designed for.

6.1 EXAMPLES OF PREVIOUS APPLICATIONS

Spreadsheet-based fate and transport models, using the same governing equations as ECTran, have been applied in other RCRA and CERCLA projects. These projects were located in U.S. EPA Regions III, VI, and X. The modeling tasks included the following types: developing soil cleanup goals; ACL demonstrations; estimating groundwater cleanup times; and identifying potential contaminant source areas. Most of the sites, for which these modeling tasks were conducted, usually had insufficient information to support more complex fate and transport models. The reasons for the insufficient site information usually are that the hydrogeological and contamination conditions are too complicated or the project is still in its early stages.

Some of the previous applications are presented in one of the attached papers (Appendix C.1, Chiou and Hubbard, 1992). Other applications such as parameter sensitivity analyses using these models were also frequently conducted. The other attached paper (Appendix C.2, Chiou et al., 1992) summarizes some of the typical sensitivity analyses conducted during cleanup goal development processes.

6.2 PROPOSED APPLICATIONS AT FEMP

Considering the capabilities and limitations of ODAST, SWIFT, and ECTran models, possible applications of ECTran are identified. These applications should be able to streamline and enhance the qualities of the fate and transport modeling tasks required in the RI/FS processes at the FEMP. The following subsections describe the proposed ECTran applications.

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6.2.1 Working PRG Development

The ECTran model could be used at the FEMP to develop Working Preliminary Remediation Goals (WPRGs). The prefix "Working" is used to describe PRG since the goals which are developed by the ECTran model will be preliminary and considered as "ballpark numbers." The purpose for developing WPRGs using ECTran is to assist the FS process in evaluating remedial alternatives in a timely and cost-effective manner, before all the contaminant and hydrogeological data for detailed designs is available. The FS team may require these WPRGs since at the FEMP each Operable Unit is conducting the RI and FS in parallel in order to "fast track" their completions. This situation is a detriment to the FS team since they have to develop remediation strategies without the benefit of having the complete RI results. However, by estimating the WPRGs using ECTran, the FS team can determine what contaminants will have a major impact on remediation and identify and resolve potential difficulties for selecting the final remedial alternative earlier.

The ECTran model is well suited for developing WPRGs since there are numerous contaminants and exposure scenarios to be investigated in the early stages of the FS. WPRGs can be determined for any number of contaminants, exposure scenarios, and risk-based groundwater or soil criteria. The ECTran model can be used to calculate WPRGs more than 300 times quicker than the ODAST and SWIFT models. Applications of the model will also allow the FS team to investigate several possible remediation strategies without relying on the complex models.

A typical WPRG development procedure for a contaminant consists of: (1) calibrating the source leachate concentration against the available groundwater contaminant concentrations in 1000 and 2000 series monitoring wells; (2) using the calibration results to determine the current contaminant concentrations in Layers 1 and 2 which can be subsequently used as the initial conditions for these layers during WPRG development; (3) estimate WPRGs based on a chosen remediation strategy (e.g., source removal/reduction or capping); (4) for source removal, the Layer 2, Layer 1, and source leachate concentrations would be modified, in that order, until the modeled maximum contaminant concentration at the exposure point equals the risk-based criteria; (5) for capping alternative, the infiltration rate would be reduced until the modeled maximum contaminant concentration at the exposure point equals the risk-based criteria; and (6) A sensitivity analysis on pertinent model parameters could also be performed in order to assess the effects of these parameters on WPRGs.

6.2.2 Scoping and Cross-Verification

In addition to WPRG development, ECTran can be applied for individual contaminant source areas during the initial stages of the following tasks:

- Transport model calibrations
- ACL demonstrations
- Sensitivity analyses of model parameters
- COC screening

Due to ECTran's short run time, large numbers of simulations can be run when the uncertainties associated with model parameters are still high. Results of these preliminary runs can then be used to select specific or a smaller range of values for each model parameter to be assigned in the ODAST and SWIFT models. Therefore, the number of necessary ODAST and SWIFT model runs, which will require very long run times, can be significantly reduced.

Because of the conservative nature of the ECTran model, it can be used to screen out contaminants that are very unlikely to cause future impact on the groundwater from the pathways simulated by the model. Therefore, the number of contaminants which need to be further studied by ODAST and SWIFT can be reduced.

When both ECTran and ODAST/SWIFT modeling results for the same case scenario are available, cross-verification can also be conducted. During cross-verification the predicted levels and occurring times of the maximum groundwater concentration can be compared. Although exactly the same results are not expected from these two different models, the cross-verification process can ensure that the models have been applied properly when similar results are obtained from both models.

6.2.3 Stochastical Modeling

With the Monte Carlo simulation capability, ECTran can be used to perform stochastical/probabilistical groundwater contaminant fate and transport modeling. The uncertainty associated with the model predictions can be quantified. Also, the probability of success of a given remedial alternative can be estimated.

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Water Environment Federation
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Important Factors in Cleanup Goal Development for Contaminated Soil and Groundwater - Sensitivity Analyses by Model Simulations

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AC92-044-005

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SUMMARY

The model is based on straight forward mass-balances and advection/dispersion equations but can be used to simulate a variety of complex conditions. To date, HALLIBURTON NUS has employed the model to determine soil cleanup goals, Alternative Concentration Limits, and to support baseline risk assessment/human health and environmental evaluations for both CERCLA and RCRA applications. The model is extremely user friendly and can be used by personnel with diverse technical backgrounds.

Several advantages of a spreadsheet-based model over a traditional "pre/post-processor and main program approach" are apparent. Because the simulation is implemented by a spreadsheet, the model input and output data are contained in the same file. It is extremely easy for the user to change values of any specific input parameters, and the effects of various input values can be seen on the computer screen. The graphical and statistical capability provided by the spreadsheet makes presentation of the model results very efficient and flexible.

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points. The lengths of the flow paths from each site (or discrete site-specific sources) were divided by the simulated travel times to determine an interstitial pore velocity. The annual recharge (Q_1) for each site was determined using the HELP Model.

Soil remediation goals were determined based on the assumption that the groundwater was either uncontaminated or that it would be restored to acceptable concentrations. Therefore, for model execution, C (the concentration in infiltrating precipitation), C_u (the concentration in upgradient groundwater, and C_{wa} (the concentration in groundwater beneath the site) were all set equal to zero at time t = 0. Furthermore, the concentration in infiltrating precipitation and the upgradient concentration remained at zero throughout the model execution. The saturated zone groundwater concentration is contingent upon loading from the source and fluctuates as a function of time.

Once the input parameters had been established for each site and contaminant, an interactive, trial-and-error approach was used to determine acceptable source concentrations. A soil concentration was entered and adjusted until the maximum downgradient concentration at the point of exposure did not exceed the groundwater goal.

ACL Demonstration - Major Chemical Manufacturer

An Alternate Concentration Limit (ACL) demonstration based on discharge of contaminated groundwater to surface waters in the vicinity of a major chemical manufacturer's facility was completed. Incidental ingestion of surface water and ingestion of aquatic organisms that have accumulated discharged groundwater contaminants were considered the exposure routes of concern for human receptors. These points of exposure and exposure routes were considered to develop Maximum Allowable Exposure Concentrations (MAECs). ACLs were then determined via contaminant fate and transport analysis such that the MAECs are not exceeded.

Several unsuccessful attempts to develop a complex, numerical, groundwater flow and transport simulation model for the facility had been completed by other consulting firms. In view of the complexity of the site hydrologic conditions, HALLIBURTON NUS deemed it appropriate to employ simplified analytical solutions to simulate contaminant migration. Nevertheless, the previous studies provided input values for most of the required parameters for the ACL demonstration.

Figure 6 depicts a conceptual cross-section of the study area. Two of the three surface water bodies in the vicinity of the site were treated as quiescent bodies with no dilution potential. An accumulation/volatilization model was developed and incorporated into the spreadsheet to simulate the exposure point concentrations in these two surface water bodies. A tidal dilution model was developed for the third surface water body to estimate chemical concentration distributions. Based on groundwater discharge rate, chemical concentrations in the groundwater, and a tidal amplitude, the model was used to estimate the steady-state daily maximum or average chemical concentrations in the bay. Therefore, the dilution factor between groundwater and each model segment resulting from mixing and tidal movement was determined

ACLs were eventually developed for each of the chemicals of concern using the model. The observed concentrations of some chemicals exceed the ACLs based on the exposure pathways of concern. The fact that some of the protective ACLs have been exceeded indicates that containment efforts (interceptor trenches) are necessary and were implemented in a timely manner. Continued interception of groundwater plume is planned until acceptable concentrations (ACLs) are attained at the unit boundary.

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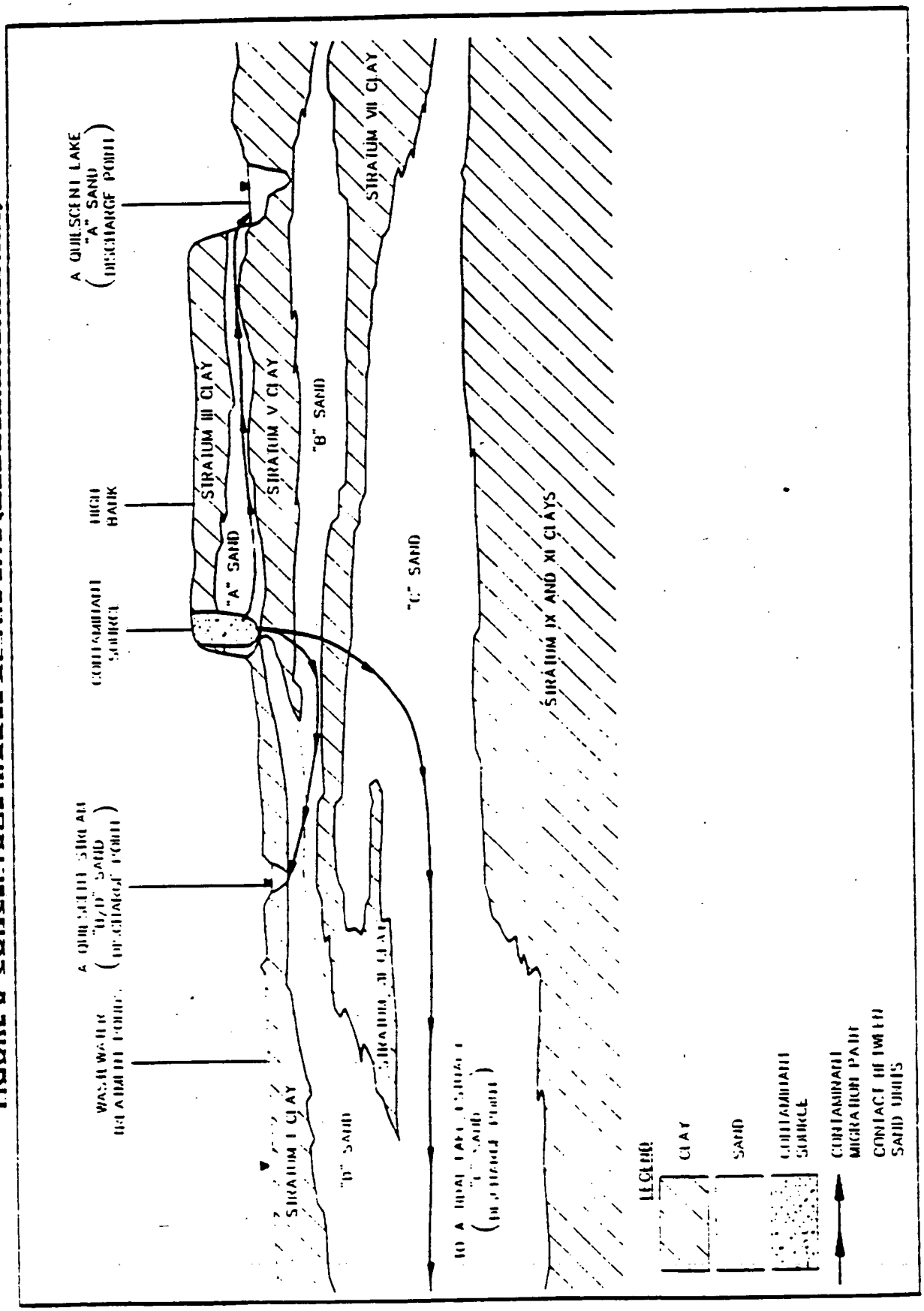
FIGURE 6 CONCEPTUAL MODEL OF THE SITE (ACL DEMONSTRATION)



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DEVELOPMENT AND APPLICATION OF A SPREADSHEET-BASED MULTIMEDIA CONTAMINANT FATE AND TRANSPORT MODEL

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INTRODUCTION

A spreadsheet-based, multimedia, contaminant fate and transport model was developed to support screening-level risk assessment, cleanup goal development, and Alternate Concentration Limit determination for hazardous waste treatment, storage, and disposal facilities. This paper discusses various components of the model used to simulate contaminant washout from a source area, downgradient solute transport, and estimation of receptor concentrations under various types of exposure scenarios. A spreadsheet was used to implement and link various simulation modules and to simplify the model input, interactive execution, and output presentation processes. The model guides the user regarding the influence of various parameters on the contaminant concentration at the point of exposure and, therefore, focuses remedial measures or data collection efforts.

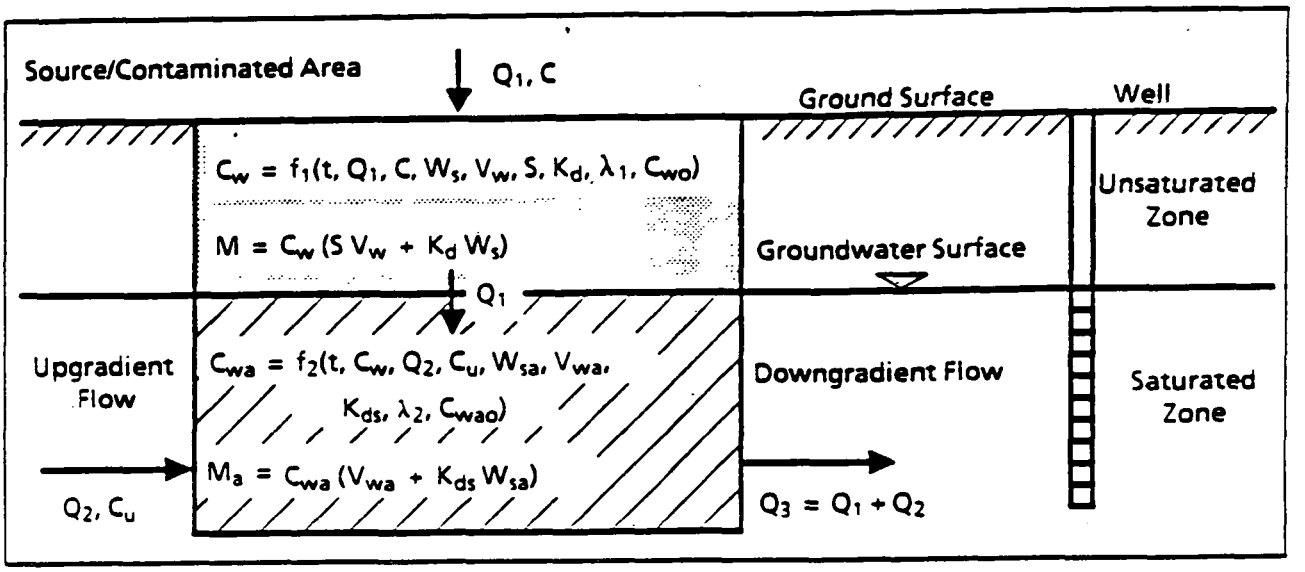
MODEL DEVELOPMENT

Contaminant Source Module

A system of analytical models which describe various aspects of source loading and contaminant washout from both the unsaturated and saturated zones was configured via straightforward mass balances. Although several simplifying assumptions were made, the model can simulate very complex source-loading scenarios, as shown in Figure 1. For example, any combination of the following aspects of source loading and contaminant washout may be simulated:

- Surface infiltration and percolation
- Contaminant loading via infiltration
- Sorption in the unsaturated zone
- Upgradient groundwater flow
- Contaminant loading via upgradient flow
- Sorption in the saturated zone
- Zone-specific contaminant decay rates
- Zone-specific initial contaminant concentrations
- Constant or time varying concentration in the unsaturated zone

FIGURE 1: CONCEPTUAL MODEL OF THE SOURCE AREA



Variables used to describe/quantify these processes are shown in Figure 1 and are defined as follows:

- C is the contaminant concentration in infiltrating precipitation (mg/L)
- Q_1 is the infiltration rate (L/day)
- C_w is the aqueous concentration in the unsaturated zone (mg/L)
- C_{wo} is the initial value of C_w (mg/L)
- S is the saturation fraction (dimensionless)
- M is the total mass of contaminant in the unsaturated zone (mg)
- W_s is the weight of soil in the unsaturated zone (kg)
- V_w is the void volume in the unsaturated zone (L)
- C_u is the contaminant concentration in upgradient groundwater (mg/L)
- Q_2 is the upgradient groundwater flow rate (L/day)
- C_{wa} is the aqueous concentration in the saturated zone (mg/L)
- C_{wao} is the initial value of C_{wa} (mg/L)
- M_a is the total mass of contaminant in the saturated zone below the source (mg)
- V_{wa} is the void volume in the saturated zone (L)
- W_{sa} is the weight of soil in the saturated zone (kg)
- Q_3 is the combined downgradient flow [$Q_1 + Q_2$] (L/day)
- λ_1, λ_2 are the first-order decay rates in the unsaturated and saturated zone (day^{-1})
- K_d, K_{ds} are the aqueous/solid phase distribution coefficients in the unsaturated and saturated zone, respectively (L/kg)
- t is time (days)

Unsaturated Zone

A mass balance for the wash out of contaminants from an unsaturated source area, assuming that the infiltrating precipitation contains background contamination and that dispersion in the unsaturated zone is negligible, yields the following expression for the time-dependent concentration in the unsaturated zone:

$$\frac{dC_w}{dt} = \left[\frac{Q_1}{SV_w - K_d W_s}\right] \cdot \left[C - C_w\right] - \lambda_1 C_w \qquad (1)$$

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For an initial condition of $C_w = C_{wo}$, this equation may be solved via direct integration to yield the following solution:

$$C_w = \frac{C - \left\{C - \left[1 + \left(SV_w + K_d W_s\right)\left(\lambda_1/Q_1\right)\right] C_{wo}\right\} \exp\left[-\frac{Q_1 + \left(SV_w + K_d W_s\right)\lambda_1}{SV_w + K_d W_s} t\right]}{\left[1 + \left(SV_w + K_d W_s\right)\left(\lambda_1/Q_1\right)\right]} \qquad (2)$$

Saturated Zone

Using a similar approach, a general case for the saturated zone which includes a time-dependent source loading term (C_w as described above) and an upgradient contribution as a result of background contamination may be written in the following form:

$$\frac{dC_{wa}}{dt} + \frac{K_2}{K_1} C_{wa} = \frac{K_3}{K_1} + \frac{K_4}{K_1} \exp\left[-K_5 t\right] \qquad (3)$$

Where:

$K_1 = V_{wa} + K_{ds} W_{sa}$
$K_2 = Q_3 + (V_{wa} + K_{ds} W_{sa}) \lambda_2$
$K_3 = Q_1 C / [1 + (SV_w + K_d W_s)(\lambda_1/Q_1)] + Q_2 C_u$
$K_4 = Q_1 C_{wo} - Q_1 C / [1 + (SV_w + K_d W_s)(\lambda_1/Q_1)]$
$K_5 = [Q_1 + (SV_w + K_d W_s)\lambda_1]/(SV_w + K_d W_s)$

This equation is of the general form:

$$C'_{wa} + p(t) C_{wa} = r(t)$$

and has a general solution as follows:

$$C_{wa} = \exp[-h] * [\int \exp(h) r(t)\, dt + K]$$

Where: $h = \int p(t) dt$ and K is a constant of integration

This equation may be solved for the initial condition of $C_{wa} = C_{wao}$ using the preceding integrating factor approach or the method of undetermined coefficients to yield the following:

$$C_{wa} = \frac{K_3}{K_2} + \frac{K_4}{K_2 - K_1 K_5} \exp\left(-K_5 t\right) - \left[C_{wao} - \frac{K_3}{K_2} - \frac{K_4}{K_2 - K_1 K_5}\right] \exp\left(-\frac{K_2 t}{K_1}\right) \qquad (4)$$

Special Cases

In addition to this standard form of the solution, the following two special cases were also considered:

- For a constant-concentration unsaturated zone (i.e., $C_w = C$), the saturated zone equation becomes:

$$C_{wa} = \frac{Q_1C + Q_2C_u - \left\{Q_1C + Q_2C_u - K_2C_{wao}\right\}\exp\left(-\frac{K_2t}{K_1}\right)}{K_2} \quad (5)$$

- In the case of $K_2 = K_1K_5$, the solution of Eq. (3) and thus the saturated zone equation becomes:

$$C_{wa} = \frac{K_3}{K_2} + \left[C_{wao} - \frac{K_3}{K_2} + \frac{K_4}{K_1}t\right]\exp\left(-K_5t\right) \quad (6)$$

<u>Downgradient Solute Transport Module</u>

A simplified version of a general solution to a three-dimensional advection/dispersion/sorption/decay equation was used to simulate solute transport. It provides an estimate of the contaminant concentration at a receptor location or discharge area downgradient of the source area under different source-loading conditions. As a result of the complexity of this model, a separate, executable FORTRAN program was required to perform the calculations. The linkage between the main spreadsheet and this executable file was accomplished using macro commands in the spreadsheet.

The basic equation, a modified version of a general constant-source equation developed by Domenico (1987), for the plume centerline is as follows:

$$C(X, t, Co) = \frac{Co}{2}\exp\left\{\left(\frac{X}{2\left(D_x/V\right)}\right)\left[1-\left(1+\frac{4\lambda_3D_x}{V^2}\right)^{1/2}\right]\right\}$$

$$\operatorname{erfc}\left[\frac{X - Vt\left(1-\frac{4\lambda_3D_x}{V^2}\right)^{1/2}}{2\left(D_xt\right)^{1/2}}\right]\operatorname{erf}\left[\frac{Y}{4\left(\frac{D_y}{V}X\right)^{1/2}}\right] \quad (7)$$

Where:
- C = the downgradient concentration along the plume centerline (mg/L)
- C_o = the constant groundwater concentration at/below the source (mg/L)
- X = the distance downgradient of the source (ft)
- V = the contaminant velocity (ft/year)
- t = elapsed time since the beginning of the source loading (years)
- D_x = the principle value of the dispersion tensor in the x (longitudinal) direction (ft^2/year)
- Y = source dimension in the y (lateral) direction (ft)
- D_y = the principle value of the dispersion tensor in the y (lateral) direction (ft^2/year)
- λ_3 = decay rate ($years^{-1}$)

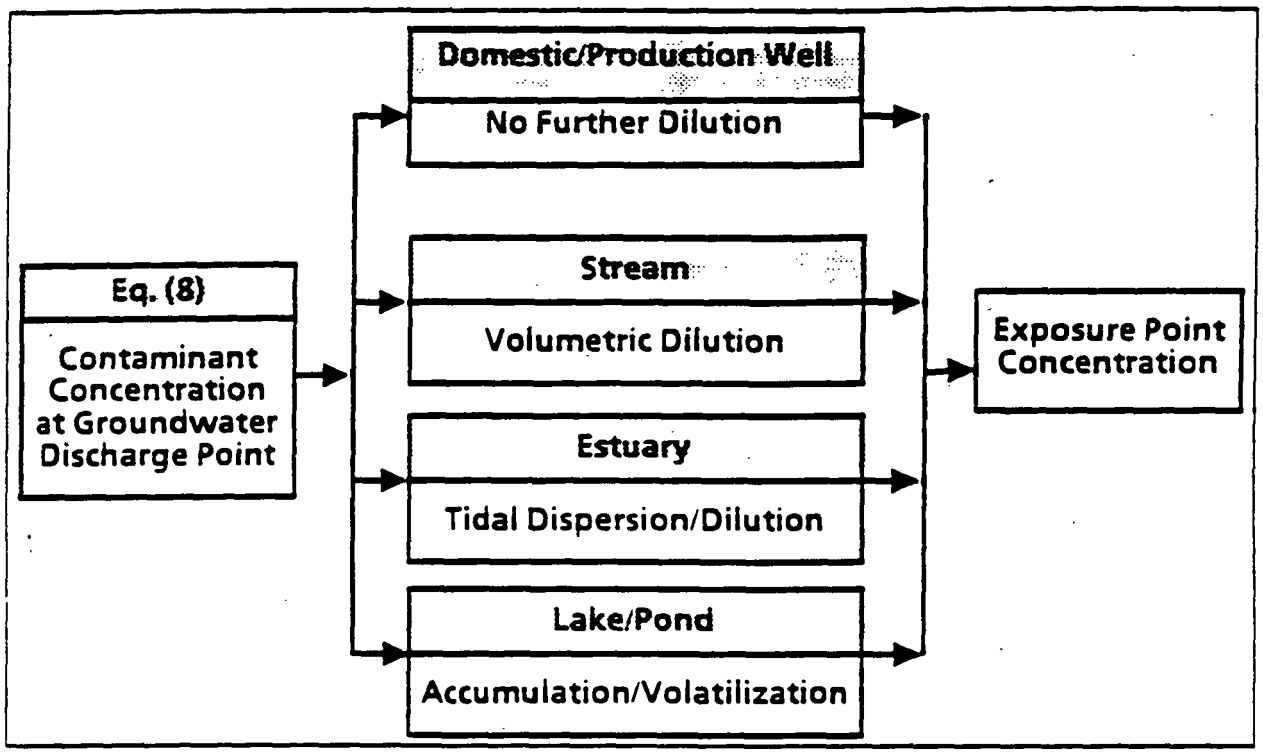
In the preceding expression, erf and erfc are the error function and the complimentary error function, respectively. Vertical dispersion was not considered in equation (7) in order to provide a conservative estimate of the exposure point concentration. The contaminant velocity is determined as the groundwater interstitial pore velocity divided by the retardation factor. The retardation factor can be estimated using the distribution coefficient (K_d) and the bulk density and porosity of the soil. Equation (7) was applied using superposition to simulate the time-dependent source loading. For this

system that assists the user to estimate necessary hydrogeological and chemical parameters for the model. The source loading from the unsaturated zone must be specified by the user.

Discharge/Exposure Module

Analytical models for estimating contaminant concentrations at four different types of exposure points were developed and incorporated into the spreadsheet. They include direct use of groundwater, as well as groundwater discharge into a flowing stream, a closed lake/pond, or a tidally affected water body. As shown in Figure 3, the discharge/exposure module of the model estimates the dilution caused by mixing of contaminated groundwater with surface water and, thus, the contaminant concentration at an appropriate exposure point.

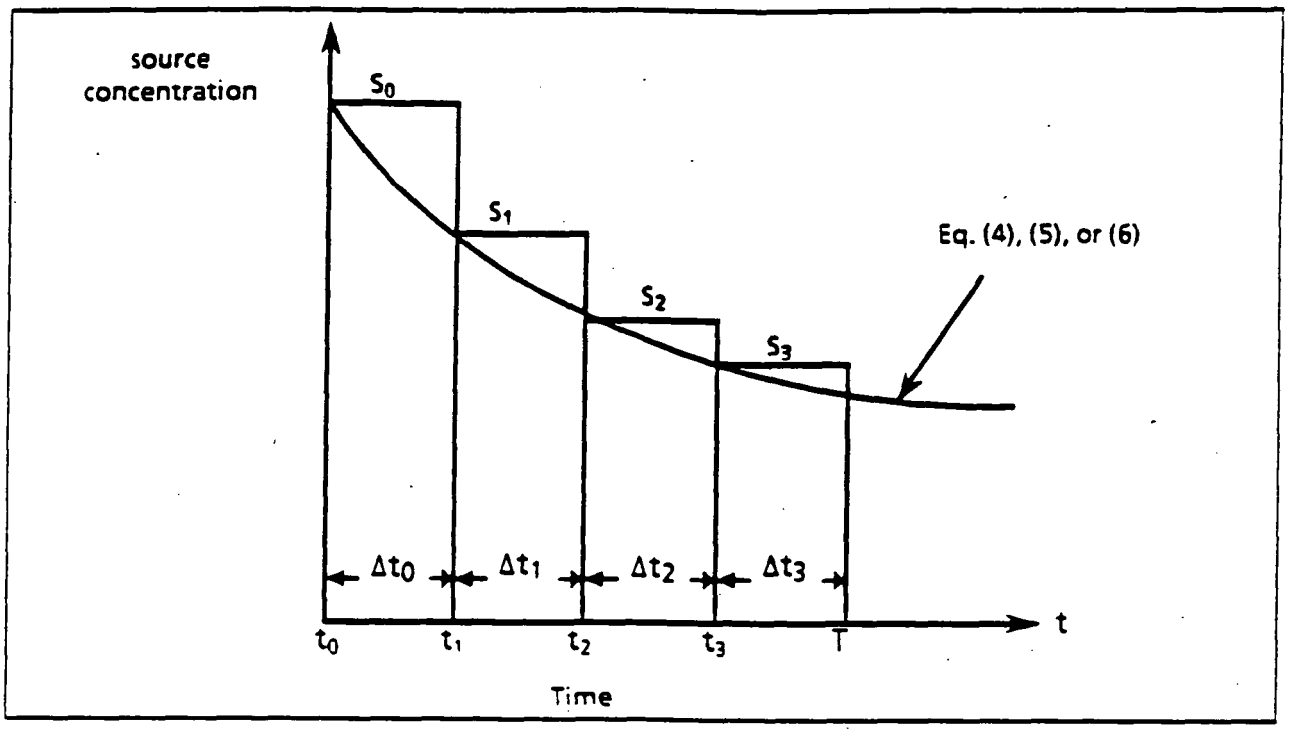
FIGURE 3: TYPES OF EXPOSURE POINT AND ASSOCIATED ATTENUATION IMPLEMENTED



Although the basic equations for estimating dilution factors in streams, estuarys, and lakes (Thomann and Mueller, 1987) are simple, it is usually necessary to modify or combine several equations, based on the site-specific conditions, to obtain the final dilution model. Therefore, details or a generalized approach regarding the development of the dilution factors used in this module will not be described in this paper.

time-dependent source, the concentration at a downgradient location at a given time T can be estimated using the following procedure. First the continuous function of the time-dependent source concentration [Eq. (4), (5), or (6)] is approximated by a series of step impulses which simplifies the solution and is also more conservative than the original function as shown in Figure 2.

FIGURE 2: CONCEPTUAL MODEL OF THE SOURCE CONCENTRATION



The concentration at X feet downgradient of the source at time T can therefore be estimated by superposition of constant source solutions [Eq. (7)] for all impulses prior to time T as follows:

$$C(x,T) = \sum_{i=0}^{n} \left[C\left(X, T-t_i, S_i\right) - C\left(X, T-t_i-\Delta t_i, S_i\right) \right]$$

$$= C\left(X, T-t_0, S_0\right) - C\left(X, T-t_0-\Delta t_0, S_0\right) +$$

$$C\left(X, T-t_1, S_1\right) - C\left(X, T-t_1-\Delta t_1, S_1\right) + \ldots +$$

$$C\left(X, T-t_n, S_n\right) - C\left(X, T-t_n-\Delta t_n, S_n\right) \qquad (8)$$

Where: S_i is the source concentration of the ith impulse; t_i is the starting time of the ith impulse; Δt_i is the time interval for the ith impulse; $T-t_n-\Delta t_n = 0$; and C (X, T) is the combined effects of n + 1 impulses. In the preceding equation, C (X, t, S) [i.e., Eq. (7)] is the concentration at X caused by a constant source with concentration S for a duration of t. Therefore, C(X,t,S) needs to be applied twice to determine each single impulse's net lasting effect at time T. This approach is similar to the procedure used in the Expert ROKEY Computer System (McClymont and Schivarte, 1987). The Expert ROKEY Computer System is a saturated-zone contaminant fate and transport model with an expert

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MODEL PARAMETER ESTIMATION

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Table 1 is an example of the output generated using the developed model for a direct groundwater use scenario. Values of input parameters that must be specified by the user are circled. These parameters can be estimated based on site-specific conditions such as the extent of source contamination (i.e., LENGTH and WIDTH); soil characteristics (i.e., POROSITY, DENSITY, and FOC); hydrogeologic information (i.e., GW VEL., DISTANCE, DISPERSIVITY, and THICKNESS); water budget information generated using models such as the Hydrologic Evaluation of Landfill Performance (HELP) Model (i.e., INFILT. and SATURATION); contaminant concentration (i.e., CWAO); and background contamination (i.e., C and CU). As one of the user-specified input values, the upgradient groundwater flow velocity (GW VEL.) can be estimated by the following equation:

GW VEL. = average GW gradient x average hydraulic conductivity/POROSITY (9)

The longitudinal dispersivity (Ax) is usually taken as 1/10 of the DISTANCE, where the transverse dispersivity (Ay) is equal to 1/3 of the longitudinal value. The rest of the parameters in Table 1, as well as some parameters used in Figure 1 and Equations (4) and (7) are internally calculated automatically by the spreadsheet, using the following equations and the user-specified parameters (proper conversions of units):

Contaminant source model parameters shown in Figure 1:

- Q_1 = INFILT. x LENGTH x WIDTH
- V_w = POROSITY x LENGTH x WIDTH x THICKNESS (unsaturated zone)
- K_d = KOC x FOC (unsaturated zone)
- W_s = DENSITY x LENGTH x WIDTH x THICKNESS (unsaturated zone)
- M = C_w x (SATURATION x V_w + K_d x W_s)
- C_{w0} = CLEAN-UP GOAL / K_d
- Q_2 = GW VEL. x WIDTH x THICKNESS (saturated zone) x POROSITY
- V_{wa} = POROSITY x LENGTH x WIDTH x THICKNESS (saturated zone)
- K_{ds} = KOC x FOC (saturated zone)
- W_{sa} = DENSITY x LENGTH x WIDTH x THICKNESS (saturated zone)
- M_a = C_{wa} x (V_{wa} + K_{ds} x W_{sa})
- Q_3 = Q_1 + Q_2
- λ = DECAY RATE = -ln(0.5) / HALF LIFE (zone specific)

Downgradient solute transport module parameters used in Equation (7):

- RETARDATION = 1 + DENSITY x KD / POROSITY
- C_0 = S_0, S_1, S_2, or S_3 as shown in Figure 2.
- X = DISTANCE (distance from the downgradient edge of the source area to the exposure point)
- GW V. = Q_3/ (POROSITY x WIDTH x THICKNESS)
- V = GW V. / RETARDATION
- Y = WIDTH
- D_x = V x DISPERSIVITY (Ax) = V x 0.1 x DISTANCE
- D_y = V x DISPERSIVITY (Ay) = D_x / 3
- λ_3 = DECAY RATE = -ln(0.5) / HALF LIFE (zone specific)

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TABLE 1: EXAMPLE OF MODEL OUTPUT

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HALLIBURTON NUS ENVIRONMENTAL CORPORATION
SCREENING-LEVEL MULTIMEDIA CONTAMINANT FATE AND TRANSPORT MODEL
EXPOSURE SCENARIO #1: TIME VARYING SOURCE AND DIRECT USE OF GROUNDWATER

SITE: X CHEMICAL SUPERFUND SITE
INVESTIGATOR: J. D. CHIOU
DATE: 10-21-91

CONTAMINANT: BENZENE
KOC (L/KG): 45.00
HALF LIFE (YRS):
UNSATURATED: 5.00
SATURATED: 5.00
D.G. PLUME: 5.00

ALLOWABLE EXPOSURE CONC. (UG/L): 5.0
UNSATURATED ZONE SOIL CLEAN UP GOAL (MG/KG): 5.026

SOURCE AREA:		UNSATURATED ZONE		SATURATED ZONE		DOWN GRADIENT AREA / EXPOSURE POINT			
LENGTH (FT):	224	FOC (KG/KG):	.001	FOC (KG/KG):	.0010	Q3 (L/DAY):	1462.40	FOC (KG/KG):	.001
WIDTH (FT):	160	KD (L/KG):	.065	KD (L/KG):	.065	GW V.(FT/YR):	48.09	KD (L/KG):	.065
		SATURATION:	.32	SATURATION:	1.00	DISTANCE (FT):	120.00	RETARDATION:	1.316
POROSITY:	.32	THICKNESS (FT):	7.00	THICKNESS (FT):	7.00	POROSITY:	.35		
DENSITY (G/CM3):	1.7	DECAY (1/DAY):	3.5e-4	DECAY (1/DAY):	3.798e-4	DECAY (1/YR):	1.386e-1	ACCEPT THE GOAL!	
		CWO (PPB):	4.65e4	CWAO (PPB):	1e2	DISPERSIVITY:			
INFILT. (FT/YR):	0.275	C (PPB):	0	CU (PPB):	0	Ax (FT):	112.00		
GW VEL. (FT/YR):	.35	Q1 (L/DAY):	245.80	Q2 (L/DAY):	1216.60	Ay (FT):	37.30		

ELAPSED TIME - YRS	DAYS	UNSATURATED ZONE CONC. (UG/L)	SATURATED ZONE CONC. (UG/L)	EXPOSURE POINT CONC. (UG/L)	70-YEAR AVERAGE (UG/L)
0	0	46523.08	100.00	.0000	
2	730	34168.82	631.62	.0000	
4	1460	25095.25	846.07	.0000	
6	2190	18431.17	883.06	.0003	
8	2920	13536.75	827.72	.0069	
10	3650	9942.05	730.59	.0600	
12	4380	7301.93	620.57	.2621	
14	5110	5362.89	513.28	.7179	
16	5840	3938.77	416.36	1.4400	
18	6570	2892.82	332.75	2.3340	
20	7300	2124.63	262.85	3.2480	
22	8030	1560.43	205.69	4.0400	
24	8760	1146.06	159.72	4.6140	
26	9490	841.72	123.23	4.9310	
28	10220	618.20	94.56	4.9990	
30	10950	454.04	72.23	4.8560	
32	11680	333.47	54.95	4.5540	
34	12410	244.91	41.66	4.1490	
36	13140	179.88	31.49	3.6870	
38	13870	132.11	23.74	3.2090	
40	14600	97.03	17.85	2.7430	
42	15330	71.26	13.40	2.3090	
44	16060	52.34	10.04	1.9180	
46	16790	38.44	7.50	1.5740	
48	17520	28.23	5.60	1.2780	
50	18250	20.74	4.18	1.0290	
52	18980	15.23	3.11	.8213	
54	19710	11.18	2.32	.6509	
56	20440	8.21	1.72	.5125	
58	21170	6.03	1.28	.4011	
60	21900	4.43	.95	.3123	
62	22630	3.25	.70	.2421	
64	23360	2.39	.52	.1868	
66	24090	1.76	.39	.1436	
68	24820	1.29	.29	.1099	
70	25550	.95	.21	.0839	1.7062
72	26280	.70	.16	.0639	1.7080
74	27010	.51	.12	.0485	1.7093
76	27740	.38	.08	.0367	1.7103
78	28470	.28	.06	.0277	1.7111
80	29200	.20	.05	.0209	1.7115
82	29930	.15	.03	.0157	1.7103
84	30660	.11	.03	.0118	1.7033
86	31390	.08	.02	.0089	1.6836
88	32120	.06	.01	.0066	1.6438
90	32850	.04	.01	.0050	1.5791
92	33580	.03	.01	.0037	1.4890
94	34310	.02	.01	.0028	1.3769
96	35040	.02	.00	.0021	1.2487
98	35770	.01	.00	.0015	1.1118
100	36500	.01	.00	.0011	.9730
MAXIMUM:		46523.08	883.06	4.999	1.7115

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Assuming simple hydrolysis and biodegradation, the zone-specific decay rates (i.e. λ_1, λ_2, and λ_3) can also be estimated by the following equations (Huyakorn et al., 1987; Salhotra et al., 1990):

$$\lambda_1 = \left(\frac{\lambda_d \theta_u + \lambda_s K_d \rho_b}{\theta_u + K_d \rho_b} \right) + \lambda_b \tag{10}$$

$$\lambda_2 \text{ (or } \lambda_3) = \left(\frac{\lambda_d \theta + \lambda_s K_{ds} \rho_b}{\theta + K_{ds} \rho_b} \right) + \lambda_b \tag{11}$$

Where:

λ_d = first-order hydrolysis rate constant for the dissolved constituent (day^{-1})
λ_s = first-order hydrolysis rate constant for the sorbed constituent (day^{-1})
λ_b = first-order lumped biodegradation rate (day^{-1})
Θ_u = volumetric water content in the unsaturated zone (dimensionless)
Θ = volumetric water content in the saturated zone (i.e. total porosity)
ρ_b = soil bulk density, g/cm^3

λ_d and λ_s are chemical specific and dependent on the soil and groundwater conditions. The required information and method for estimating λ_d and λ_s are described by Huyakorn (Huyakorn et al., 1987).

Although the contaminant source module assumes a homogeneous unsaturated zone, the use of the HELP Model to determine the infiltration rate and the degree of saturation externally can allow the layered structure of the unsaturated zone to be considered, if necessary. The percolation from the bottom layer and the weighted average of saturation in each layer estimated by the HELP Model can be used as the infiltration rate and the unsaturated zone saturation ratio in this model. The thickness of the saturated zone, which represents the vertical extent of contamination in the model, is usually based on the minimum of the following three possible values:

- The thickness of the entire saturated zone.
- The lowest position of detected contaminants of concern.
- The mixing zone depth calculated by the following equation (Salhotra et al., 1990):

$$H = B\left[1 - \exp\left(-V_{zo} L / (B V_x)\right)\right] - \left(2 \alpha_v L\right)^{1/2} \tag{12}$$

Where: H is the mixing zone depth (ft); B is the total saturated zone thickness (ft); V_{zo} is the vertical seepage velocity (ft/yr); L is the length of the source area (ft); V_x is the horizontal seepage velocity (ft/yr); and α_v is the vertical dispersivity (ft).

In cases where the net recharge outside the source area percolating directly into and diluting the downgradient contaminant plume is significant, the effective decay rate in the downgradient area can be increased to λ_3^*, as follows

$$\lambda_3^* = \lambda_3 - \frac{q}{B\theta} \tag{13}$$

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where q is the annual infiltration rate in the downgradient area (ft/year).

With all of the parameters determined (either via direct input or internal calculation), Eqs. (2), (4) [or (5) and (6)], and (8) are then used in the model to calculate C_w, C_{wa}, and C, respectively. Since the model is implemented on a spreadsheet, the graphical capability of the spreadsheet can be directly utilized for presenting the model results. Figure 4 shows the graphical presentations of simulated C_w, C_{wa}, and C for the example in Table 1. Both Table 1 and graphs in Figure 4 are generated by the spreadsheet.

APPLICATION

Three case studies describing instances in which the model has been used to determine cleanup goals are described below.

Cleanup Goal Selection - EPA Superfund Site

The model was used to determine soil cleanup goals at a Superfund site in Virginia. Soil media in localized areas was contaminated in both the saturated and unsaturated zones. The model was run under an interactive approach to determine the maximum unsaturated zone soil concentrations that will result in attainment of the Safe Drinking Water Act Maximum Contaminant Levels (MCLs) at the downgradient edge of the saturated zone beneath the site.

For this particular application, existing contamination was specified based on actual analytical data for saturated zone. The infiltration rate (Q_1) was estimated using the HELP Model, based on local meteorological conditions. Soil mechanical and hydraulic properties, which were determined from samples collected from the site, were used as model inputs to simulate contaminant washout from the unsaturated zone and contaminant transport in the saturated zone. The model was run for 19 different compounds and for various concentrations. Based on the results of the modeling efforts, a variety of potential cleanup scenarios were identified. Remedial alternatives for each scenario were developed for EPA review.

Cleanup Goal Selection - DOD Facility

The model was used to develop cleanup goals for numerous contaminated areas at a DOD facility in Texas based on specific remedial objectives. Figure 5 shows the contaminated zones at the facility and the chemicals of concern. The overall remedial objective was to protect human health and the environment and achieve Applicable, or Relevant and Appropriate Requirements (ARARs) at a location immediately adjacent to a receiving surface water body or at the base boundary. The goals were established based on EPA and TWC (Texas Water Commission) "acceptable" risk levels and assumptions regarding ultimate land uses and contaminant exposure pathways.

Leachate generation, dilution in the aquifer beneath the sites, and downgradient transport, including hydrodynamic dispersion and sorption, were considered to determine soil concentrations that correspond to the groundwater remediation goals at the point of exposure. Although many of the soil contaminants at the various sites are subject to environmental degradation via hydrolysis or microbial degradation, these decay mechanisms were not considered. Model input parameters were determined based on available site information and on professional judgment if site-specific values were not available.

Two other models were used to determine certain input parameters. The groundwater velocity for each site was determined from a calibrated, particle-tracking, groundwater model completed in support of a Remedial Investigation at the facility. This model was used to delineate flow paths and to predict the travel time of a particle from the various sources to the stream or other exposure

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FIGURE 4: GRAPHICAL PRESENTATION OF THE MODEL RESULTS

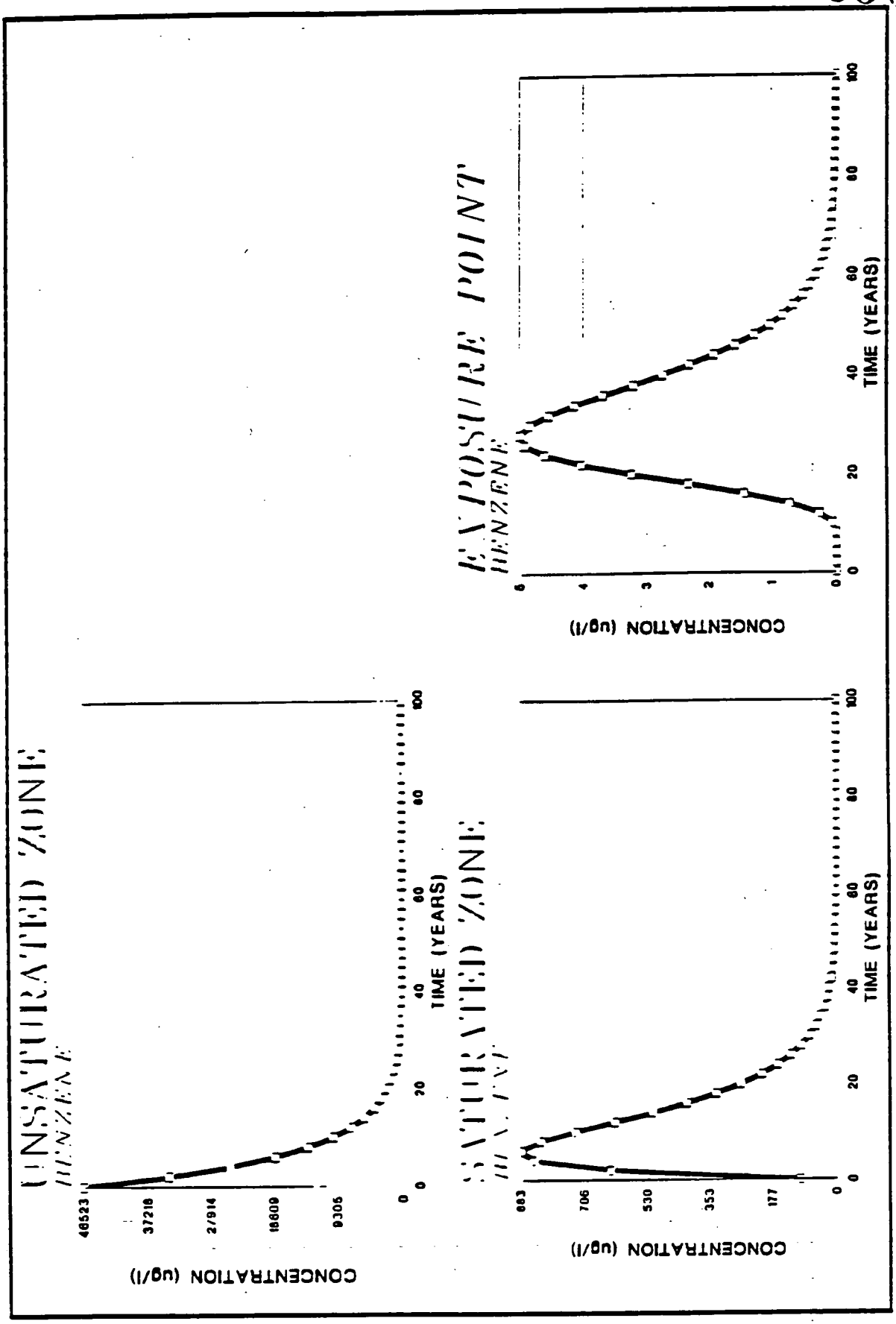

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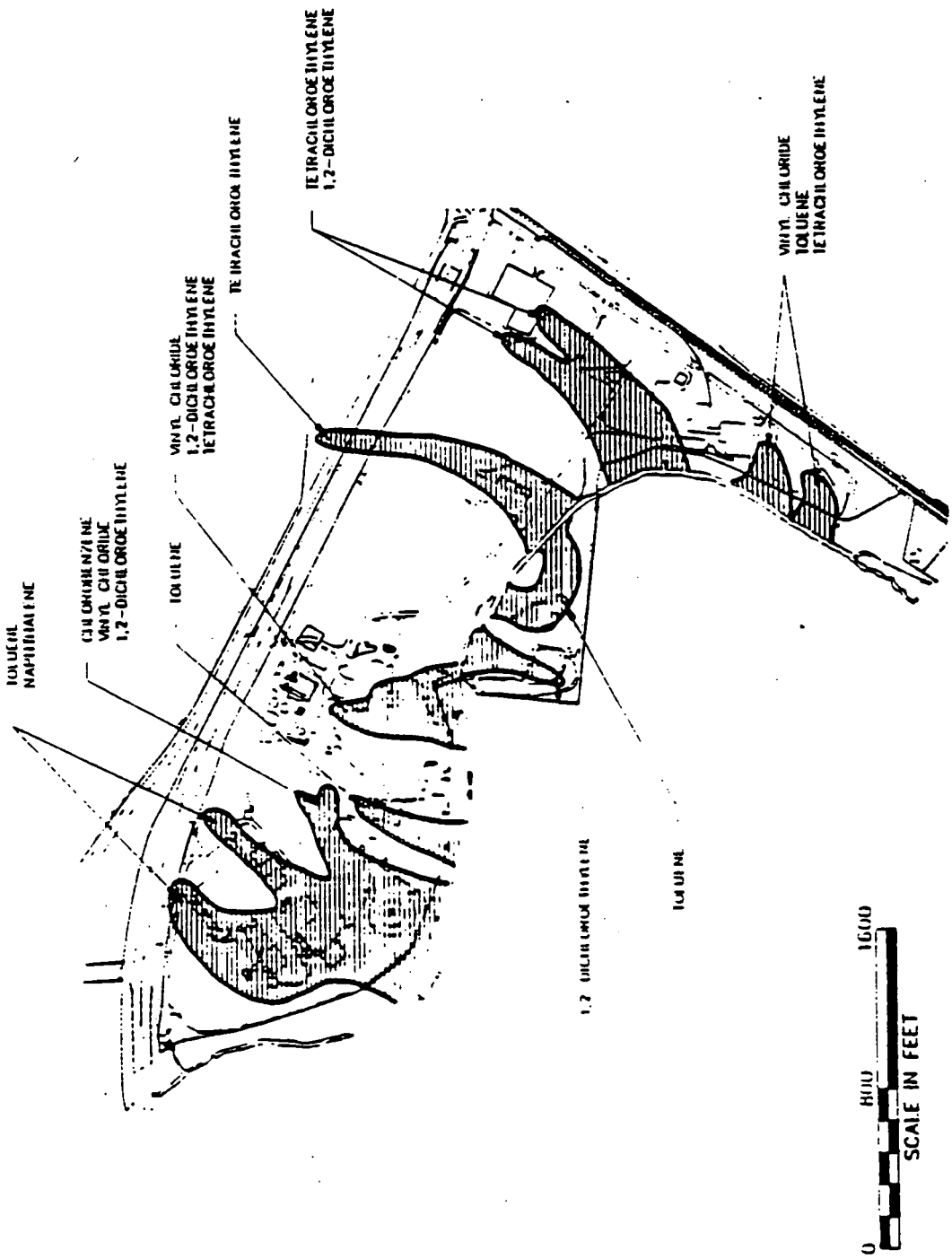
FIGURE 5 SITE MAP AND ROUTE OF CONTAMINANT MIGRATION



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APPENDIX C.1

PREVIOUS APPLICATIONS

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```
      IMPLICIT REAL*8 (A-H, L, O-Z)
      DIMENSION CO(55),TCO(55)
C-----------------------------------
      OPEN(UNIT=10,FILE='SOURCE.DAT',STATUS='OLD')
      OPEN(UNIT=11,FILE='EXPO.DAT',STATUS='NEW')
C-----------------------------------
      READ(10,*) V,RF,DIST,Y,HL,AX,AGE,PTY
      READ(10,*) (TCO(J),CO(J),J=1,51)
C-----------------------------------
      DT1 = TCO(2)-TCO(1)
      DT = DT1
      CAGE = CO(1)
      DO 400 I=1,51
        IF((TCO(I)+DT).LE.PTY) THEN
          CO(I) = 0.0
        ELSE IF(TCO(I).LT.PTY) THEN
          DT1 = DT - (PTY - TCO(I))
        ENDIF
400   CONTINUE
C-----------------------------------
      AY=AX/3.
      V=V/RF
      DX=AX*V
      DY=AY*V
      IF(HL.GT.0.D0) THEN
        LAMDA=DLOG(2.D0)/HL
      ELSE
        LAMDA=0.D0
      ENDIF
      TIME=0.0D0
      X3=DERF(Y/(4.0D0*DSQRT(DY/V*DIST)))*
     1  EXP((DIST/(2.0D0*DX/V))*
     2  (1.0D0-DSQRT(1.0D0+(4.0D0*LAMDA*DX)/(V**2.D0))))
      print *, 'Please wait!  Calculating exposure point concentration.'
300   C500=0.0D0
      IF(TIME.LE.PTY) GO TO 200
      DO 100 I=1,51
        IF(CO(I).EQ.0.0) GO TO 100
        IF(TCO(I).LT.(TIME-DT)) THEN
          IF(TCO(I).GE.PTY) THEN
            T1 = TIME - TCO(I)
            T2 = TIME - TCO(I) - DT
          ELSE IF((TCO(I)+DT).GT.PTY) THEN
            T1 = TIME - PTY
            T2 = TIME - PTY - DT1
          ENDIF
          X1=DERF((DIST-V*T1*DSQRT(1.D0+(4.D0*LAMDA*DX)/(V**2.D0)))
     1      /(2.D0*DSQRT(DX*T1)) )
          X2=DERF((DIST-V*T2*DSQRT(1.D0+(4.D0*LAMDA*DX)/(V**2.D0)))
     1      /(2.D0*DSQRT(DX*T2)) )
          CX = CO(I)*X3/2.D0*(X2-X1)
          C500 = C500 + CX
        ELSE IF(TCO(I).GE.(TIME-DT).AND.TCO(I).LT.TIME) THEN
          IF(TCO(I).GE.PTY) THEN
```

000604

```
          T1 = TIME - TCO(I)
        ELSE IF((TCO(I)+DT).GT.PTY) THEN
          T1 = TIME - PTY
        ENDIF
        X1=DERF((DIST-V*T1*DSQRT(1.D0+(4.D0*LAMDA*DX)/(V**2.D0)))
     1    /(2.D0*DSQRT(DX*T1)) )
        CX = CO(I)*X3/2*(1-X1)
        C500 = C500 + CX
      ELSE
        GO TO 200
      ENDIF
100   CONTINUE
200   T1 = TIME + AGE
      T2 = TIME
      X1=DERF((DIST-V*T1*DSQRT(1.D0+(4.D0*LAMDA*DX)/(V**2.D0)))
     1  /(2.D0*DSQRT(DX*T1)) )
      X2=DERF((DIST-V*T2*DSQRT(1.D0+(4.D0*LAMDA*DX)/(V**2.D0)))
     1  /(2.D0*DSQRT(DX*T2)) )
      CX = CAGE*X3/2.D0*(X2-X1)
      C500 = C500 + CX
      WRITE(11,2000) TIME,C500
      TIME = TIME + DT
      IF(TIME.LE.DT*50.) GO TO 300
      STOP
900   FORMAT(4X,7D9.3)
1000  FORMAT(4X,D9.3,D9.3)
2000  FORMAT(F11.3,2X,E12.4)
      END
C
      FUNCTION DERF(X)
C
      IMPLICIT REAL*8 (A-H, O-Z)
      DIMENSION A(5)
      DATA A/0.254829592D0,-0.284496736D0,1.421413741D0,-1.453152027D0,
     *1.061405429D0/,P/0.3275911D0/
      SP1=0.0D0
      IF(DABS(X).GT.5.0D0) GO TO 6
      IF(X) 2,4,2
 4    SP1=1.0D0
      GO TO 6
 2    SP=DABS(X)
      T=1.0D0/(1.0D0+P*SP)
      SP1=0.0D0
      DO 1 I=1,5
 1    SP1=SP1+A(I)*T**I
      SP1=SP1*DEXP(-SP**2.)
 6    DERF = 1.0D0-SP1
      IF(X.LT.0.0D0) DERF = -DERF
      RETURN
      END
```

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APPENDIX B

FORTRAN IMPLEMENTATION OF DOWNGRADIENT TRANSPORT

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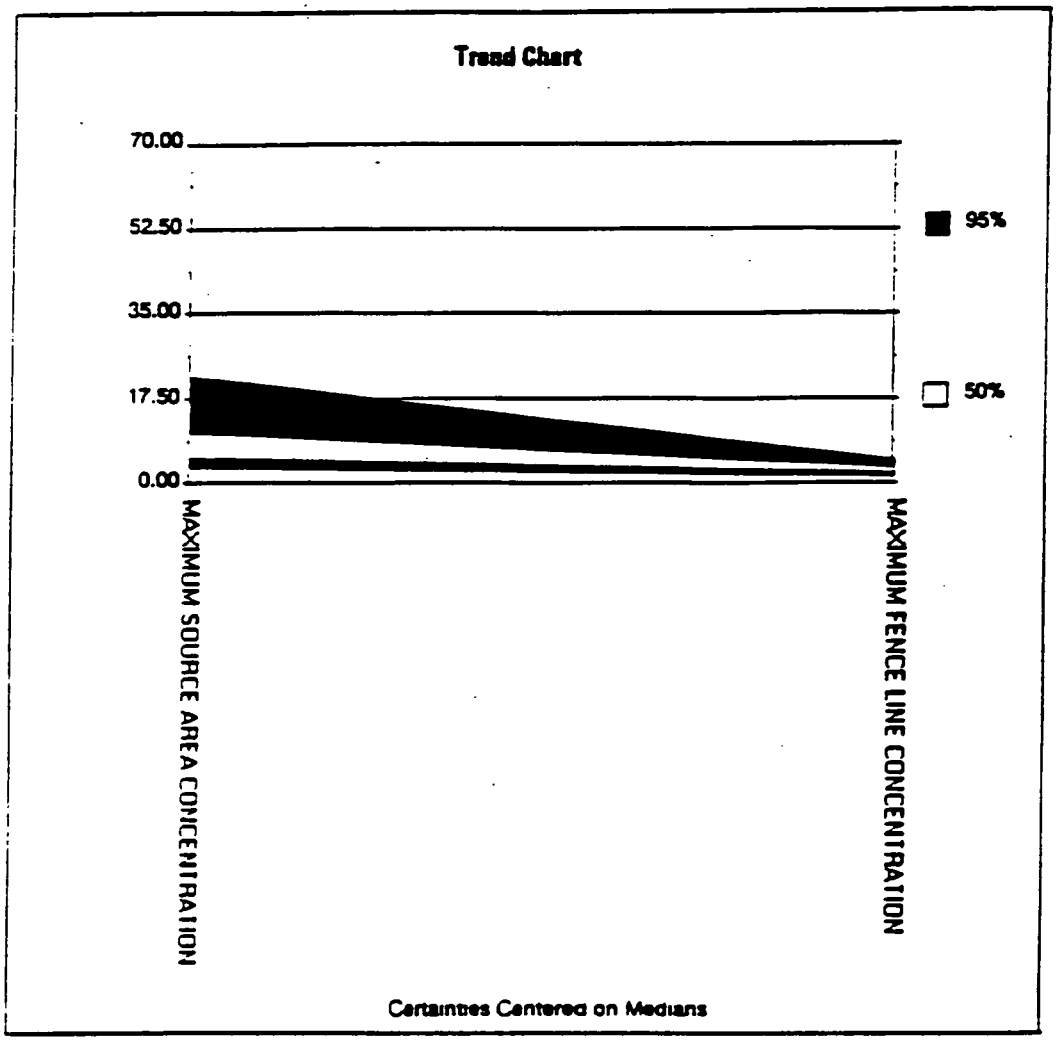
Crystal Ball Report
Simulation started on 8/6/93 at 16:46:48
Simulation stopped on 8/6/93 at 17:21:36



This trend chart displays the certainty ranges of the concentrations at the source area and fence line. The bands of certainty narrow down from the maximum source area concentration to the maximum fence line concentration. This indicates that the maximum source area concentration is higher than that of the maximum fence line concentration and the standard deviation of the source area concentration is greater than that of the fence line concentration.

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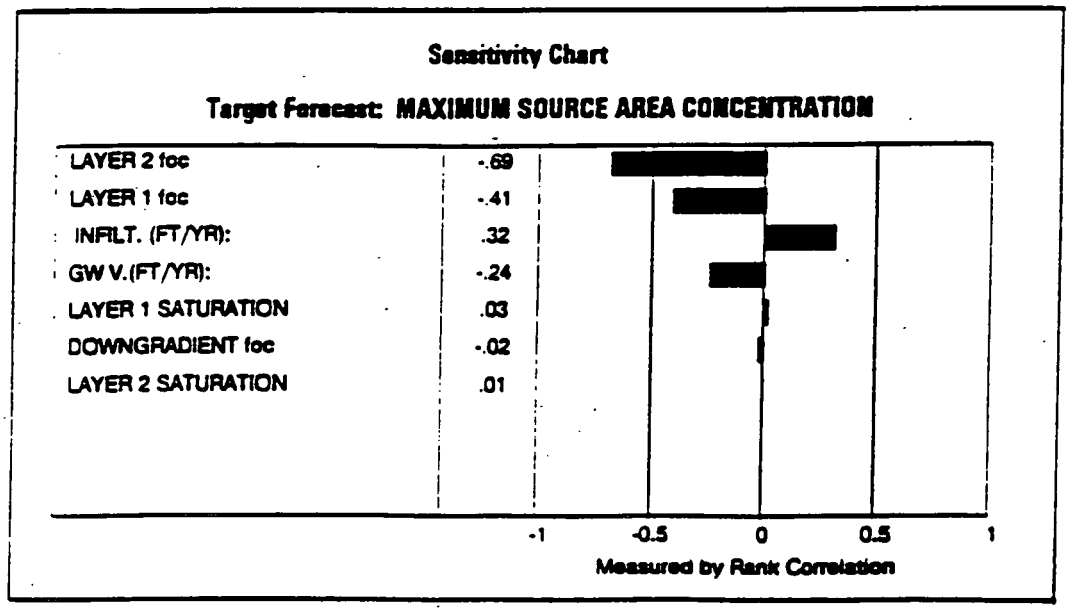
Report6



The sensitivity chart shows which variables are the most important or least important ones in the model. In this example, there are seven variables listed in the sensitivity chart. The first variable, Layer 2 foc, has the highest sensitivity ranking and can be considered the most important variable in the model. Therefore, the value of Layer 2 foc should be carefully selected in order to compute the correct maximum source area concentration. Since the rank correlation between Layer 2 foc and maximum source area concentration is negative, it indicates that the increase of the value of foc will make the maximum source area concentration smaller. The last variable, Layer 2 saturation, has the lowest sensitivity ranking and is the least important variable in the model. The effect of this variable on the maximum source area concentration is not as great as the other variables.

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. Report6

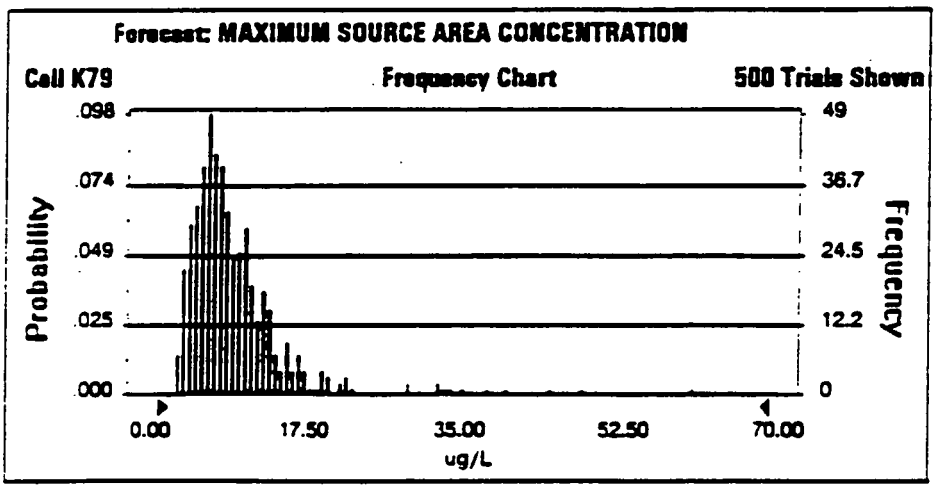
5004

Forecast: MAXIMUM SOURCE AREA CONCENTRATION **Cell: K79**

Summary:

Display Range is from 0.00 to 70.00 ug/L
Entire Range is from 2.24 to 61.39 ug/L
After 500 Trials, the Std. Error of the Mean is 0.28

Statistics:	Value
Trials	500
Mean	9.00
Median (approx.)	7.43
Mode (approx.)	6.09
Standard Deviation	6.20
Variance	38.46
Skewness	3.51
Kurtosis	21.81
Coeff. of Variability	0.69
Range Minimum	2.24
Range Maximum	61.39
Range Width	59.15
Mean Std. Error	0.28



This figure shows the frequency distribution of the maximum source area concentration. In 500 trials, the minimum value of the maximum source area concentration is 2.24 ug/l and the maximum value of it is 61.39 ug/l. The most frequently simulated value of the maximum source area concentration is about 6.09 ug/l, which appears 49 times in 500 trials.

Report6

Forecast: MAXIMUM SOURCE AREA CONCENTRATION (cont'd) **Cell: K79**

Percentiles:

Percentile	ug/L (approx.)
0%	2.24
10%	4.05
25%	5.46
50%	7.43
75%	10.58
90%	14.76
100%	61.39

End of Forecast

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Report6

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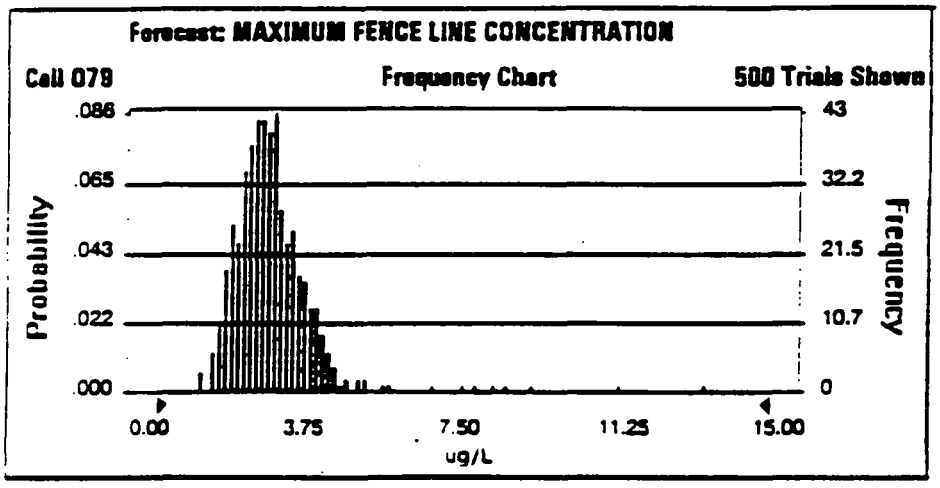
Forecast: MAXIMUM FENCE LINE CONCENTRATION **Cell: O79**

Summary:

Display Range is from 0.00 to 15.00 ug/L
Entire Range is from 1.16 to 13.48 ug/L
After 500 Trials, the Std. Error of the Mean is 0.05

Statistics:	Value
Trials	500
Mean	2.89
Median (approx.)	2.72
Mode (approx.)	2.94
Standard Deviation	1.13
Variance	1.27
Skewness	3.82
Kurtosis	28.78
Coeff. of Variability	0.39
Range Minimum	1.16
Range Maximum	13.48
Range Width	12.33
Mean Std. Error	0.05



This figure shows the frequency distribution of the maximum fence line concentration. In 500 trials, the minimum value of the maximum fence line concentration is 1.16 ug/l and the maximum value of it is 13.48 ug/l. The most frequently simulated value of the maximum fence line concentration is about 2.94 ug/l, which appears 43 times in 500 trials.

Report6

Forecast: MAXIMUM FENCE LINE CONCENTRATION (cont'd) **Cell: O79**

Percentiles:

Percentile	ug/L (approx.)
0%	1.16
10%	1.88
25%	2.26
50%	2.72
75%	3.28
90%	3.87
100%	13.48

End of Forecast

000612

Report6

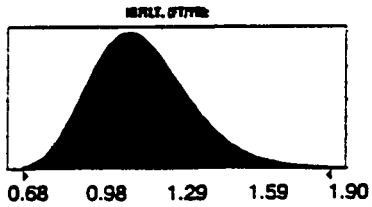
Assumptions

Assumption: INFILT. (FT/YR): **Cell: C20**

Lognormal distribution with parameters:

Mean	1.15
Standard Dev.	0.20

Selected range is from 0.00 to +Infinity
Mean value in simulation was 1.16

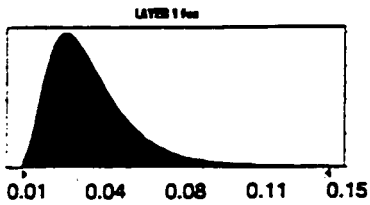


Assumption: LAYER 1 foc **Cell: F15**

Lognormal distribution with parameters:

Mean	0.04
Standard Dev.	0.02

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.04

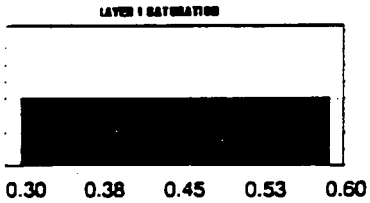


Assumption: LAYER 1 SATURATION **Cell: F17**

Uniform distribution with parameters:

Minimum	0.30
Maximum	0.60

Mean value in simulation was 0.45

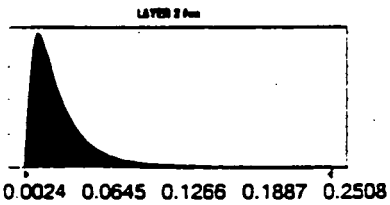


Assumption: LAYER 2 foc **Cell: I15**

Lognormal distribution with parameters:

Mean	0.0329
Standard Dev.	0.0300

Selected range is from 0.0000 to +Infinity
Mean value in simulation was 0.0311



000613

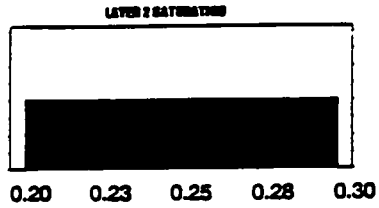
Report6

Assumption: LAYER 2 SATURATION **Cell: I17**

Uniform distribution with parameters:

Minimum	0.20
Maximum	0.30

Mean value in simulation was 0.25

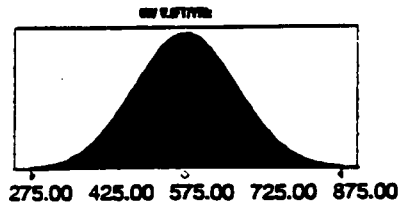


Assumption: GW V.(FT/YR): **Cell: L16**

Normal distribution with parameters:

Mean	575.00
Standard Dev.	100.00

Selected range is from -Infinity to +Infinity
Mean value in simulation was 573.75

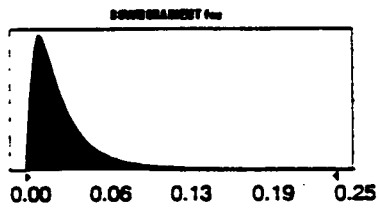


Assumption: DOWNGRADIENT foc **Cell: P15**

Lognormal distribution with parameters:

Mean	0.03
Standard Dev.	0.03

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.03



End of Assumptions

000614

5504

APPENDIX A.2

MONTE CARLO SIMULATION REPORT
30 YEARS PUMPING

000615

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BROWN & ROOT ENVIRONMENTAL

SCREENING-LEVEL EXCEL-CRYSTAL BALL TRANSPORT (ECTrans) MODEL

5504

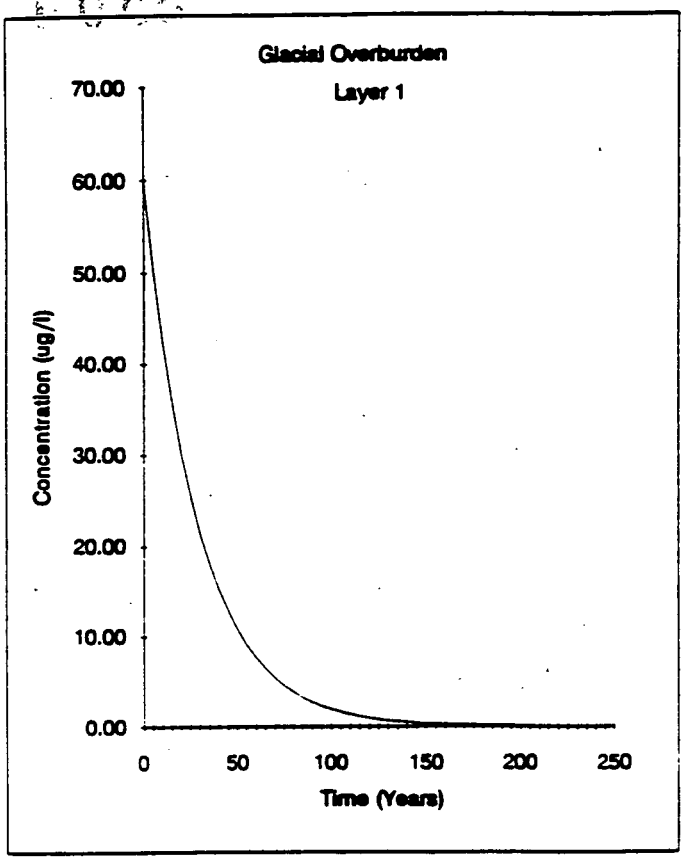
TE:	HYPOTHETICAL, FEMP, FERNALD, OH
	AGE = 10 YRS; SOURCE REMOVED
	RESIDUAL CONTAMINATION IN LAYER 1 & 2
	PUMPING = 30 YRS
INVESTIGATOR:	CAR
DATE:	8/7/93

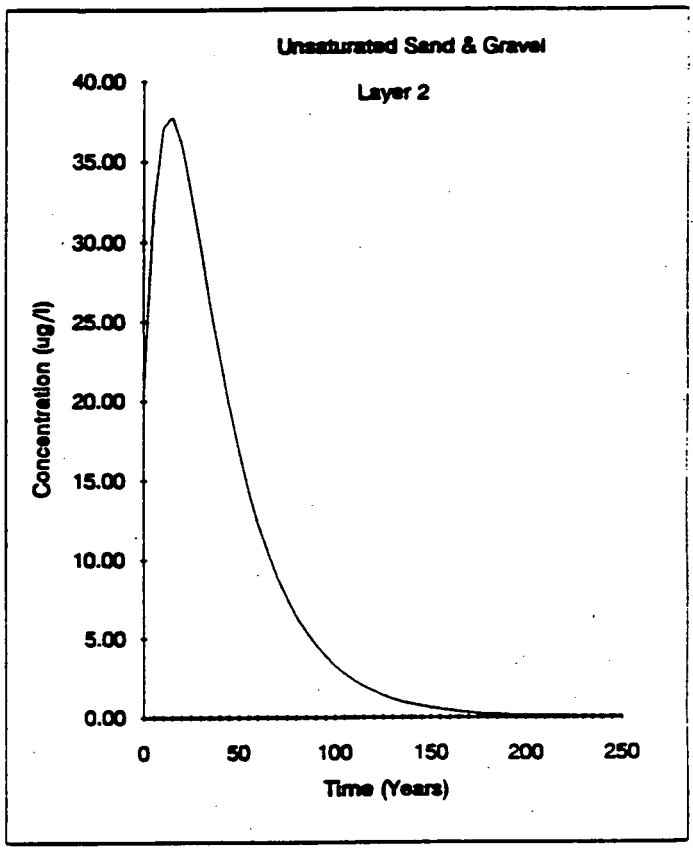
CONTAMINANT:		CHEMICAL X	
KOC (L/KG):	45.00	WATER CRITERIA (UG/L):	3.00E+00
HALF LIFE (YRS):		CONSTANT SOURCE LEACHATE (UG/L):	0.00E+00
LAYER 1:	4.47E+09	INITIAL LAYER 1 SOIL CONC. (MG/KG):	1.08E-01
LAYER 2:	4.47E+09	INITIAL LAYER 2 SOIL CONC. (MG/KG):	3.03E-02
GMA:	4.47E+09		

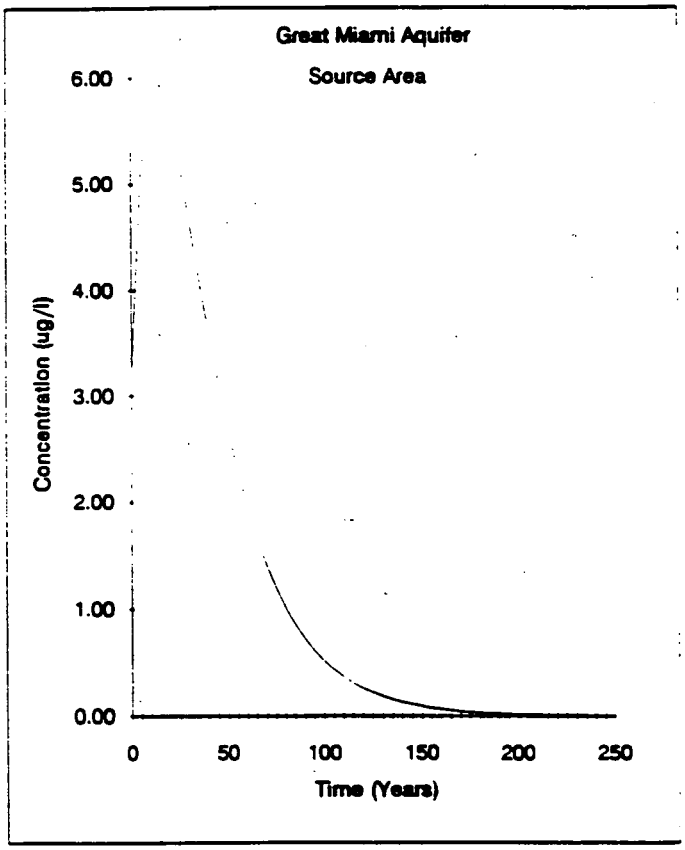
UNSAT. SOURCE	AREA:	LAYER 1 (GLACIAL OVERBURDEN)		LAYER 2 (SAND & GRAVEL)		GREAT MIAMI AQUIFER (SAT. S. & G.)			
						B (FT):	67	Vzo (FT/YR)	11.5445
LENGTH (FT):	250	FOC (KG/KG):	0.04	FOC (KG/KG):	0.0329	GW Q3 (L/DAY)	3.26E+04	FOC (KG/KG)	0.0329
WIDTH (FT):	230	Kd (L/KG):	1.8	Kd (L/KG)	1.481	GW V.(FT/YR):	575.00	Kd (L/KG)	1.4805
		SATURATION:	0.45	SATURATION	0.25	H (FT):	12.7100	RETARDATION	11.5412
POROSITY:	0.34	THICKNESS (FT):	10.00	THICKNESS (FT)	5.00	EFF. POROSITY	0.25	q (FT/YR)	0
DENSITY (G/CM3):	1.78	DECAY (1/DAY):	4.25E-13	DECAY (1/DAY)	4.25E-13	DISPERSIVITY:		DECAY (1/YR)	1.6E-10
INFILT. (FT/YR):	1.15	CAo (UG/L):	6.01E+01	CBo (PPB)	2.05E+01	Az(FT):	0.12	CU3 (PPB):	0
		CU1 (PPB):	0	CU2 (PPB):	0.00E+00	Ax (FT):	100.00	P&T(YEARS)	30
AGE (YEARS)	10	Q1 (L/DAY):	5.13E+03	Q2 (L/DAY)	0.00E+00	Ay (FT):	33.33	DISTANCE TO F.L.(FT)	275

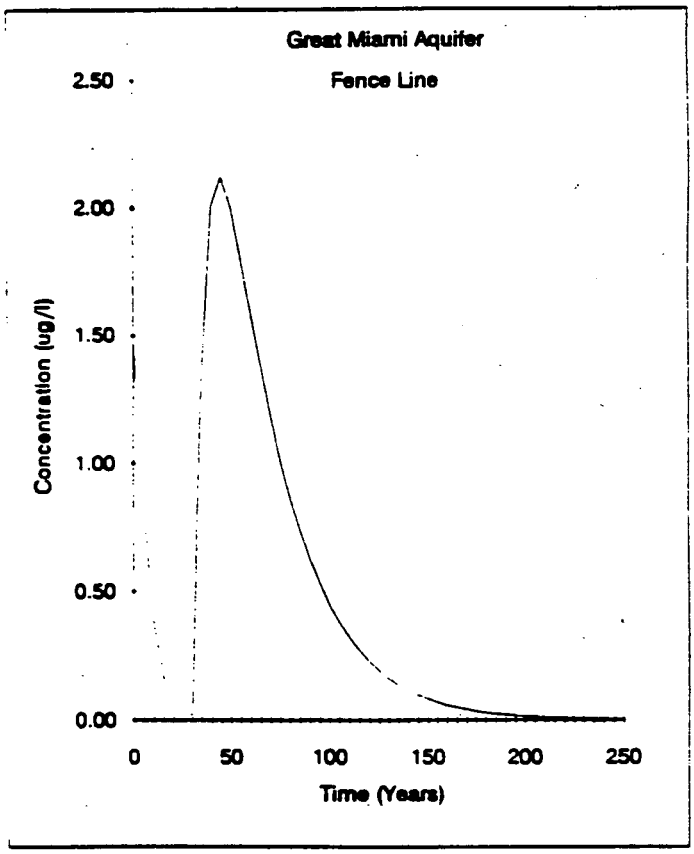
TIME INTERVAL (YRS) 5		LAYER 1 LEACHATE CONC.	LAYER 2 LEACHATE CONC.	SOURCE AREA CONC.	FENCE LINE CONC.
ELAPSED TIME - YRS	DAYS	(UG/L)	(UG/L)	(UG/L)	(UG/L)
0	0	60.06	20.49	3.22	1.48
5	1825	50.60	32.34	5.09	0.85
10	3650	42.63	37.13	5.84	0.36
15	5475	35.91	37.75	5.94	0.17
20	7300	30.26	36.05	5.67	0.08
25	9125	25.49	33.15	5.22	0.04
30	10950	21.48	29.75	4.68	0.02
35	12775	18.09	26.25	4.13	1.29
40	14600	15.25	22.90	3.60	2.00
45	16425	12.84	19.80	3.12	2.12
50	18250	10.82	17.02	2.68	2.01
55	20075	9.12	14.56	2.29	1.81
60	21900	7.68	12.41	1.95	1.60
65	23725	6.47	10.55	1.66	1.39
70	25550	5.45	8.95	1.41	1.19
75	27375	4.59	7.58	1.19	1.02
80	29200	3.87	6.41	1.01	0.87
85	31025	3.26	5.42	0.85	0.74
90	32850	2.75	4.58	0.72	0.63
95	34675	2.31	3.86	0.61	0.53
100	36500	1.95	3.26	0.51	0.45
105	38325	1.64	2.75	0.43	0.38
110	40150	1.38	2.32	0.36	0.32
115	41975	1.17	1.96	0.31	0.27
120	43800	0.98	1.65	0.26	0.23
125	45625	0.83	1.39	0.22	0.19
130	47450	0.70	1.17	0.18	0.16
135	49275	0.59	0.99	0.16	0.14
140	51100	0.49	0.83	0.13	0.11
145	52925	0.42	0.70	0.11	0.10
150	54750	0.35	0.59	0.09	0.08
155	56575	0.30	0.50	0.08	0.07
160	58400	0.25	0.42	0.07	0.06
165	60225	0.21	0.35	0.06	0.05
170	62050	0.18	0.30	0.05	0.04
175	63875	0.15	0.25	0.04	0.03
180	65700	0.13	0.21	0.03	0.03
185	67525	0.11	0.18	0.03	0.02
190	69350	0.09	0.15	0.02	0.02
195	71175	0.08	0.13	0.02	0.02
200	73000	0.06	0.11	0.02	0.01
205	74825	0.05	0.09	0.01	0.01
210	76650	0.04	0.08	0.01	0.01
215	78475	0.04	0.06	0.01	0.01
220	80300	0.03	0.05	0.01	0.01
225	82125	0.03	0.05	0.01	0.01
230	83950	0.02	0.04	0.01	0.01
235	85775	0.02	0.03	0.01	0.00
240	87600	0.02	0.03	0.00	0.00
245	89425	0.01	0.02	0.00	0.00
250	91250	0.01	0.02	0.00	0.00
MAXIMUM		60.06	37.75	5.94	2.12

000616


Glacial Overburden
Layer 1
Concentration (ug/l)
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
0
50
100
150
200
250
Time (Years)


Unsaturated Sand & Gravel
Layer 2
Concentration (ug/l)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
0
50
100
150
200
250
Time (Years)


Great Miami Aquifer
Source Area
Concentration (ug/l)
6.00
5.00
4.00
3.00
2.00
1.00
0.00
0
50
100
150
200
250
Time (Years)

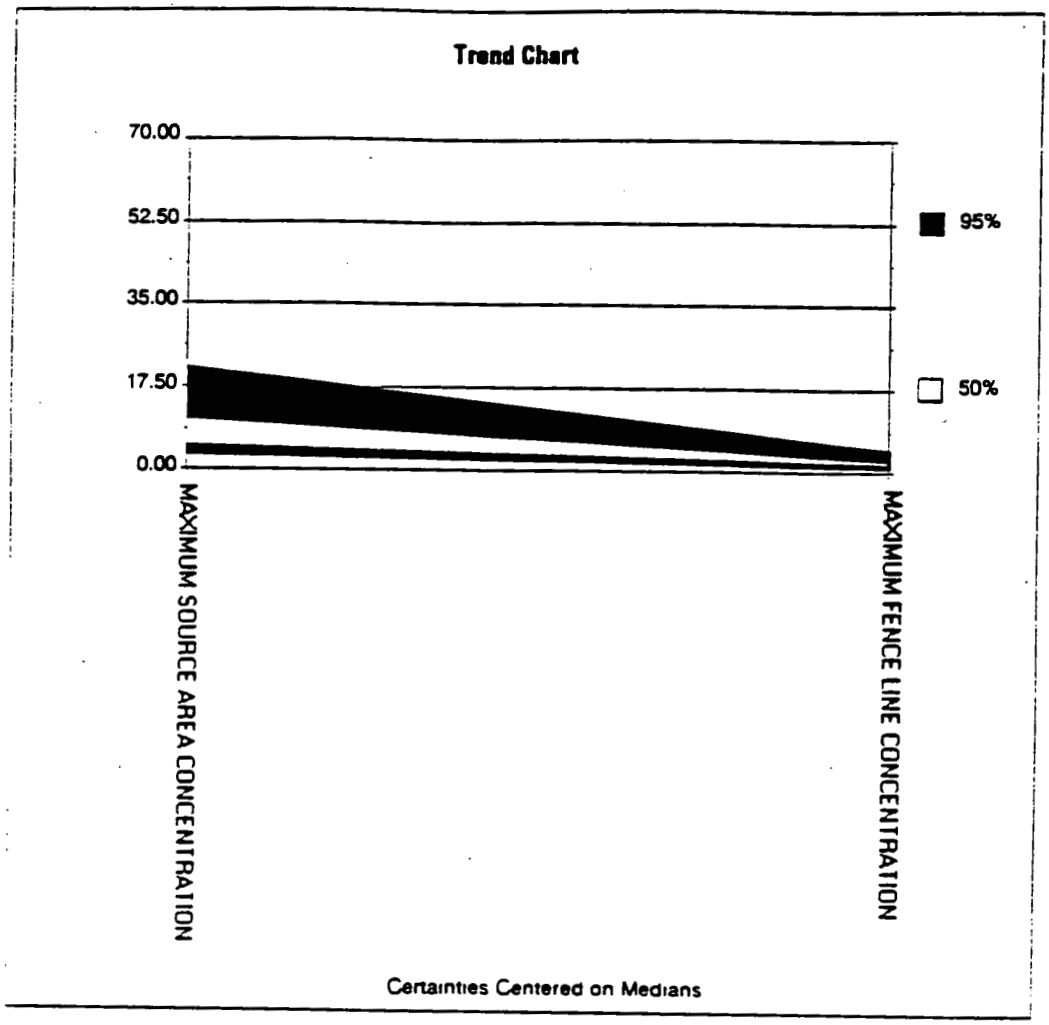

Great Miami Aquifer
Fence Line
Concentration (ug/l)
2.50
2.00
1.50
1.00
0.50
0.00
0
50
100
150
200
250
Time (Years)

000617

Report1

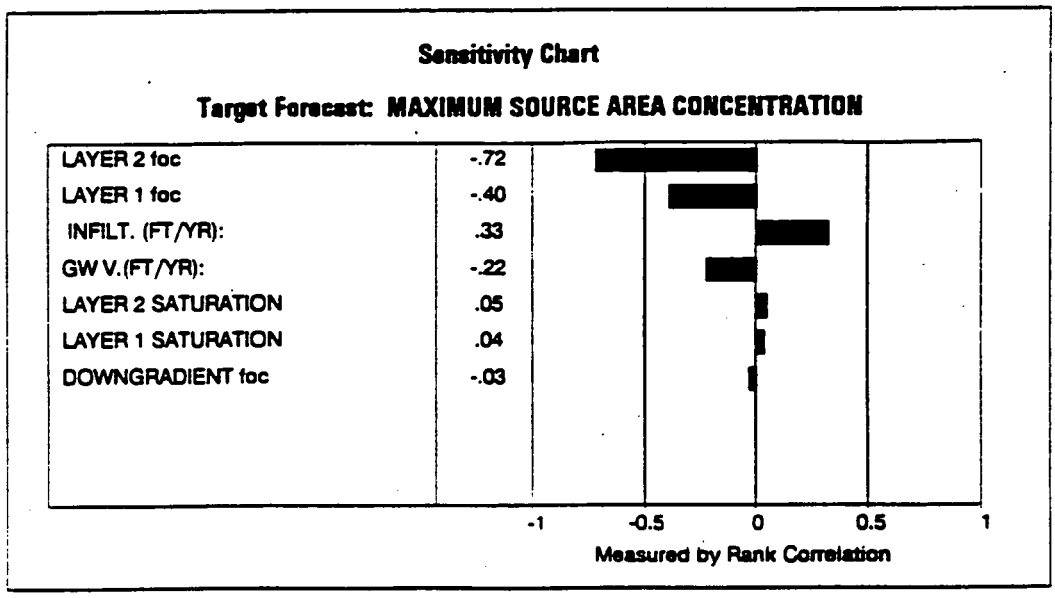
5504

Crystal Ball Report
Simulation started on 8/7/93 at 8:10:26
Simulation stopped on 8/7/93 at 8:30:00



000618

Report1



000619

Report1

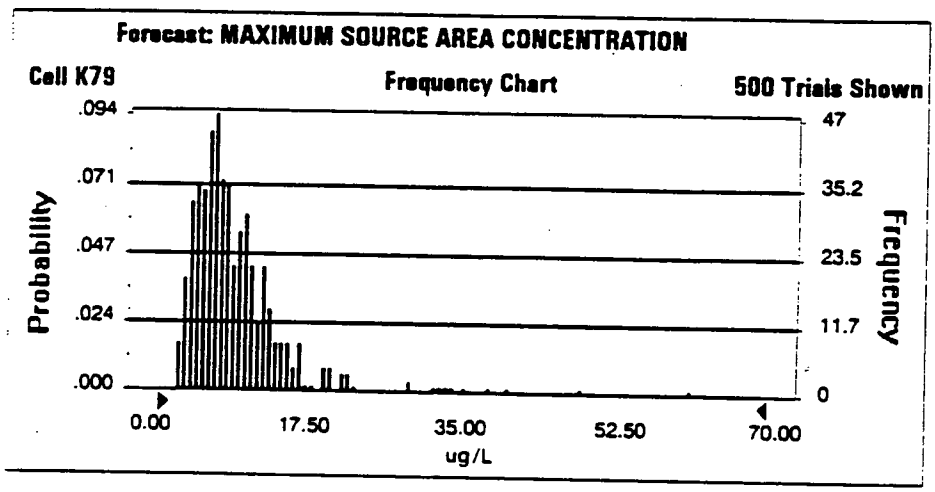
5504

Forecast: MAXIMUM SOURCE AREA CONCENTRATION **Cell: K79**

Summary:

Display Range is from 0.00 to 70.00 ug/L
Entire Range is from 2.17 to 61.39 ug/L
After 500 Trials, the Std. Error of the Mean is 0.27

Statistics:	Value
Trials	500
Mean	9.02
Median (approx.)	7.58
Mode (approx.)	6.02
Standard Deviation	5.99
Variance	35.83
Skewness	3.45
Kurtosis	22.31
Coeff. of Variability	0.66
Range Minimum	2.17
Range Maximum	61.39
Range Width	59.22
Mean Std. Error	0.27



000620

Report1

Forecast: MAXIMUM SOURCE AREA CONCENTRATION (cont'd) **Cell: K79**

Percentiles:

Percentile	ug/L (approx.)
0%	2.17
10%	4.09
25%	5.49
50%	7.58
75%	10.69
90%	14.34
100%	61.39

End of Forecast

Report1

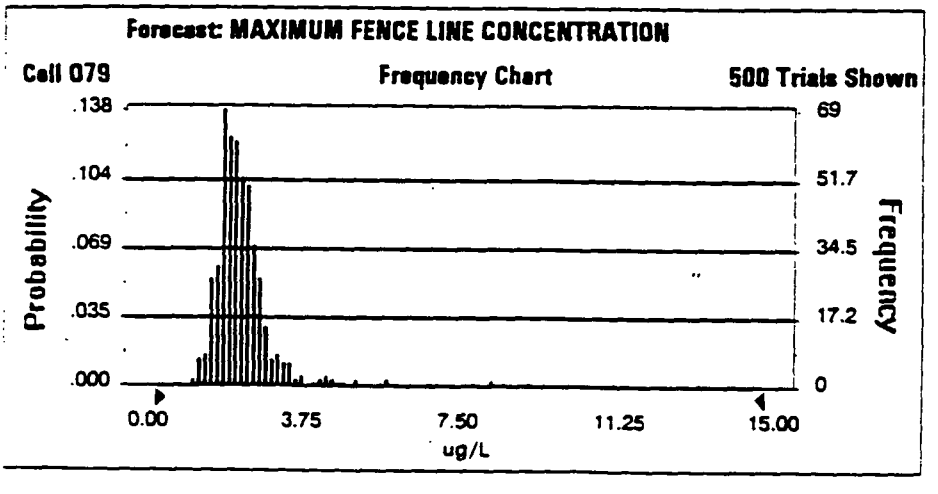
5504

Forecast: MAXIMUM FENCE LINE CONCENTRATION **Cell: O79**

Summary:

Display Range is from 0.00 to 15.00 ug/L
Entire Range is from 1.02 to 13.48 ug/L
After 500 Trials, the Std. Error of the Mean is 0.05

Statistics:	Value
Trials	500
Mean	2.28
Median (approx.)	2.06
Mode (approx.)	1.70
Standard Deviation	1.14
Variance	1.29
Skewness	5.01
Kurtosis	37.68
Coeff. of Variability	0.50
Range Minimum	1.02
Range Maximum	13.48
Range Width	12.47
Mean Std. Error	0.05



Report1

Forecast: MAXIMUM FENCE LINE CONCENTRATION (cont'd) **Cell: O79**

Percentiles:

Percentile	ug/L (approx.)
0%	1.02
10%	1.56
25%	1.75
50%	2.06
75%	2.42
90%	2.93
100%	13.48

End of Forecast

000623

Report1

5504

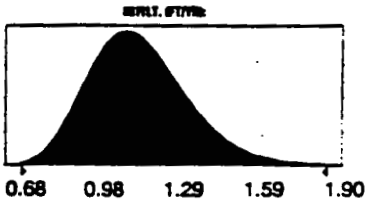
Assumptions

Assumption: INFILT. (FT/YR): **Cell: C20**

Lognormal distribution with parameters:

Mean	1.15
Standard Dev.	0.20

Selected range is from 0.00 to +Infinity
Mean value in simulation was 1.16

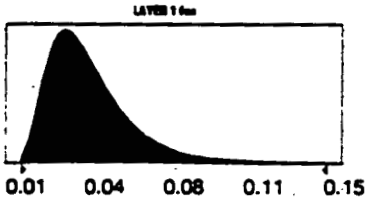


Assumption: LAYER 1 foc **Cell: F15**

Lognormal distribution with parameters:

Mean	0.04
Standard Dev.	0.02

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.04

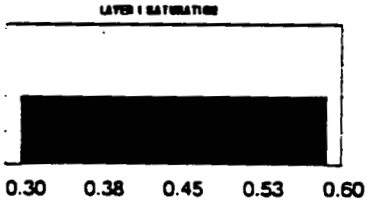


Assumption: LAYER 1 SATURATION **Cell: F17**

Uniform distribution with parameters:

Minimum	0.30
Maximum	0.60

Mean value in simulation was 0.45

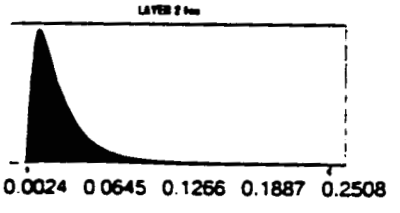


Assumption: LAYER 2 foc **Cell: I15**

Lognormal distribution with parameters:

Mean	0.0329
Standard Dev.	0.0300

Selected range is from 0.0000 to +Infinity
Mean value in simulation was 0.0312



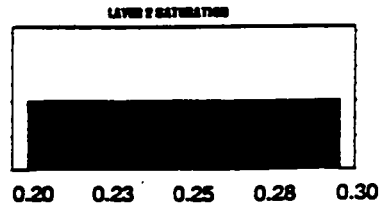
Report1

Assumption: LAYER 2 SATURATION **Cell: I17**

Uniform distribution with parameters:

Minimum	0.20
Maximum	0.30

Mean value in simulation was 0.25

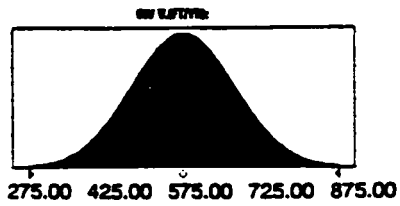


Assumption: GW V.(FT/YR): **Cell: L16**

Normal distribution with parameters:

Mean	575.00
Standard Dev.	100.00

Selected range is from -Infinity to +Infinity
Mean value in simulation was 570.89

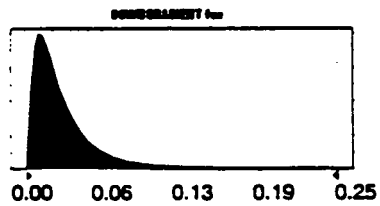


Assumption: DOWNGRADIENT foc **Cell: P15**

Lognormal distribution with parameters:

Mean	0.03
Standard Dev.	0.03

Selected range is from 0.00 to +Infinity
Mean value in simulation was 0.03



End of Assumptions

000625

5504

APPENDIX A.1

MONTE CARLO SIMULATION REPORT
20 YEARS PUMPING

000626

APPENDIX C.2

TYPICAL SENSITIVITY ANALYSES

(and its associated financial implications), determination of the final cleanup goal or ACL may involve lengthy negotiation between an industry and regulatory agencies.

The objective of this paper is to provide a systematic overview of the impact of these factors on cleanup goal and ACL development.

IMPORTANT FACTORS IN CLEANUP GOAL OR ACL DEVELOPMENT

The first step in soil cleanup goal and/or ACL development includes defining the source of contamination, the physical, chemical, and toxic characteristics of the contaminants, and the site physical features that affect contaminant fate and transport. Once this is completed, current and future impacts on the environment and human health may be estimated. The second step is to define the extent and degree of source reduction and/or containment required to attain acceptable concentrations (if necessary). This process includes consideration of many chemical processes and hydrogeologic conditions that affect the migration and attenuation of contaminants. In general, site-specific combinations of the following factors are considered during the cleanup goal or ACL development process:

- Source Loading
- Contaminant Characteristics
- Hydrogeological Conditions
- Points of Exposure/Exposure Routes

In addition, exposure assessment assumptions and the impacts of feasible corrective measures will also affect the cleanup goals or ACLs.

THE COMPUTER MODEL USED IN THE STUDY

A spreadsheet-based multimedia contaminant fate and transport model developed to support screening-level risk assessment and cleanup goal/ACL development was used to complete the sensitivity analysis (Chiou and Hubbard, 1992). The model includes various components for simulating contaminant washout from a source area, downgradient solute transport, and estimation of receptor concentrations under various types of exposure scenarios. The model was implemented using a spreadsheet to accommodate linking of the various simulation modules and to simplify the model input, interactive execution, and output presentation processes.

The contaminant source module of the model relies on analytical equations based on straightforward mass balances to describe various aspects of source loading and contaminant washout from both the unsaturated and saturated zones. Any combination of the following conditions or processes may be simulated:

- Surface infiltration and percolation
- Contaminant loading via leakage or infiltration
- Sorption in the unsaturated zone
- Upgradient groundwater flow

IMPORTANT FACTORS IN CLEANUP GOAL DEVELOPMENT FOR CONTAMINATED SOIL AND GROUNDWATER - SENSITIVITY ANALYSES BY MODEL SIMULATIONS

by

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R. J. Hubbard, Manager of Risk Assessment
A. E. Hubbard, Risk Assessment Specialist
HALLIBURTON NUS Environmental Corp., Pittsburgh, PA 15220

ABSTRACT

An overview of the numerical effects of variable input parameters, exposure assessment methods, and physical/chemical processes on cleanup goals and/or Alternate Concentration Limits (ACLs) for contaminated soil and groundwater is provided. The impact of uncertainties in key parameters and different conceptual models for contaminant attenuation assessment is studied using a spreadsheet-based multimedia contaminant fate and transport model. Important factors in six major categories are considered under hypothetical site conditions. A sensitivity analysis approach is used to demonstrate the individual and cumulative effects of various input parameters and conceptual approaches on cleanup goals or ACLs. Soil cleanup goals and groundwater ACLs range over six orders of magnitude for a hypothetical site.

KEY WORDS

Cleanup Goal, Alternate Concentration Limit, Contaminated Soil, Contaminated Groundwater, Spreadsheet-based Contaminant Fate and Transport Model, Sensitivity Analysis.

INTRODUCTION

Groundwater and soil cleanup goals for uncontrolled hazardous waste sites and ACLs for treatment, storage, and disposal facilities are usually determined based on relevant regulations and/or risk assessment methods coupled with analytical or numerical modeling techniques. When concentrations of hazardous constituents in groundwater exceed background or Maximum Contaminant Levels, Alternate Concentration Limits (ACLs) [40 CFR 264.93(a)] can be established at the point of compliance [40 CFR 264.94(b)] if they are protective of human health and the environment. Because of the complexity involved, general guidelines for conceptualizing or quantifying most of the important factors to be considered in the cleanup goal development process are seldom available. Therefore, cleanup goal or ACL development usually requires selection of a proposed value from a large range of possible values. This large range may be the result of uncertainties in the specific values of input parameters, different conceptual models of the site (e.g., migration pathways and exposure routes), or as a result of decisions to include or neglect certain physical or chemical attenuation processes. Because of this large range

- Contaminant loading via upgradient flow
- Sorption in the saturated zone
- Zone-specific contaminant decay rates
- Zone-specific initial contaminant concentrations
- Constant or time-varying concentration in the unsaturated zone

The downgradient solute transport module of the model uses a simplified version of a general solution to a three-dimensional advection/dispersion/sorption/decay equation and the superposition technique to simulate solute transport (Domenico, 1987). The transport module calculates the contaminant concentration at a receptor location or discharge area downgradient of the source area under different source-loading conditions. Downgradient contamination caused by the source (or other sources) prior to remediation can also be considered.

The discharge/exposure module of the model uses analytical methods to estimate contaminant concentrations under four different types of exposure scenarios, including direct use of groundwater or various surface water uses based on groundwater discharge into a flowing stream, a closed lake/pond, or a tidally-affected estuary. This module can be used to estimate the dilution caused by mixing of contaminated groundwater with surface water and can account for various surface water attenuation mechanisms. Based on the requirements of the risk assessment, the model output provides the maximum or lifetime average (70-year) contaminant concentrations at the exposure point.

The simplicity of the model and the wide range of conditions that can be simulated make it suitable for testing different conceptual approaches as well as for performing a sensitivity analysis using variable input parameters.

SCENARIOS AND ASSUMPTIONS FOR A HYPOTHETICAL INDUSTRIAL SITE

As shown in Figures 1 and 2, a hypothetical (but typical) site with a drum disposal area was used as the basis for the modeling and sensitivity analyses. The source area consists of an unknown number of leaking buried drums which contain an organic chemical (X). The source has been defined as a 60 by 60 foot area at the center of the industrial facility. The groundwater table is 15 feet deep and the top of underlying impermeable bedrock is 50 feet from the ground surface. A stream is located 300 feet east of the property line. Local groundwater flows toward (and discharges into) the stream. As a result of high concentrations of chemical X in soil samples taken from both the unsaturated and saturated zones, source control measures are determined to be necessary. The proposed action includes removal of the buried drums, in-situ treatment of soil in the unsaturated zone, and pumping and treatment of contaminated groundwater. To support analysis of corrective measures and closure plan preparation, an unsaturated zone cleanup goal and a groundwater ACL are to be developed.

As required by 40 CFR 264.94(b), the following information was compiled:

- Potential adverse effects on groundwater quality, considering:
  a. The proximity and withdrawal rates of groundwater users

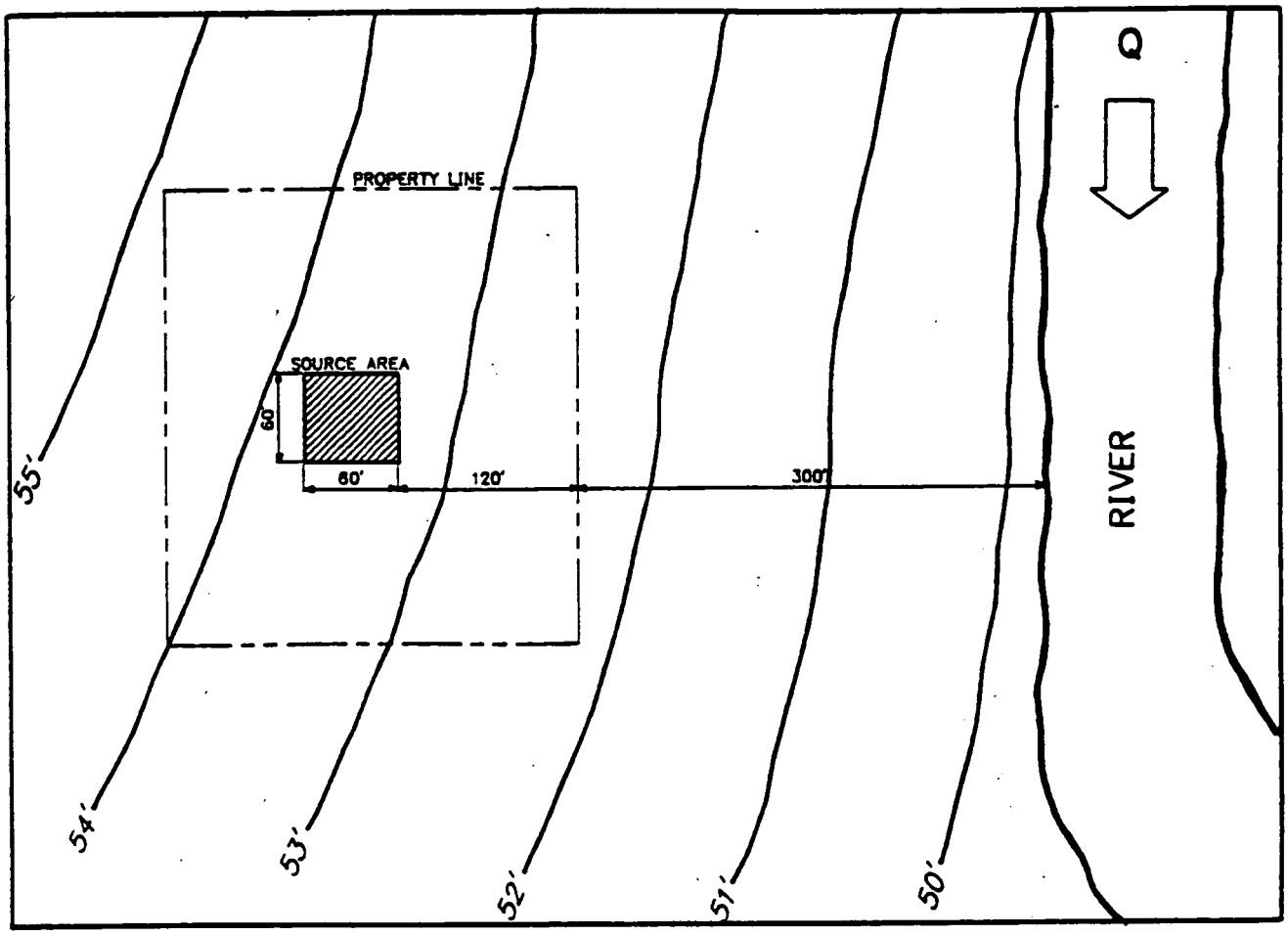

FIGURE 1 - SITE MAP AND GROUNDWATER CONTOURS

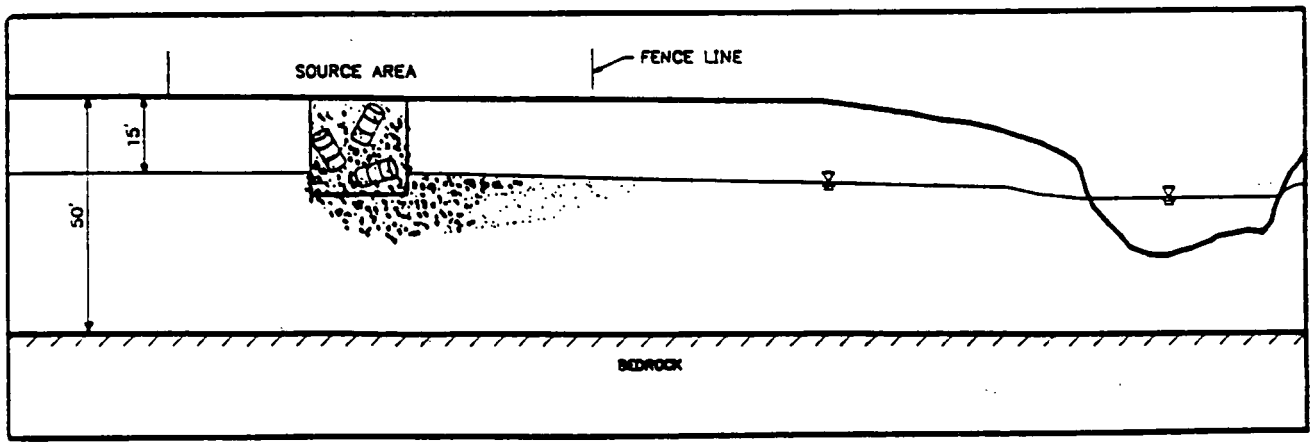

FIGURE 2 - REPRESENTATIVE CROSS-SECTION OF THE SITE

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b. The current and future uses of groundwater in the area
c. The existing quality of groundwater, including other sources of contamination and their cumulative impact on the groundwater quality

- Potential adverse effects on the quality of hydraulically connected surface water bodies, considering:
  a. The patterns of rainfall in the region
  b. The proximity of the regulated unit to surface waters
  c. The current and future uses of surface waters in the area and any water quality standards
  d. The existing quality of surface water, including other sources of contamination and the cumulative impacts on surface water quality
- General considerations common to groundwater and surface water environment:
  a. The volume and physical and chemical characteristics of the waste in the regulated unit
  b. The hydrogeological characteristics of the facility and surrounding land
  c. The quantity and quality of groundwater, and the direction of groundwater flow
  d. The potential for health risks caused by human exposure to waste constituents
  e. The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to waste constituents
  f. The persistence and permanence of potential adverse effects

The soil cleanup goal and groundwater ACL are to be developed based on the preceding information. Although the ACL demonstration must justify all claims regarding the potential effects of groundwater/surface water contamination on human health and environment, detailed guidelines for establishing the soil cleanup goal and the ACL are not available. A decision was made to examine the range of possible cleanup goals and ACLs for various conceptual approaches to the problem using a computer model to simulate the different scenarios. To achieve this, the requisite information was categorized in six distinct groups. Different conceptual models/approaches were then identified and simulated, as follows:

- **Group 1 : Source Loading**
  a. Constant source vs. limited source
  b. With and without additional source loading
  c. Historical source vs. recent/instantaneous source
  d. With and without an upgradient source
- **Group 2 : Contaminant Characteristics**
  a. With and without decay
  b. With and without adsorption
- **Group 3 : Hydrogeological Conditions**
  a. Limited mixing depth vs. entire saturated thickness
  b. With and without hydrodynamic dispersion
  c. With and without downgradient groundwater recharge
  d. With and without upgradient flow
- **Group 4 : Points of Exposure/Exposure Routes**
  a. Various distances to the point of exposure
  b. Unsaturated zone vs. saturated zone

c. Groundwater vs. surface water (discharge point)

- **Group 5 : Risk Assessment Assumptions**
  a. Lifetime average dose vs. maximum dose
  b. Various exposure scenarios
  c. Current vs. future land and water use
- **Group 6 : Impacts of Feasible Corrective Measures**
  a. With and without short-term containment
  b. With and without a surface cap
  c. Duration of remedial action

In addition to simulations for the preceding scenarios, the most conservative and reasonable cases developed through combinations of each set of controlling factors were also simulated and considered for final cleanup goal and ACL selection.

THE BASELINE SCENARIO

For the sensitivity analysis, a baseline scenario was first established to serve as a point of reference for the various approaches. The following conditions were assumed for the baseline scenario:

- **Group 1 :** After removal of the buried drums it was assumed that no additional loading occurs (limited residual contamination in the soil). The impact of upgradient sources and existing contamination in the downgradient area were neglected in the baseline scenario.
- **Group 2 :** The effect of adsorption of chemical X was considered. Chemical decay was not simulated because of the uncertainty in the decay rate of chemical X.
- **Group 3 :** The entire saturated thickness was used as the mixing depth for the contaminant and groundwater. Upgradient groundwater flow and both longitudinal and lateral dispersion were also considered. Dilution as a result of infiltration in the downgradient area was not simulated in the baseline scenario.
- **Group 4 :** The point of exposure was assumed to be a drinking water well along the stream. Therefore, no dilution by the stream was considered.
- **Group 5 :** Direct comparison between the maximum concentration at the exposure point with a risk-based criterion for chemical X was used to determine the acceptability of the cleanup goal.
- **Group 6 :** The baseline scenario did not include the possible impact of additional corrective measures (beyond drum removal) in the source area.

The conditions assumed for the baseline scenario are considered to be typical. Table I presents the printout from the spreadsheet model for the baseline scenario showing the model input parameters and simulated results. Figure 3 is a graphical presentation of the simulated contaminant concentrations at the source area and at the exposure point. With a maximum allowable exposure concentration of 5 µg/L, a cleanup goal of 126 µg/kg for the soil in the unsaturated zone of the source area was calculated using the model. The groundwater ACL was determined to be 43.5 µg/L using the downgradient edge of the source area as the Point of Compliance.

TABLE I - MODEL INPUTS AND OUTPUTS FOR THE BASELINE SCENARIO

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HALLIBURTON NUS ENVIRONMENTAL CORPORATION
SCREENING-LEVEL MULTIMEDIA CONTAMINANT FATE AND TRANSPORT MODEL
EXPOSURE SCENARIO #1: TIME VARYING SOURCE AND DIRECT USE OF GROUNDWATER

SITE: X CHEMICAL SOMEWHERE

INVESTGATOR: J. D. CHIOU
DATE: 7-5-92

CONTAMINANT: X
KOC (L/KG): 65.00
HALF LIFE (YRS):
UNSATURATED: .00
SATURATED: .00
D.G. PLUME: .00

ALLOWABLE EXPOSURE CONC. (UG/L): 5.0
UNSATURATED ZONE SOIL CLEAN UP GOAL (MG/KG): .126

SOURCE AREA:		UNSATURATED ZONE		SATURATED ZONE		DOWN GRADIENT AREA / EXPOSURE POINT			
LENGTH (FT):	60	FOC (KG/KG):	.002	FOC (KG/KG):	.0020	Q3 (L/DAY):	1826.06	FOC (KG/KG):	.002
WIDTH (FT):	60	KD (L/KG):	.13	KD (L/KG):	.130	GW V.(FT/YR):	37.36	KD (L/KG):	.13
		SATURATION:	.3	SATURATION:	1.00	DISTANCE (FT):	420.00	RETARDATION:	1.737
POROSITY:	.3	THICKNESS (FT):	15.00	THICKNESS (FT):	35.00	EFF. POROSITY:	.30		
DENSITY (G/CM3):	1.7	DECAY (1/DAY):	0	DECAY (1/DAY):	0	DECAY (1/YR):	0	ACCEPT THE GOAL!	
AGE (YEARS):	0	CWO (PPB):	9.65e2	CWAO (PPB):	0	DISPERSIVITY:			
INFILT. (FT/YR):	.5	C (PPB):	0	CU (PPB):	0	Ax (FT):	42.00		
GW VEL. (FT/YR):	34.5	Q1 (L/DAY):	139.66	Q2 (L/DAY):	1686.40	Ay (FT):	14.00		

TIME INTERVAL(YRS): ELAPSED TIME - YRS	2 DAYS	UNSATURATED ZONE CONC. (UG/L)	SATURATED ZONE CONC. (UG/L)	EXPOSURE POINT CONC. (UG/L)	70-YEAR AVERAGE (UG/L)
0	0	965.38	.00	.0000	
2	730	779.05	33.59	.0000	
4	1460	628.67	43.50	.0000	
6	2190	507.33	43.10	.0003	
8	2920	409.40	38.69	.0192	
10	3650	330.38	33.13	.1492	
12	4380	266.61	27.66	.5089	
14	5110	215.15	22.78	1.1280	
16	5840	173.62	18.60	1.9320	
18	6570	140.11	15.12	2.7920	
20	7300	113.06	12.25	3.5870	
22	8030	91.24	9.92	4.2310	
24	8760	73.63	8.01	4.6800	
26	9490	59.42	6.47	4.9280	
28	10220	47.95	5.23	4.9900	
30	10950	38.69	4.22	4.8970	
32	11680	31.22	3.41	4.6860	
34	12410	25.20	2.75	4.3920	
36	13140	20.33	2.22	4.0440	
38	13870	16.41	1.79	3.6700	
40	14600	13.24	1.44	3.2890	
42	15330	10.69	1.17	2.9170	
44	16060	8.62	.94	2.5630	
46	16790	6.96	.76	2.2340	
48	17520	5.62	.61	1.9330	
50	18250	4.53	.49	1.6630	
52	18980	3.66	.40	1.4230	
54	19710	2.95	.32	1.2110	
56	20440	2.38	.26	1.0270	
58	21170	1.92	.21	.8674	
60	21900	1.55	.17	.7300	
62	22630	1.25	.14	.6125	
64	23360	1.01	.11	.5124	
66	24090	.82	.09	.4276	
68	24820	.66	.07	.3561	
70	25550	.53	.06	.2958	2.0193
72	26280	.43	.05	.2453	2.0262
74	27010	.35	.04	.2030	2.0318
76	27740	.28	.03	.1678	2.0365
78	28470	.23	.02	.1385	2.0403
80	29200	.18	.02	.1141	2.0429
82	29930	.15	.02	.0939	2.0414
84	30660	.12	.01	.0772	2.0294
86	31390	.10	.01	.0634	1.9998
88	32120	.08	.01	.0520	1.9476
90	32850	.06	.01	.0426	1.8712
92	33580	.05	.01	.0349	1.7726
94	34310	.04	.00	.0285	1.6558
96	35040	.03	.00	.0233	1.5265
98	35770	.03	.00	.0191	1.3901
100	36500	.02	.00	.0156	1.2519
MAXIMUM:		965.38	43.50	4.990	2.0429

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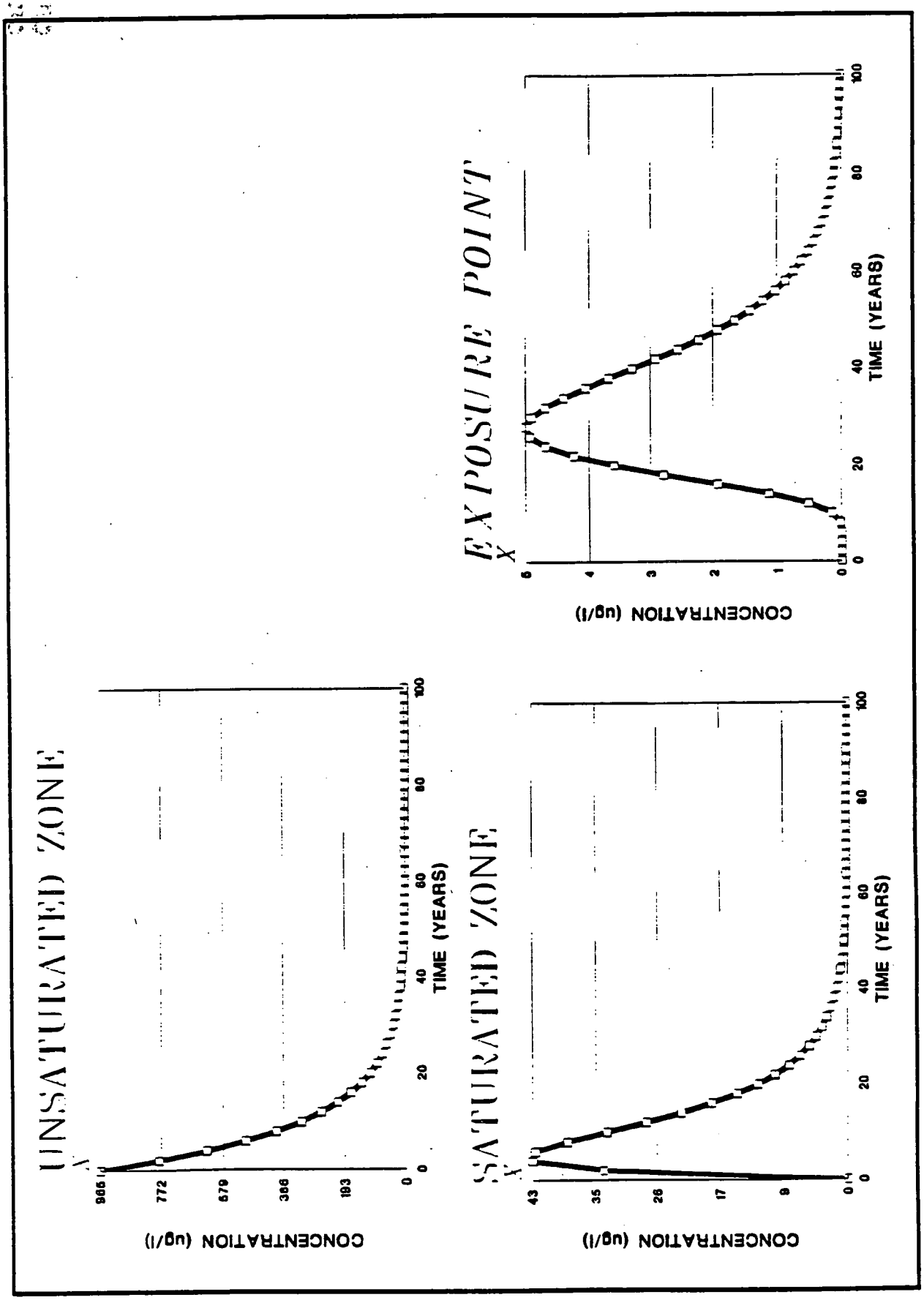

FIGURE 3 - SIMULATED CONTAMINANT CONCENTRATIONS VS. TIME FOR THE BASELINE SCENARIO

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SENSITIVITY ANALYSIS AND IMPLICATIONS

After the baseline condition was established, the sensitivity of the cleanup goal and ACL to the different controlling factors was investigated. Table II shows the soil cleanup

TABLE II - RANGE OF THE SOIL CLEANUP GOALS BY CHANGING ONE CONTROLLING FACTOR

CONTROLLING FACTOR GROUP	CASE	DEVIATIONS FROM THE BASELINE SCENARIO	SOIL CLEANUP GOAL (ug/kg)	% CHANGE
	BASELINE	NONE	126	0
GROUP 1	1-1	AS A CONSTANT SOURCE	39	-69
	1-2	WITH ADDITIONAL LOADING	123	-2
	1-3	AS A HISTORICAL SOURCE	35	-72
	1-4	WITH UPGRADIENT SOURCE	109	-13
GROUP 2	2-1	WITH DECAY	2037	1,517
	2-2	NO ADSORPTION	10	-92
GROUP 3	3-1	LIMITED MIXING DEPTH	65	-48
	3-2	NO DISPERSION	14	-89
	3-3	WITH DOWNGRADIENT RECHARGE	262	108
	3-4	NO UPGRADIENT FLOW	90	-29
GROUP 4	4-1	PROPERTY LINE AS THE POE	25	-80
	4-2	USE SOIL CRITERIA	230000	182,440
	4-3	SURFACE WATER EXPOSURE	6288	4,890
GROUP 5	5-1	LIFE-TIME AVERAGE	307	144
	5-2	FISH CONSUMPTION	2500	1,884
	5-3	CONSIDER FUTURE WATER USE	66	-48
GROUP 6	6-1	WITH SHORT-TERM CONTAINMENT	280	122
	6-2	SURFACE CAP	1960	1,456
	6-3	DURATION OF THE CLEANUP	92	-27

goals for different scenarios created by changing only one controlling factor from the baseline condition. The following assumptions were made for the sensitivity analysis:

- Case 1-1 : To simulate a continuous leak, the unsaturated zone concentration in the source area was set as a constant (i.e., the cleanup goal).
- Case 1-2 : To consider possible additional spills in the facility, the contaminant concentration of the surface infiltration into the source area was set at 5 µg/L.
- Case 1-3 : The source was assumed to have been releasing contamination at a constant rate and concentration for the past 10 years (resulting in a 35 µg/L concentration in the saturated zone beneath the source).
- Case 1-4 : To include the possible upgradient contaminant source, the concentration of the upgradient groundwater was set at 5 µg/L.
- Case 2-1 : The half life of chemical X in the contaminant (biodegradation or other chemical reactions), was set at 5 years.
- Case 2-2 : To reduce the effect of adsorption, the fractional organic carbon content of the saturated and unsaturated zones were set at 0.0001 (20 times lower than the baseline condition).

- Case 3-1 : The saturated thickness available for contaminant migration was set at 17.5 feet (the top half of the saturated zone).
- Case 3-2 : The longitudinal and lateral dispersivity were set at 0.001 and 0.0003, respectively.
- Case 3-3 : Dilution by surface infiltration in the downgradient area was simulated by adjusting the decay rate in the transport simulation.
- Case 3-4 : The upgradient groundwater flow was set at 0.
- Case 4-1 : The point of exposure was moved to the property line.
- Case 4-2 : Assuming local groundwater was not a drinking water source, allowable soil concentration based on human exposure during construction and maintenance activities (dermal contact and inhalation of dust) was used as the cleanup criterion directly.
- Case 4-3 : Surface water in the stream (which was assumed to have a dilution factor of 50) was used as the exposure media (i.e., source of drinking water).
- Case 5-1 : Lifetime (70 years) averaged contaminant concentrations at the point of exposure were compared to the water quality criteria.
- Case 5-2 : Water criteria based on bioaccumulation of the contaminant and human consumption of fish from the stream was used as acceptable surface water concentration.
- Case 5-3 : A drinking water well is to be installed 150 feet from the property line.
- Case 6-1 : A hydraulic containment (pumping) system was designed to intercept the downgradient migration of contaminated groundwater for 10 years.
- Case 6-2 : A surface cap on the source area was designed to reduce the surface infiltration rate to 0.01 feet/year.
- Case 6-3 : It was assumed that the remedial action will take 1.5 years thus allowing the contaminant to be released from the source during the cleanup.

Cleanup goal/ACL simulations for scenarios with more than one variable controlling factor were also determined. Results and assumptions for four illustrative examples are shown in Table III. The first three cases show that the soil cleanup goal based on surface water exposures can exceed the soil exposure criteria (230 mg/kg based on dermal contact and inhalation) under certain conditions. The last case shows that under very conservative scenario the cleanup goal can be lower than a typical detection limit for a volatile organic chemical. Soil cleanup goals for this hypothetical site ranged from the detection limit (approximately 0.01 mg/kg) to as high as 3,450 mg/kg (see Table III).

CONCLUSIONS

The hypothetical chemical used in the simulations is considered typical of the moderately water-soluble volatile organic chemicals typically found in soils and groundwater at active industrial facilities or abandoned hazardous waste sites. The results of the sensitivity analysis demonstrate that variations in all of the important input parameters and exposure assessment assumption may have a significant impact on cleanup goals for such chemicals.

As shown in Table II, variations in aquifer physical properties, temporal source characteristics, and adsorption potential have a substantial impact of the final soil (and

TABLE III - SOIL CLEANUP GOALS FOR ILLUSTRATIVE CASES WITH MULTIPLE CONTROLLING FACTORS CHANGED

CASE	SAME ASSUMPTION AS IN CASE	DEVIATIONS FROM THE BASELINE SCENARIO	SOIL CLEANUP GOAL (ug/kg)	% CHANGE
BASELINE		NONE	126	0
A	2-1 3-3 5-1 5-2	WITH DECAY WITH DOWNGRADIENT RECHARGE LIFE-TIME AVERAGE FISH CONSUMPTION	456753	362,402
B	2-1 3-3 5-1 5-2 6-1 (4 YEARS)	WITH DECAY WITH DOWNGRADIENT RECHARGE LIFE-TIME AVERAGE FISH CONSUMPTION PUMP AND TREAT FOR 4 YEARS	886737	703,660
C	2-1 3-3 5-1 5-2 6-1	WITH DECAY WITH DOWNGRADIENT RECHARGE LIFE-TIME AVERAGE FISH CONSUMPTION PUMP AND TREAT FOR 10 YEARS	3452234	2,739,768
D	2-2 3-1 3-2 4-1	NO ADSORPTION LIMITED MIXING DEPTH NO DISPERSION PROPERTY LINE AS POE	.46	-100

groundwater) cleanup goals. However, three of the factors to which the simulation is most sensitive are those which are established as a result of the conceptual approach to the problem and chemical specific information.

For example, consideration of a receiving surface water body (rather than a drinking water well) as the point of exposure resulted in a 4,900 percent increase in the allowable soil cleanup goal as a result of attendant dilution. Future land and water use and aquifer classification should be carefully considered by modelers/risk assessors if an ACL demonstration/soil cleanup goal development process is to be based on such an approach.

Although the hypothetical chemical used for the sensitivity analysis is not particularly bioaccumulative, this is typical for water soluble volatile organic chemicals. Development of a soil cleanup goal based on fish consumption (rather than water ingestion) resulted in a 1,900 percent increase in the allowable cleanup goal. Fish consumption may be the primary realistic exposure route under conditions where neither surface water nor groundwater are used as a potable water source. Cleanup goals based on this route will typically greatly exceed those based on surface water or groundwater ingestion. Game and commercial fishing activities and regional consumption patterns should be carefully considered under such a scenario. Furthermore, some consideration of potential adverse effects on aquatic organisms is also generally warranted.

Inclusion of a containment measure (capping) also resulted in a substantial increase in the allowable soil cleanup goal as a result of the decrease in source loading. Inclusion of such a component in the conceptual model should be based on the feasibility of such containment, a cost evaluation, and future land use constraints. Encapsulation is

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essentially closure in place and some institutional controls on future disturbances (e.g., deed recordations) could be necessary. Furthermore, the long term maintenance and monitoring costs associated with the cap should be considered.

Finally, inclusion of a first order decay mechanism resulted in a 1,500 percent increase in the allowable soil cleanup goal. For the most part, decay mechanisms and rates are not well documented and conservative (worst-case) values should be used, if at all, during the cleanup goal development process. Under certain circumstances, it may be appropriate to perform laboratory decay rate studies (e.g., using radiolabeled isotopes) to verify the significance of chemical attenuation mechanisms.

The specific values of the cleanup goals and the increases or decreases between the different scenarios considered in this study are not representative of all sites. However, the wide range (six orders of magnitude) of soil cleanup goals developed for the hypothetical site is typical and indicates that an important component of the cleanup goal development process is selection of appropriate values for each group of controlling factors. All assumptions should be clearly defined and documented to the greatest extent possible to allow for acceptance by the regulatory agency.

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ATTACHMENT D.1.II

SUMMARY OF MODIFIED SOIL PRG MODELING RESULTS
INACTIVE FLYASH PILE

TABLE D.1.II-1

INACTIVE FLYASH PILE - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITHOUT ADMINISTRATIVE OR ENGINEERING CONTROLS

OU 2 AREA: INACTIVE FLYASH PILE CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA UNDER SOURCE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	6.20×10^{-1}	6.20×10^{-2}	6.09×10^{-3}	
b. Lateral Source (C2)	N/A	9.05×10^{0}	9.05×10^{-1}	8.89×10^{-2}	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	4.04×10^{-1}	4.04×10^{-2}	4.04×10^{-3}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	6.20×10^{-1}	6.20×10^{-2}	6.20×10^{-3}	
b. Lateral Source (C2)	N/A	9.07×10^{0}	9.07×10^{-1}	9.07×10^{-2}	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	4.04×10^{-2}	4.04×10^{-3}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	3.50×10^{-1}	3.49×10^{-2}	3.38×10^{-3}	
b. Lateral Source (C2)	N/A	5.12×10^{0}	5.09×10^{-1}	4.93×10^{-2}	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	8.50×10^{-1}	
d. Layer 2	N/A	2.28×10^{-1}	2.28×10^{-2}	2.28×10^{-3}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.II-2

INACTIVE FLYASH PILE - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITHOUT ADMINISTRATIVE OR ENGINEERING CONTROLS

OU 2 AREA: INACTIVE FLYASH PILE CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	9.05×10^{0}	9.05×10^{-1}	8.89×10^{-2}	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	4.04×10^{-1}	4.04×10^{-2}	4.04×10^{-3}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	9.07×10^{0}	9.07×10^{-1}	9.07×10^{-2}	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	4.04×10^{-2}	4.04×10^{-3}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	3.50×10^{-1}	5.09×10^{-1}	4.93×10^{-2}	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	8.50×10^{-1}	
d. Layer 2	N/A	2.28×10^{-1}	2.28×10^{-2}	2.28×10^{-3}	

[a]Case 2: Q4; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

TABLE D.1.II-3

INACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS BUT WITHOUT ENGINEERING CONTROLS

OU 2 AREA: INACTIVE FLYASH PILE CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	1.64×10^{1}	1.63×10^{0}	2.94×10^{-3}	
b. Lateral Source (C2)	N/A	2.38×10^{2}	2.38×10^{1}	4.29×10^{-2}	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	1.29×10^{0}	1.29×10^{0}	1.76×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	1.63×10^{1}	1.63×10^{0}	1.63×10^{-1}	
b. Lateral Source (C2)	N/A	2.37×10^{2}	2.37×10^{1}	2.37×10^{0}	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	7.99×10^{-2}	7.99×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	9.24×10^{0}	1.08×10^{-2}	9.93×10^{-4}	
b. Lateral Source (C2)	N/A	1.35×10^{2}	1.59×10^{-1}	1.45×10^{-2}	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	8.50×10^{-1}	
d. Layer 2	N/A	1.44×10^{0}	9.95×10^{-1}	9.95×10^{-2}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.II-4

INACTIVE FLYASH PILE - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS BUT WITHOUT ENGINEERING CONTROLS

OU 2 AREA: INACTIVE FLYASH PILE CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	2.38×10^{2}	2.38×10^{1}	4.29×10^{-2}	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	1.29×10^{0}	1.29×10^{0}	1.76×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	2.37×10^{2}	2.37×10^{1}	2.37×10^{0}	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	7.99×10^{-2}	7.99×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	1.35×10^{2}	1.59×10^{-1}	1.45×10^{-2}	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	8.50×10^{-1}	
d. Layer 2	N/A	1.44×10^{0}	9.95×10^{-1}	9.95×10^{-2}	

[a]Case 1: Q4, Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3is lateral flow.

[b]Not Applicable

TABLE D.1.II-5

INACTIVE FLYASH PILE - MODIFIED PRGS OFF-PROPERTY RESIDENT FARMER - SOIL WITH ADMINISTRATIVE CONTROLS AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: INACTIVE FLYASH PILE CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	7.11×10^{2}	7.11×10^{1}	4.83×10^{-2}	
b. Lateral Source (C2)	N/A	7.11×10^{2}	7.11×10^{1}	4.83×10^{-2}	
c. Layer 1	N/A	7.11×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	1.29×10^{0}	1.29×10^{0}	4.83×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	7.12×10^{2}	7.12×10^{1}	7.12×10^{0}	
b. Lateral Source (C2)	N/A	7.12×10^{2}	7.12×10^{1}	7.12×10^{0}	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	7.99×10^{-2}	7.99×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	4.02×10^{2}	4.02×10^{1}	5.37×10^{-5}	
b. Lateral Source (C2)	N/A	4.02×10^{2}	4.02×10^{1}	5.37×10^{-5}	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	6.72×10^{-1}	
d. Layer 2	N/A	1.44×10^{0}	1.44×10^{0}	2.73×10^{-1}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.II-6

INACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: INACTIVE FLYASH PILE CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	Background 95th Percentile
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	1.29×10^{3}	1.29×10^{2}	7.80×10^{-2}	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	1.29×10^{0}	1.29×10^{0}	4.83×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	1.28×10^{3}	1.28×10^{2}	1.28×10^{1}	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	7.99×10^{-2}	7.99×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	7.26×10^{2}	7.26×10^{1}	8.66×10^{-5}	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	6.72×10^{-1}	
d. Layer 2	N/A	1.44×10^{0}	1.44×10^{0}	2.73×10^{-1}	

[a]Case 2: Q4; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

TABLE D.1.II-7

INACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: INACTIVE FLYASH PILE CASE 3[a]: Q2, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[a]	3.24×10^{3}	3.22×10^{2}	3.20×10^{1}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	1.29×10^{0}	1.29×10^{0}	8.27×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	3.23×10^{3}	3.23×10^{2}	3.22×10^{1}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	7.99×10^{-2}	7.99×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	1.83×10^{3}	1.31×10^{2}	1.80×10^{1}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	8.50×10^{-1}	
d. Layer 2	N/A	1.44×10^{0}	1.44×10^{0}	4.67×10^{-1}	

[a]Case 3: Q2, C2 - where C is the constituent concentration and Q is the flow rate; Q2 is vertical flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

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TABLE D.1.II-8

INACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH A CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: INACTIVE FLYASH PILE CASE 1[a]: Q4, C4; Q3, C2 (WITH COMPOSITE CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	1.65×10^{4}	1.64×10^{3}	1.55×10^{2}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	1.29×10^{0}	1.29×10^{0}	1.29×10^{0}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	1.64×10^{4}	1.64×10^{3}	1.64×10^{2}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	7.99×10^{-2}	7.99×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	9.29×10^{3}	9.19×10^{2}	8.23×10^{1}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	8.50×10^{-1}	
d. Layer 2	N/A	1.44×10^{0}	1.44×10^{0}	1.44×10^{0}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

TABLE D.1.II-9

INACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH A CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: INACTIVE FLYASH PILE CASE 3[a]:Q2, C2 (WITH COMPOSITE CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[a]	2.54×10^{5}	2.52×10^{4}	2.33×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	7.71×10^{-1}	7.71×10^{-1}	7.71×10^{-1}	
d. Layer 2	N/A	1.29×10^{0}	1.29×10^{0}	1.29×10^{0}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	2.55×10^{5}	2.54×10^{4}	2.54×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	5.21×10^{-2}	5.21×10^{-2}	5.21×10^{-2}	
d. Layer 2	N/A	7.99×10^{-2}	7.99×10^{-2}	7.99×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	1.44×10^{5}	1.41×10^{4}	1.21×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	8.50×10^{-1}	8.50×10^{-1}	8.50×10^{-1}	
d. Layer 2	N/A	1.44×10^{0}	1.44×10^{0}	1.44×10^{0}	

[a]Case 3: Q2,C2 - where C is the constituent concentration and Q is the flow rate; Q2 is vertical flow.

[a]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

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ATTACHMENT D.1.III

SUMMARY OF MODIFIED SOIL PRG MODELING RESULTS
SOUTH FIELD

TABLE D.1.III-1

SOUTH FIELD - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITHOUT ADMINISTRATIVE OR ENGINEERING CONTROLS

OU 2 AREA: SOUTH FIELD CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA UNDER SOURCE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Based PRG	10^{-5} Based PRG	10^{-6} Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	2.70×10^{1}	2.70×10^{0}	2.09×10^{-1}	
b. Lateral Source (C2)	N/A	7.48×10^{1}	7.48×10^{0}	5.79×10^{-1}	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	3.51×10^{0}	
d. Layer 2	N/A	5.85×10^{-1}	6.22×10^{-2}	6.22×10^{-3}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	2.70×10^{1}	2.70×10^{0}	2.70×10^{-1}	
b. Lateral Source (C2)	N/A	7.49×10^{1}	7.49×10^{0}	7.49×10^{-1}	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	6.24×10^{-3}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	1.52×10^{1}	1.47×10^{0}	6.78×10^{-2}	
b. Lateral Source (C2)	N/A	4.22×10^{1}	4.07×10^{0}	1.88×10^{-1}	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	4.54×10^{0}	
d. Layer 2	N/A	3.53×10^{-1}	3.53×10^{-2}	3.53×10^{-3}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.III-2

SOUTH FIELD - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITHOUT ADMINISTRATIVE OR ENGINEERING CONTROLS

OU 2 AREA: SOUTH FIELD CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA UNDER SOURCE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Based PRG	10^{-5} Based PRG	10^{-6} Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	7.48×10^{1}	7.48×10^{1}	5.79×10^{-1}	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	3.51×10^{0}	
d. Layer 2	N/A	5.85×10^{-1}	6.22×10^{-2}	6.22×10^{-3}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	7.49×10^{1}	7.49×10^{0}	7.49×10^{-1}	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	6.24×10^{-3}	
Uranium-238					1.22×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	4.22×10^{1}	4.07×10^{0}	1.88×10^{-1}	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	4.54×10^{0}	
d. Layer 2	N/A	3.53×10^{-1}	3.53×10^{-2}	3.53×10^{-3}	

[a]Case 1: Q4, C3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

TABLE D.1.III-3

SOUTH FIELD - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS BUT WITHOUT ENGINEERING CONTROLS

OU 2 AREA: SOUTH FIELD CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Based PRG	10^{-5} Based PRG	10^{-6} Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	1.13×10^{3}	1.13×10^{2}	8.24×10^{-5}	
b. Lateral Source (C2)	N/A	3.14×10^{3}	3.14×10^{2}	2.28×10^{-4}	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	1.42×10^{0}	
d. Layer 2	N/A	5.85×10^{-1}	5.85×10^{-1}	4.65×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	1.14×10^{3}	1.14×10^{2}	1.14×10^{1}	
b. Lateral Source (C2)	N/A	3.15×10^{3}	3.15×10^{2}	3.15×10^{1}	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	2.00×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	6.42×10^{2}	6.43×10^{1}	3.17×10^{-5}	
b. Lateral Source (C2)	N/A	1.78×10^{3}	1.78×10^{2}	8.80×10^{-5}	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	3.39×10^{-1}	
d. Layer 2	N/A	6.59×10^{-1}	6.59×10^{-1}	2.63×10^{-1}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.III-4

SOUTH FIELD - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS BUT WITHOUT ENGINEERING CONTROLS

OU 2 AREA: SOUTH FIELD CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Based PRG	10^{-5} Based PRG	10^{-6} Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	3.14×10^{3}	3.14×10^{2}	2.28×10^{-4}	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	1.42×10^{0}	
d. Layer 2	N/A	5.85×10^{-1}	5.85×10^{-1}	4.65×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	3.15×10^{3}	3.15×10^{2}	3.15×10^{1}	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	2.00×10^{-2}	
Uranium-238					1.22×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	1.78×10^{3}	1.78×10^{2}	8.80×10^{-5}	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	3.39×10^{-1}	
d. Layer 2	N/A	6.59×10^{-1}	6.59×10^{-1}	2.63×10^{-1}	

[a]Case 1: Q4, C3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.III-5

SOUTH FIELD - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: SOUTH FIELD CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	3.63×10^{3}	3.63×10^{2}	4.87×10^{-5}	
b. Lateral Source (C2)	N/A	3.63×10^{3}	3.63×10^{2}	4.87×10^{-5}	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{1}	4.05×10^{-1}	
d. Layer 2	N/A	5.85×10^{-1}	5.85×10^{-1}	5.16×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	3.63×10^{3}	3.63×10^{2}	3.59×10^{1}	
b. Lateral Source (C2)	N/A	3.63×10^{3}	3.63×10^{2}	3.59×10^{1}	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	2.00×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	2.05×10^{3}	2.05×10^{2}	2.19×10^{-3}	
b. Lateral Source (C2)	N/A	2.05×10^{3}	2.05×10^{2}	2.19×10^{-3}	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	5.38×10^{-1}	
d. Layer 2	N/A	6.59×10^{-1}	6.59×10^{-1}	2.91×10^{-1}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.III-6

SOUTH FIELD - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: SOUTH FIELD CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	1.19×10^{4}	1.19×10^{3}	1.39×10^{-4}	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	4.05×10^{-1}	
d. Layer 2	N/A	5.85×10^{-1}	5.85×10^{-1}	5.16×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	1.19×10^{4}	1.19×10^{3}	1.19×10^{2}	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	2.00×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	6.66×10^{3}	6.66×10^{2}	6.20×10^{-3}	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	5.38×10^{-1}	
d. Layer 2	N/A	6.59×10^{-1}	6.59×10^{-1}	2.91×10^{-1}	

[a]Case 2: Q4,Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3is lateral flow.

[b]Not Applicable

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TABLE D.1.III-7

SOUTH FIELD - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: SOUTH FIELD CASE 3[a]: Q2, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRGs	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	3.37×10^{5}	3.36×10^{4}	3.24×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	3.51×10^{0}	
d. Layer 2	N/A	5.85×10^{-1}	5.85×10^{-1}	5.85×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	3.36×10^{5}	3.36×10^{4}	3.36×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	2.00×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	1.90×10^{5}	1.89×10^{4}	1.74×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	4.54×10^{0}	
d. Layer 2	N/A	6.59×10^{-1}	6.59×10^{-1}	6.59×10^{-1}	

[a]Case 3: Q2, C2 - where C is the constituent concentration and Q is the flow rate; Q2 is vertical flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

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TABLE D.1.III-8

SOUTH FIELD - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH A CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: SOUTH FIELD CASE 1[a]: Q4, C4, Q3, C2 (COMPOSITE CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	6.84×10^{4}	6.81×10^{3}	6.67×10^{2}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	3.51×10^{0}	
d. Layer 2	N/A	5.85×10^{-1}	5.85×10^{-1}	5.85×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	6.81×10^{4}	6.81×10^{3}	6.81×10^{2}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	2.00×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	3.85×10^{4}	3.84×10^{3}	3.67×10^{2}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	4.54×10^{0}	
d. Layer 2	N/A	6.59×10^{-1}	6.59×10^{-1}	6.59×10^{-1}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

TABLE D.1.III-9

SOUTH FIELD - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH A CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: SOUTH FIELD CASE 3[a]: Q2, C2 (COMPOSITE CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	4.12×10^{6}	4.18×10^{5}	4.03×10^{4}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	3.51×10^{0}	3.51×10^{0}	3.51×10^{0}	
d. Layer 2	N/A	5.85×10^{-1}	5.85×10^{-1}	5.85×10^{-1}	
Uranium-235/236					1.42×10^{-1} pCi/g
a. Vertical Source (C4)	N/A	4.17×10^{6}	4.17×10^{5}	4.17×10^{4}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	2.18×10^{-1}	2.18×10^{-1}	2.18×10^{-1}	
d. Layer 2	N/A	2.00×10^{-2}	2.00×10^{-2}	2.00×10^{-2}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	2.37×10^{6}	2.35×10^{5}	2.18×10^{4}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	4.54×10^{0}	4.54×10^{0}	4.54×10^{0}	
d. Layer 2	N/A	6.59×10^{-1}	6.59×10^{-1}	6.59×10^{-1}	

[a]Case 3: Q2, C2 - where C is the constituent concentration and Q is the flow rate; Q2 is vertical flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

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ATTACHMENT D.1.IV

SUMMARY OF MODIFIED SOIL PRG MODELING RESULTS
ACTIVE FLYASH PILE

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TABLE D.1.IV-1

ACTIVE FLYASH PILE - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITHOUT ADMINISTRATIVE OR ENGINEERING CONTROLS

OU 2 AREA: ACTIVE FLYASH PILE CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA UNDER SOURCE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	1.75×10^{1}	1.75×10^{0}	1.75×10^{-1}	
b. Lateral Source (C2)	N/A	1.75×10^{1}	1.75×10^{0}	1.75×10^{-1}	
c. Layer 1	N/A	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	
d. Layer 2	N/A	8.27×10^{-1}	8.27×10^{-2}	8.27×10^{-3}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	9.87×10^{0}	9.83×10^{-1}	9.24×10^{-2}	
b. Lateral Source (C2)	N/A	9.87×10^{0}	9.83×10^{-1}	9.24×10^{-2}	
c. Layer 1	N/A	1.05×10^{0}	1.05×10^{0}	1.05×10^{0}	
d. Layer 2	N/A	4.67×10^{-1}	4.67×10^{-2}	4.67×10^{-3}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

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TABLE D.1.IV-2

ACTIVE FLYASH PILE - MODIFIED PRGS
ON-PROPERTY RESIDENT FARMER - SOIL
WITHOUT ADMINISTRATIVE OR ENGINEERING CONTROLS

OU 2 AREA: ACTIVE FLYASH PILE CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: ON-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA UNDER SOURCE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	2.94×10^{1}	2.94×10^{0}	2.75×10^{-1}	
c. Layer 1	N/A	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	
d. Layer 2	N/A	8.27×10^{-2}	8.27×10^{-2}	8.27×10^{-3}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	1.66×10^{1}	1.65×10^{0}	1.45×10^{-1}	
c. Layer 1	N/A	1.05×10^{0}	1.05×10^{0}	1.05×10^{0}	
d. Layer 2	N/A	4.67×10^{-1}	4.67×10^{-2}	4.67×10^{-3}	

[a]Case 2: Q4, Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3is lateral flow.

[b]Not Applicable

TABLE D.1.IV-3

ACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS BUT WITHOUT ENGINEERING CONTROLS

OU 2 AREA: ACTIVE FLYASH PILE CASE 1[a]: Q4, C4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	2.47×10^{2}	2.47×10^{1}	2.50×10^{-2}	
b. Lateral Source (C2)	N/A	2.47×10^{2}	2.47×10^{1}	2.50×10^{-2}	
c. Layer 1	N/A	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	
d. Layer 2	N/A	9.21×10^{-1}	9.21×10^{-1}	1.56×10^{-1}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	5.22×10^{1}	3.48×10^{0}	2.10×10^{-2}	
b. Lateral Source (C2)	N/A	5.22×10^{1}	3.48×10^{0}	2.10×10^{-2}	
c. Layer 1	N/A	1.05×10^{0}	1.05×10^{0}	1.05×10^{0}	
d. Layer 2	N/A	7.53×10^{-1}	7.53×10^{-1}	8.80×10^{-2}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3is lateral flow.

[b]Not Applicable

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TABLE D.1.IV-4

ACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS BUT WITHOUT ENGINEERING CONTROLS

OU 2 AREA: ACTIVE FLYASH PILE CASE 2[a]: Q4; Q3, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	4.15×10^{2}	4.15×10^{1}	3.94×10^{-2}	
c. Layer 1	N/A	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	
d. Layer 2	N/A	9.21×10^{-1}	9.21×10^{-1}	1.56×10^{-1}	
Uranium-238					1.122×10^{0} pCi/L
a. Vertical Source (C4)	N/A	N/A[b]	N/A[b]	N/A[b]	
b. Lateral Source (C2)	N/A	5.22×10^{1}	2.04×10^{1}	3.33×10^{-2}	
c. Layer 1	N/A	1.05×10^{0}	1.05×10^{0}	1.05×10^{0}	
d. Layer 2	N/A	7.53×10^{-1}	7.53×10^{-1}	8.80×10^{-2}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

000666

TABLE D.1.IV-5

ACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH ADMINISTRATIVE CONTROLS BUT WITHOUT ENGINEERING CONTROLS

OU 2 AREA: ACTIVE FLYASH PILE CASE 3[a]: Q2, C2 (NO CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	2.29×10^{4}	2.27×10^{3}	2.12×10^{2}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	
d. Layer 2	N/A	9.21×10^{-1}	9.21×10^{-1}	9.21×10^{-1}	
Uranium-238					1.122×10^{0} pCi/L
a. Vertical Source (C4)	N/A	1.29×10^{4}	1.27×10^{3}	1.17×10^{2}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	1.05×10^{0}	1.05×10^{0}	1.05×10^{0}	
d. Layer 2	N/A	7.53×10^{-1}	7.53×10^{-1}	5.61×10^{-1}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3is lateral flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

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TABLE D.1.IV-6

ACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: ACTIVE FLYASH PILE CASE 1[a]: Q4, C4; Q3, C2 (WITH CLAY CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	1.10×10^{4}	1.09×10^{3}	9.98×10^{1}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	
d. Layer 2	N/A	9.21×10^{-1}	9.21×10^{-1}	9.21×10^{-1}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	6.19×10^{3}	6.11×10^{2}	5.37×10^{1}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	1.05×10^{0}	1.05×10^{0}	1.05×10^{0}	
d. Layer 2	N/A	7.53×10^{-1}	7.53×10^{-1}	7.53×10^{-1}	

[a]Case 1: Q4, CA; Q3, C2 - where C is the constituent concentration and Q is the flow rate; Q4 is vertical flow and Q3 is lateral flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

TABLE D.1.IV-7

ACTIVE FLYASH PILE - MODIFIED PRGS
OFF-PROPERTY RESIDENT FARMER - SOIL
WITH CAP AND ENGINEERING CONTROLS FOR PERCHED WATER

OU 2 AREA: ACTIVE FLYASH PILE CASE 3[a]: Q2, C2 (WITH CLAY CAP)	RECEPTOR: OFF-PROPERTY RESIDENT FARMER EXPOSURE POINT: GMA AT FEMP FENCELINE Incremental Above Background Concentrations				Background 95th Percentile
	HI = 0.2 RfD-Based PRG	10^{-4} Risk Based PRG	10^{-5} Risk Based PRG	10^{-6} Risk Based PRG	
RADIONUCLIDES (pCi/g)					
Uranium-234					1.037×10^{0} pCi/g
a. Vertical Source (C4)	N/A[b]	4.04×10^{5}	4.01×10^{4}	3.62×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	1.00×10^{0}	1.00×10^{0}	1.00×10^{0}	
d. Layer 2	N/A	9.21×10^{-1}	9.21×10^{-1}	9.21×10^{-1}	
Uranium-238					1.122×10^{0} pCi/g
a. Vertical Source (C4)	N/A	2.28×10^{5}	2.24×10^{4}	1.93×10^{3}	
b. Lateral Source (C2)	N/A	0.00×10^{0}[c]	0.00×10^{0}[c]	0.00×10^{0}[c]	
c. Layer 1	N/A	1.05×10^{0}	1.05×10^{0}	1.05×10^{0}	
d. Layer 2	N/A	7.53×10^{-1}	7.53×10^{-1}	7.53×10^{-1}	

[a]Case 1: Q2, C2 - where C is the constituent concentration and Q is the flow rate; Q2 is vertical flow.

[b]Not Applicable

[c]Soil and hence leachate concentrations are assumed to be zero for this case.

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APPENDIX D.2

EVALUATION OF IN SITU CONTAINMENT ALTERNATIVES FOR LONG-TERM RESIDUAL RISK

APPENDIX D.2

EVALUATION OF THE IMPACT OF OPERABLE UNIT 2 ALTERNATIVES ON THE GREAT MIAMI AQUIFER

D.2.1 INTRODUCTION

There are two purposes for Appendix D.2. The first purpose is to present the results of the modeling which was conducted to evaluate the impact of the consolidation/containment alternatives on the Great Miami Aquifer (see Section 5.0 of this FS for a description of the alternatives) due to vertical contaminant migration. The second purpose is to present the results of the modeling, which was performed to evaluate the impact of the consolidation/containment alternatives and the on-site disposal alternatives on the Great Miami Aquifer due to the lateral migration of contaminated perched groundwater. The goal of this second task was to determine the length of time required to collect perched groundwater in an engineered interceptor trench (see Section 5.0 for a description of the alternatives) to prevent any adverse impact to the Great Miami Aquifer. A spreadsheet-based groundwater fate and transport model was used to complete all of the modeling described here. Final confirmation modeling of the alternatives was also performed using a more complex fate and transport model; these results are presented in Appendix D.3.

D.2.2 IMPACT OF VERTICALLY MIGRATING CONTAMINATION ON GREAT MIAMI AQUIFER

D.2.2.1 Technical Approach

Operable Unit 2 proposes to dispose of waste from the Inactive Flyash Pile, South Field, and Active Flyash Pile in a contaminated material disposal area, which will be located in the northeast portion of the South Field and Active Flyash Pile (see Figure D.2-1). The location of the disposal area was selected based on the modified soil preliminary remediation goal (PRG) results. This area has substantial amounts of till (approximately 18 feet) which impedes vertical transport of contaminants. This area corresponds to the Case 3 area investigated for the development of modified soil PRGs (see Appendix D.1). Modified soil PRGs for this area were typically several orders of magnitude higher than for areas with minimal amounts of till, which confirmed that the till impedes vertical transport of contaminants.

The ECTran fate and transport model was used to evaluate the impact of the residual uranium-238 contamination, which will be disposed of in this contaminated material disposal area. A complete

description of the ECTran model is included in Attachment D.1.I of Appendix D.1. The One-Dimensional Analytical Solute Transport/Sandia Waste Isolation Flow and Transport (ODAST/SWIFT) model was used to confirm the final remedial alternatives (see Appendix D.3).

Several details of the proposed alternatives were important to the modeling approach including:

- All Inactive Flyash Pile contaminated material above the preliminary remediation levels (PRLs) will be moved to the contaminated material disposal area and capped with a composite cap. Modeling will be performed using the South Field conceptual model for Case 3b from the modified soil PRG modeling (see Appendix D.1).

- South Field contaminated material above the PRLs in areas with less than 18 feet of till will be moved to the contaminated material disposal area and capped with a composite cap. Modeling will be performed using the South Field conceptual model for Case 3b from the modified soil PRG modeling (see Appendix D.1).

- Active Flyash Pile contaminated material above the PRLs in areas with less than 18 feet of till will be moved to the contaminated material disposal area and capped with a clay cap. Modeling will be performed using the Active Flyash Pile conceptual model for Case 3 from the modified soil PRG modeling (see Appendix D.1).

- Perched groundwater will be collected using an engineered interceptor trench (see Section D.2.3).

Several conservative assumptions were made to simplify the modeling task including:

- To evaluate the impact of the contaminated material which will be disposed in the contaminated material disposal area, the maximum detected uranium-238 concentration for each contaminated material unit will be used as the source for the contaminated material unit-specific area of the disposal area (see Appendix A for contaminated material unit maximum uranium-238 concentrations).

- The source will remain constant in the ECTran model for the 1,000 year modeling time. This is an imposed condition to ensure conservativeness.

- Areas of the contaminated material disposal area have till thicknesses in excess of 18 feet. This additional till was not considered during the modeling.

D.2.2.2 Conceptual Model

The Inactive Flyash Pile and South Field disposal areas of the contaminated material disposal area were conceptualized as the Case 3b area of the South Field (see Appendix D.1). The Active Flyash Pile disposal area of the contaminated material disposal area was conceptualized as the Case 3 area of the Active Flyash Pile (see Appendix D.1)

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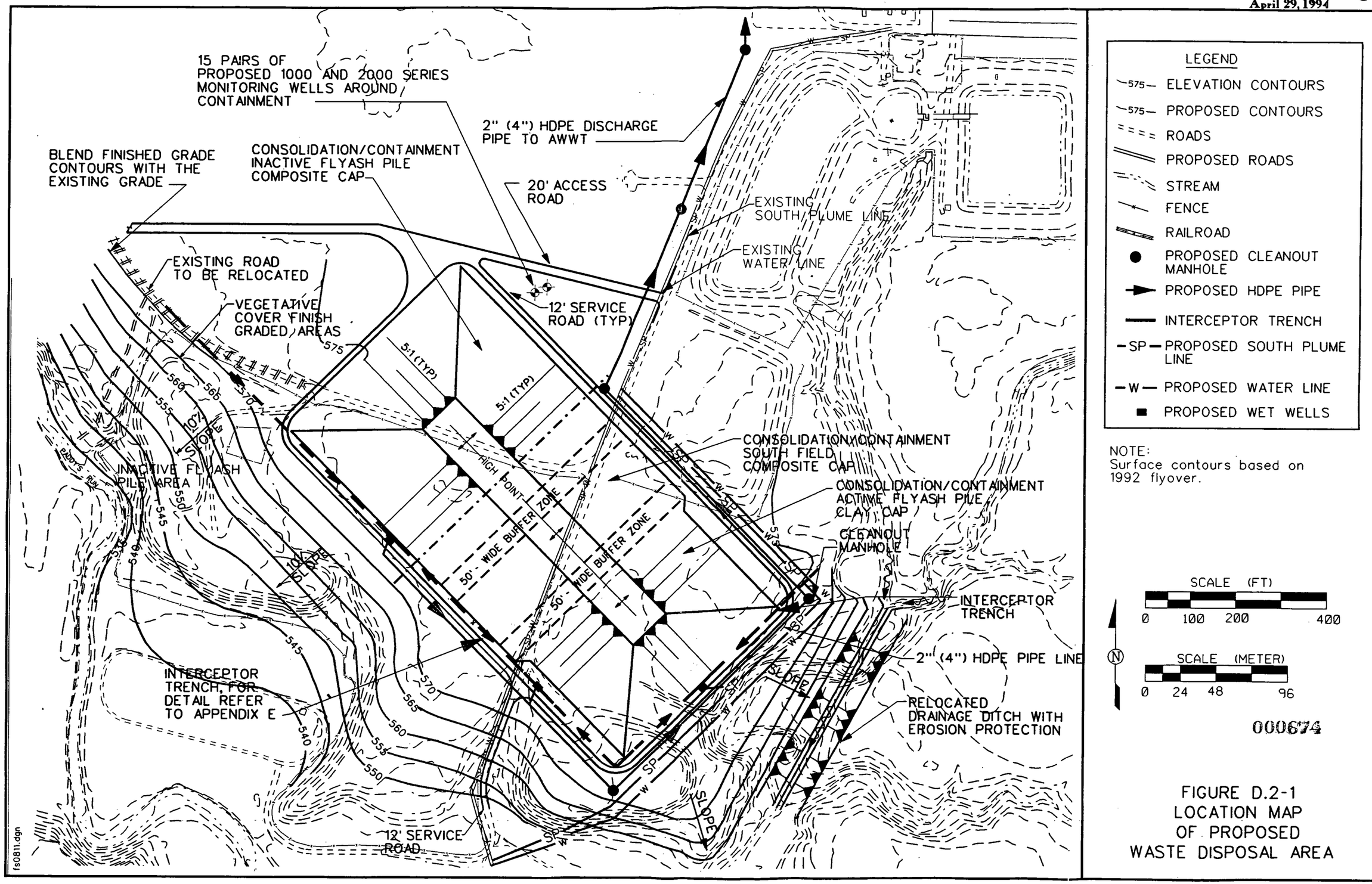

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FIGURE D.2-1
LOCATION MAP
OF PROPOSED
WASTE DISPOSAL AREA

Identical hydrogeologic, geologic, and contaminant of concern (COC) information for the South Field and Active Flyash Pile was used for this modeling and was also used for the Case 3 modified soil PRG development. It was assumed that an engineered interceptor trench will be built to intercept laterally migrating perched groundwater. Two potential exposure points were investigated, including the Great Miami Aquifer under the source and the Great Miami Aquifer at the FEMP fence line, to evaluate the potential risk to the potential receptors: the on-property and off-property resident farmers.

The uranium-238 concentrations in the contaminated material and glacial overburden (till) were used as input for the ECTran model and are summarized in Table D.2-1. Current measured uranium-238 concentrations in the glacial overburden (till) (Layer 1) of the Active Flyash Pile are below background for soil and were assumed to not impact the dissolved uranium-238 concentration in the Great Miami Aquifer. Current measured uranium-238 concentrations in the unsaturated sand and gravel (Layer 2) of the Inactive Flyash Pile, South Field, and Active Flyash Pile were also below background for soil and consequently were also assumed to not impact the dissolved uranium-238 concentration in the Great Miami Aquifer.

D.2.2.3 Modeling Results

The results of the ECTran modeling are summarized in Table D.2-1. The results are organized by the three waste units and the two potential exposure points. The results show that the maximum predicted uranium-238 concentrations for the Great Miami Aquifer under the source and the Great Miami Aquifer at the FEMP fence line were the result of the Inactive Flyash Pile contaminated material. The concentrations ranged from 2.07×10^{0} picoCuries per liter (pCi/L) for the Great Miami Aquifer under the source exposure point to 7.40×10^{-2} pCi/L for the FEMP fence line exposure point. The maximum predicted uranium-238 concentration in the Great Miami Aquifer under the source (2.07×10^{0} pCi/L) is below the proposed maximum contaminant level (MCL), which is 6.7×10^{0} pCi/L [20 parts per billion (ppb)], while the maximum predicted uranium-238 concentration in the Great Miami Aquifer at the FEMP fence line is below the 10^{-6} risk-based criteria, which is 6.20×10^{-1} pCi/L (1.85 ppb).

TABLE D.2-1

SUMMARY OF EVALUATION OF CONSOLIDATION/CONTAINMENT ALTERNATIVES SOUTH FIELD AREA

	ECTran Model Input			ECTran Model Results	
Operable Unit 2 Waste Unit	Source Concentration (pCi/g)	Layer 1 Concentration (pCi/g)	Layer 2 Concentration (pCi/g)	Predicted U-238 Concentration in GMA Under Source (pCi/L)	Predicted U-238 Concentration in GMA at FEMP Fence Line (pCi/L)
Inactive Flyash Pile	1.57×10^{3}	4.54×10^{0}	0.00×10^{0}	2.07×10^{0}	7.40×10^{-2}
South Field	3.97×10^{2}	4.54×10^{0}	0.00×10^{0}	7.49×10^{-1}	2.72×10^{-2}
Active Flyash Pile	7.98×10^{0}	0.00×10^{0}	0.00×10^{0}	4.74×10^{-2}	3.15×10^{-3}

D.2.3 IMPACT OF LATERALLY MIGRATING CONTAMINATION ON GREAT MIAMI AQUIFER

D.2.3.1 Technical Approach

Operable Unit 2 proposes to dispose of or leave in-place contaminated material in the South Field area under the consolidation/containment alternatives and on-site disposal alternatives, respectively. For the consolidation/containment alternatives, contaminated material from the Inactive Flyash Pile, South Field, and Active Flyash Pile will be excavated and then placed in a contaminated material disposal area in the northeast portion of the South Field and Active Flyash Pile (see Figure D.2-1) and capped. Under the on-site disposal alternatives, contaminated material from all Operable Unit 2 contaminated material units will be removed and placed in an on-site disposal cell with the exception of some contaminated material in the northeastern portion of the South Field, which has significant amounts of till. Figure D.2-2 shows the area of the South Field where contaminated material will be left in place.

Currently, contaminated perched groundwater in the South Field area adversely impacts the Great Miami Aquifer via lateral migration and subsequent discharge to the Great Miami Aquifer. In addition, loading from contaminated material to the perched groundwater zone will occur under the two proposed alternatives. Therefore, under these two alternatives, Operable Unit 2 proposes to collect the perched groundwater with an engineered interceptor trench until the risk associated with the perched groundwater is reduced to acceptable levels. This trench would essentially eliminate the perched groundwater source of contamination to the Great Miami Aquifer during its operation. The operation time required for the interceptor trench would equal the time required for contaminated perched groundwater and additional loadings to reach acceptable risk levels (i.e., washout).

The ECTran model was used to predict the uranium-238 concentration in the perched groundwater over time. Collection times were estimated by comparing the uranium-238 modified PRGs for the 10^{-4}, 10^{-5} and 10^{-6} risk levels under Case 2 (see Appendix D.1 for a description of Case 2) to the predicted concentrations in the perched groundwater. The washout time was equal to the time when the predicted concentration equaled the modified PRG.

Several assumptions were made for modeling the consolidation/containment alternatives including:

- Both the South Field and Inactive Flyash Pile contaminated material, which will be disposed of in separate areas under the consolidation/containment alternatives, were modeled considering the contaminated material with the greatest impact to the perched groundwater. The Active Flyash Pile contaminated material was not modeled because the level of contamination in this material was not as significant as the contamination in other two contaminated material units.

- Two contaminated material concentrations were used as vertical source concentrations including an upper confidence level (UCL) and a value obtained by kriging (see Table D.2.2 for concentration values).

- The current uranium-238 perched groundwater concentration of 220 pCi/L was used as the contaminant concentration in the perched groundwater zone.

- The contaminated material source concentration will remain constant in the ECTran model for the 1,000 year modeling time. This is an imposed condition to ensure conservativeness. The current contamination in the perched groundwater zone is allowed to decay with time.

Several assumptions were also made for modeling the on-site disposal alternatives including:

- The contaminated material remaining in the South Field will not be capped, and is considered as a vertical source of contamination to the perched groundwater zone.

- Two contaminated material concentrations were used as source concentrations including a volume weighted average and a value obtained by kriging (see Table D.2.2 for concentration values).

- The current uranium-238 perched groundwater concentration of 220 pCi/L was used as the contaminant concentration in the perched groundwater zone.

- The contaminated material source concentration will remain constant in the ECTran model for the 1,000 year modeling time. This is an imposed condition to ensure conservativeness. The current contamination in the perched groundwater zone is allowed to decay with time.

D.2.3.2 Conceptual Model

Hydrogeologic, geologic, chemical, and geochemical information for the South Field area were used for the modeling. An average hydraulic conductivity and hydraulic gradient were used to estimate perched groundwater flow rates. Infiltration rates for both the capped and uncapped scenarios were estimated using the Hydrologic Evaluation of Landfill Performance (HELP) model. The perched groundwater zone was assumed to be approximately three feet thick. In addition, a three-foot thick layer of unweathered till was assumed to overlie the perched groundwater. Uranium-238 was the COC modeled for this task. Chemical information such as current uranium-238 concentrations in the

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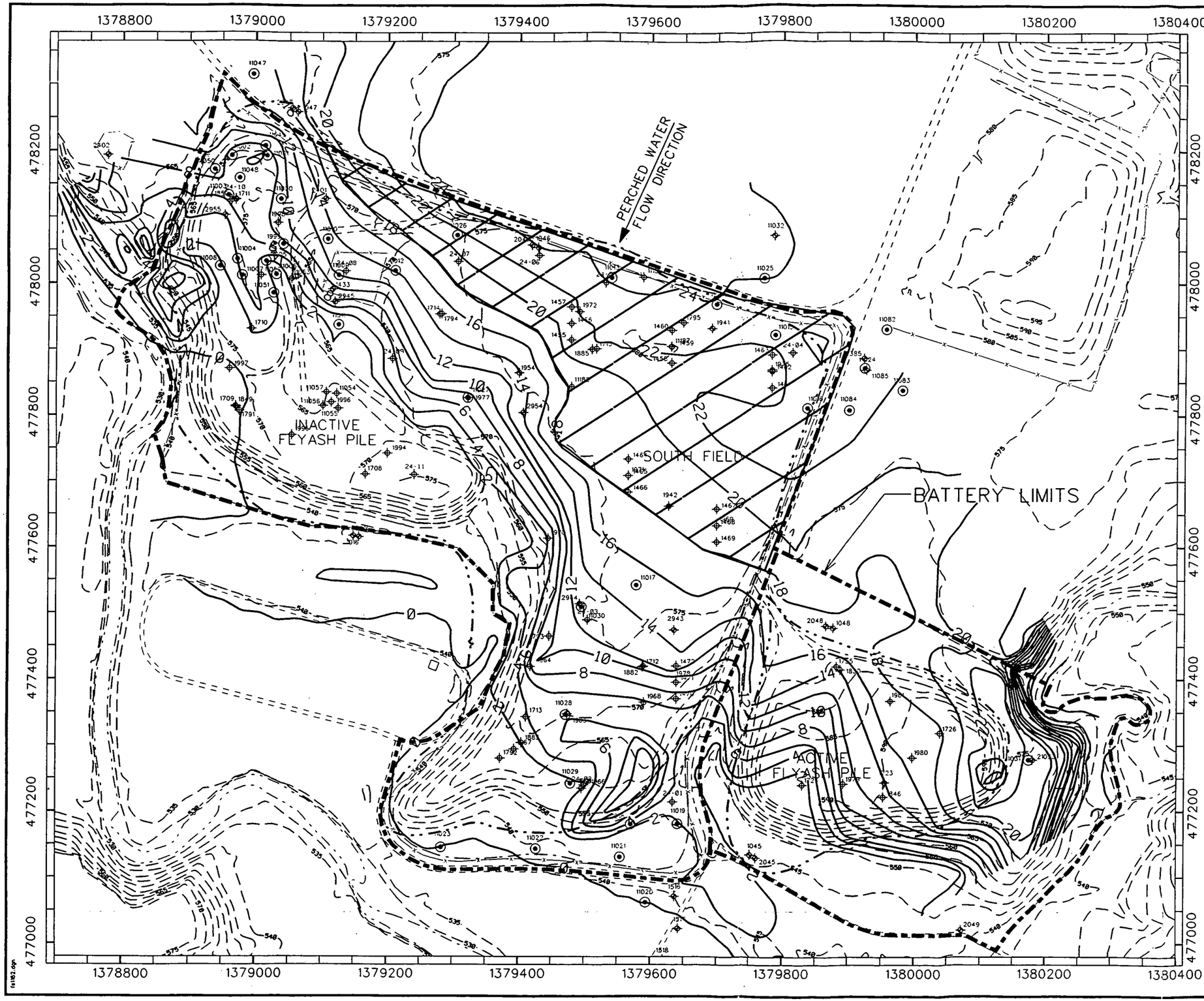

LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- DRAINAGE
- FENCE
- 1000 MONITORING WELLS
- 2000 MONITORING WELLS
- SOIL BORING
- HYDROPUNCH
- THICKNESS OF TILL CONTOUR
- AREA WHERE RESIDUAL CONTAMINATION BELOW PRLS WILL BE LEFT

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 150 300

SCALE (M)
0 36 72

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FIGURE D.2-2
LOCATION OF CONTAMINATED MATERIAL TO BE LEFT UNDER ON-SITE DISPOSAL ALTERNATIVE

perched groundwater and the contaminated material were taken from Appendix A, which summarizes current media-specific contamination levels. Geochemical information such as the uranium-238 distribution coefficient (K_d) was also used for the modeling. Several K_ds were used including: K_d equals 37.5 liters per kilogram (L/kg) for Inactive Flyash Pile contaminated material; K_d equals 177 L/kg for the South Field contaminated material; K_d equals 200 L/kg for the till; and K_d equals 15 L/kg for the perched groundwater zone.

The flow and contaminant migration conditions in the South Field area were simulated during modeling and can be conceptualized as follows:

- Rainfall infiltrates through the contaminated material under either alternative, leaches contamination, and passes into the perched groundwater zone.
- Uncontaminated perched groundwater flows into the South Field area from the northeast and flows across the site, picking up contamination from the contaminated material, which loads into the perched groundwater vertically and from the current contamination in the perched groundwater zone. The perched groundwater discharges along the southwest side of the South Field area.
- Sources considered during modeling include the current contamination in the perched groundwater zone and the contaminated material remaining on site under the two alternatives.

D.2.3.3 Results

The objective of this modeling task was to determine the amount of time the engineered interceptor trench must collect perched groundwater. Table D.2-1 summarizes the collection times, which were estimated for both the consolidation/containment and on-site containment alternatives. The table shows that the collection times for the consolidation/containment alternatives varied from greater than 1,000 years to 80 years, depending on the source concentration and the risk level. The Inactive Flyash Pile contaminated material created the longest collection times due to the higher source concentrations. For the on-site disposal alternative, the collection times varied from greater than 1,000 years (10^{-6} risk) to 38 years (10^{-4} risk).

The collection times estimated for this task are conservative due to modeling assumptions. Additional modeling was performed to confirm these results using the ODAST/SWIFT model; these results are presented in Appendix D.3.

TABLE D.2-2

SUMMARY OF COLLECTION TIMES

ALTERNATIVE	SOURCE OF CONTAMINATED MATERIAL	CONTAMINANT OF CONCERN	CRITERIA FOR WASHOUT TIME (pCi/L)	CONTAMINATED MATERIAL CONCENTRATIONS (pCi/g)	COLLECTION TIME UNTIL PERCHED GROUNDWATER REDUCES BELOW CASE 2 MODIFIED PRG (YEARS)		
					10^{-6}	10^{-5}	10^{-4}
CONSOLIDATION/ CONTAINMENT	SOUTH FIELD	Uranium-238	10^{-6}=0.62 pCi/L 10^{-5}=6.2 pCi/L 10^{-4}=62 pCi/L	UCL=82.7 pCi/g	>1,000	500	80
				Kriged=14.3 pCi/g	>1,000	460	80
	INACTIVE FLYASH PILE	Uranium-238	10^{-6}=0.62 pCi/L 10^{-5}=6.2 pCi/L 10^{-4}=62 pCi/L	UCL=830 pCi/g	>1,000	>1,000	>1,000
				Kriged=97.4 pCi/g	>1,000	>1,000	80
ON-SITE DISPOSAL	SOUTH FIELD	Uranium-238	10^{-6}=0.62 pCi/L 10^{-5}=6.2 pCi/L 10^{-4}=62 pCi/L	Weighted Average =57.1 pCi/g	>1,000	230	38
				Kriged=14.3 pCi/g	>1,000	220	38

UCL = Upper Confidence Level

APPENDIX D.3

GROUNDWATER FATE AND TRANSPORT FOR CONTAMINANTS OF CONCERN

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D.3.0 GROUNDWATER FATE AND TRANSPORT FOR CONTAMINANTS OF CONCERN

This section summarizes the results of fate and transport modeling that was used to simulate constituent movement from the Operable Unit 2 subunits to potential human receptors from residual soils, in-situ containment of waste with cap, and waste deposited in a disposal cell. The fate and transport models provide the only means of predicting potential groundwater concentrations at receptor locations in the future under assumed conditions. Results of the fate and transport modeling are needed to evaluate various alternatives and are used in the risk assessment to evaluate residual risk from Operable Unit 2 waste. Conservative assumptions were used to simulate "worst-case" contaminant migration scenarios. The impact of surface water runoff, deposition of airborne contaminated dust, and leaching of sediments were not considered here. Impact of these mechanisms will be considered under Operable Unit 5 modeling efforts. The models used were as follows:

- The hydrological evaluation of landfill performance (HELP) model was used to estimate exfiltration and infiltration rates
- The ODAST/SWIFTLOAD model was used to predict contaminant movement through the vadose zone and prepare input files for the SWIFT III model
- The SWIFT III model was used to predict contaminant movement through the Great Miami Aquifer

Only a brief description of the methodology used to quantitatively predict concentrations of contaminants is presented here. For a more complete description of the methods and parameters used for the Operable Unit 2 modeling, please refer to Appendix A of the Final RI Report for Operable Unit 2.

D.3.1 CONCEPTUAL GROUNDWATER FLOW MODEL

Based on characteristics of the geology underlying the Operable Unit 2 subunits, and on-site disposal facility, a conceptual model was developed for the pathways between the disposal areas and receptor locations. Figure D.3-1 shows a generalized picture of contaminant migration at the FEMP. Two pathways for contaminant migration from the Operable Unit 2 disposal area to the Great Miami Aquifer after the remediation were identified. First, migration from the waste unit vertically through

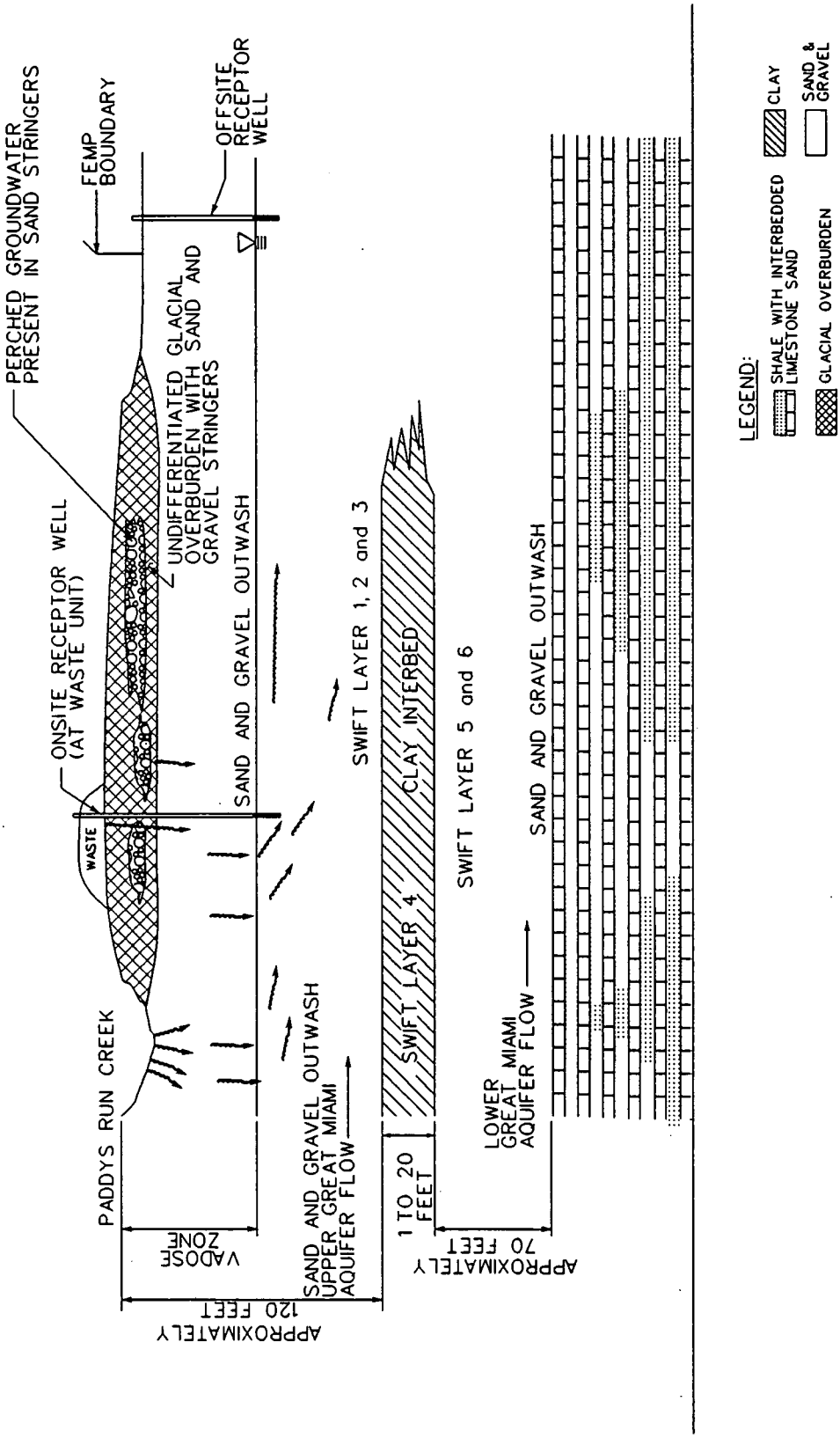

FIGURE D.3-1
CONCEPTUAL MODEL OF LOADING TO THE GREAT MIAMI AQUIFER AND CONTAMINANT TRANSPORT BY GROUNDWATER

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the vadose zone to the aquifer was designated the vadose zone pathway. Second, vertical migration of perched water and infiltration to the aquifer was designated the perched water infiltration pathway.

Three other pathways (the perched water subsurface seep, seep, and surface water pathways) were identified during Operable Unit 2 RI fate and transport modelling. The perched water subsurface seep pathway for the Inactive Flyash Pile/South Field was modeled by itself to determine the need for an engineering control for perched water. Results of this modeling (see Section D.3.4) indicated that an engineering control for perched water will be required. Therefore, all modeling assumed that subsurface and surface seep pathways will be eliminated through an engineering control. RI modeling indicated that impact of surface water (runoff) pathway on the Great Miami Aquifer is very small for COCs. Furthermore, all remediation areas would be covered with backfill and vegetated to eliminate surface water pathways to the Great Miami Aquifer. Therefore, the surface water pathway was not included in the fate and transport modeling for FS.

The geology of the FEMP site is dominated by glacial sediments. Well sorted sand and gravel glacial outwash forms the regional Great Miami Aquifer. Beneath the site, this aquifer is divided by a 1- to 20-foot (0.3- to 6.6 meter) thick clay interbed at an approximate depth of 120 feet (37 meter) (Figure D.3-1). The receptor pathway considered for this modeling is the upper part of the Great Miami Aquifer above the clay interbed. The term glacial overburden has been selected to describe the deposits located stratigraphically above the glaciofluvial material of the Great Miami Aquifer. A sequence of fine-grained till deposits interbedded with sand and gravel glaciofluvial stringers forms the glacial overburden at the site.

The migration of contaminants from sources to the groundwater begins with the infiltration of rainwater (Figure D.3-2). As the water percolates through the waste, contaminants in the waste are dissolved into the water to form a leachate. Fluid and/or leachate entering from the waste areas migrates first through the glacial overburden (if present), then through the unsaturated outwash deposits, and finally into the Great Miami Aquifer. Downward movement of water, driven by the forces resulting from gravitational potential, capillary pressure, and other components of total fluid potential, mobilize the constituents and carry them through the vadose zone.

The vadose zone, applicable to all subunits and modeled disposal areas, was modeled as two layers (Figure D.3-2), the glacial overburden underlying the subunits (Layer 1) and the unsaturated portion

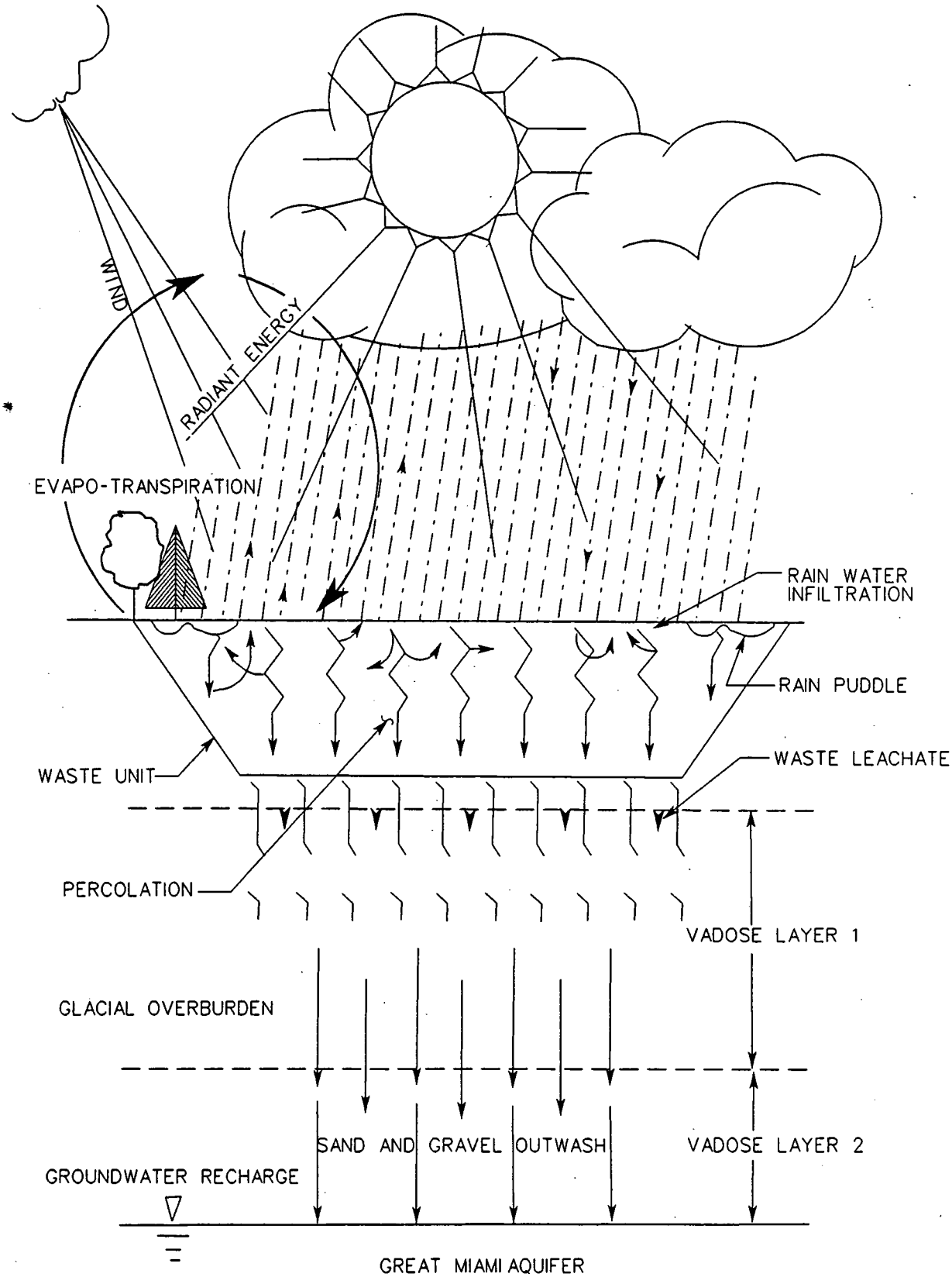

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FIGURE D.3-2
CONCEPTUAL VADOSE ZONE MODEL

of the underlying Great Miami Aquifer (Layer 2). Layer 1 soils consist of tills in the glacial overburden. The sand and gravel unit within the glacial overburden was not included in the vadose zone modeling because this layer has much higher permeability and less adsorption potential as compared to clay and silts in the glacial overburden. Similarly weathered till was not included in the vadose zone modeling as vertical permeability of this zone can be significantly higher than the unweathered till. The thickness of till for the vadose zone model ranges between 0 and 35 feet for the proposed disposal cell and subunits. Beneath the till is the unsaturated sand and gravel outwash layer (Layer 2), which is present beneath all the subunits/disposal areas. The thickness of Layer 2 ranges from 16 to 44 feet (4.8 to 13.4 meters).

Another pathway which was applicable after remediation was perched water infiltration. The conceptual model for the perched water infiltration pathway is similar to that of the vadose zone pathway. This pathway was modeled with two layers. Layer 1 soils consist of tills below the perched water zone and Layer 2 soils consist of the unsaturated portion of the Great Miami Aquifer. The thickness of Layer 1 ranged from 2 to 11 feet (0.6 to 3.4 meters) and the thickness of Layer 2 ranged from 27 to 33 feet (8 to 10 meters). Contaminant mass in the perched water, as well as adsorbed to the sand layer, was considered in the source term for the perched water infiltration. The perched water was simulated as additional source of contaminant loading based on the contaminant concentrations detected in the 1000 series wells located within the Operable Unit 2 subunits.

Based on characteristics of the material underlying each Operable Unit 2 subunit and disposal area, a detailed conceptual model was developed for the pathways between each subunit and the receptor locations. These more detailed models were developed to account for the variable stratigraphies of the soils of the subunits of Operable Unit 2. Areas overlying each SWIFT III grid block in all subunits were modeled separately with individual stratigraphy, contaminant concentration, and infiltration rate parameters, and each contaminant of concern (COC) was simulated using retardation and decay factors taken from literature studies or site-specific data. Contribution to COC concentrations from other FEMP sources and soils at background concentrations was not included in the results presented in this Appendix. The results presented here represent the incremental change in COC concentrations in the Great Miami Aquifer due to loading from Operable Unit 2 areas only.

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D.3.2 TECHNICAL APPROACH

This section describes the technical approach used for defining parameters required for groundwater modeling. Section D.3.3 provides a brief description of the models used in groundwater fate and transport modeling. Groundwater COCs identified in the Final RI report for the Operable Unit 2 were technetium-99 and uranium isotopes. For modeling of uranium isotopes, only uranium-238 was modeled in order to more efficiently utilize computation time. Uranium-238 was selected for modeling as more samples were analyzed for uranium-238 than any other uranium isotopes and uranium-238 constitutes more than 99 percent of total uranium mass. Concentrations of uranium-234, uranium-235/236 were estimated by using site-specific activity ratios for uranium. The following relationships were derived between various uranium forms in the Final RI Report for Operable Unit 2:

Uranium-234 = 0.91 (Uranium-238)	activity ratio
Uranium-235/236 = 0.048 (Uranium-238)	activity ratio
Uranium-238 = 0.9925 (Uranium-total)	mass ratio

It is worth noting that these ratios are very close to the uranium isotope ratios for naturally occurring uranium. Although these relationships were developed from soil samples, these relationships should apply to uranium concentrations in the groundwater because all uranium isotopes have very long half-lives (greater than 10,000 years). The simulation time period of 1000 years was selected based on the Risk Assessment Work Plan Addendum (DOE 1992a).

D.3.2.1 Source Term Development

The source included waste as well as the impacted till. The impacted till was defined as the till immediately below the fill and waste to a depth of 4 feet (1.2 meters) for the South Field, 2 feet (0.6 meters) for the Inactive Flyash Pile, and 2.5 feet (0.8 meters) for the Active Flyash Pile. Depths of impacted till were selected from the analytical results for uranium for the soil samples. At the Solid Waste Landfill, technetium-99 was the only COC for groundwater but it was not detected in the till. Therefore, no till was included in the source for the Solid Waste Landfill.

Technetium-99 was identified as a COC from the Solid Waste Landfill. The alternative modeled for the Solid Waste Landfill assumes that waste will be contained in-place with a cap. Therefore, the technetium-99 concentrations used in the groundwater modeling were the upper 95 percent confidence

level on the means (UCL) of the waste concentrations from the RI/FS subsurface soil database for Operable Unit 2.

Uranium isotopes were identified as COCs for the South Field, Inactive Flyash Pile, and Active Flyash Pile. Uranium-238 concentration in each block was estimated using kriging. This approach was selected for uranium, as uranium controls the risk from groundwater pathways and to simulate known hot spots identified during field investigations. All validated uranium-238 results from RI/FS Phase I and Phase II field investigations for each subunit were segregated by waste/fill, impacted till, remaining glacial overburden, and the unsaturated Great Miami Aquifer soils. Uranium-238 concentrations in each 25 x 25 x 2.5 foot (7.6 x 7.6 x 0.76 meter) block were estimated using three-dimensional kriging for each media type. Average waste concentrations in each 125 x 125 foot (38 x 38 meter) SWIFT III grid cell were then calculated from all 25 x 25 x 2.5 foot (7.6 x 7.6 x 0.76 meter) thick blocks within each SWIFT III grid cell.

Source terms for residual soils were determined by evaluating the kriged uranium-238 concentration on a block by block basis against the cleanup criteria selected for the alternative. All blocks above a block containing uranium-238 concentration exceeding the cleanup level were removed from the source term. Within a grid cell, when uranium-238 concentration in any block exceeded the cleanup level, then all remaining blocks in that grid cell were conservatively assigned a uranium-238 concentration equal to the cleanup level. However, if all the blocks in a grid cell were below the cleanup level, the kriged average concentration in that grid cell was used as the source term for modeling purposes.

As excavated soils can be placed anywhere under the cap, the source term for fate and transport modeling for consolidation and placement under a cap was based on maximum detected uranium-238 concentration in each media type. If existing soils in a grid cell contained uranium-238 (at the South Field for example), the uranium-238 mass from existing soils was added to the total mass for that grid cell. However, leachate concentrations were estimated from the layer containing the highest level of uranium-238. This approach was selected to simulate a "worst-case" scenario since the sequence of contaminated soil removal and placement was not determined in detail during Feasibility Study.

The source terms for perched water infiltration pathways were estimated using the following equation:

$$\text{Mass} = (\phi\, C_w + \rho_b K_d C_w)\, Ab$$

where

A = Area of cell (125 ft x 125 ft or 1452 square meter)
b = Average perched water zone thickness
C_w = Upper 95 percent confidence level on the mean (UCL) of the perched water concentration
K_d = Distribution coefficient
ϕ = Porosity
ρ_b = Bulk (dry) density

D.3.2.2 Methods of Estimating Leachate Concentrations

The in-situ leachate concentration for technetium-99 was used as the initial leachate concentration in the vadose zone fate and transport model to predict concentrations at the top of the Great Miami Aquifer. The preferred data for estimating contaminant concentrations in leachate was analyses of in situ leachate. When these data were unavailable, an approach of using the next best available data, TCLP results, was followed. However, in-situ leachate or TCLP analyses were not available for uranium-238 at the South Field, Inactive Flyash Pile, and Active Flyash Pile. Therefore, leachate concentration for uranium-238 was estimated from the ratio between waste concentration and distribution coefficient for the waste. Distribution coefficients for the uranium-238 were 180 L/Kg and 37.5 L/Kg for the South Field waste and flyash, respectively.

D.3.2.3 Parameters

A majority of the input parameters were directly taken from the Operable Unit 2 RI fate and transport modeling sections. Only critical parameters and parameters whose values have changed are discussed here. The most important parameter are the distribution coefficient and retardation factor. The retardation factors used in the FS modeling are the same as the ones used in the RI modeling. However, during SWIFT based Great Miami Aquifer model improvement, effective porosity in the saturated Great Miami Aquifer was changed from 25 percent to 30 percent. In order to hold the retardation factor for uranium-238 constant, the distribution coefficient was increased from 1.48 L/Kg to 1.78 L/Kg. Uranium-238 distribution coefficient for glacial overburden used in FS modeling was 200 L/Kg. This value remains unchanged from the RI modeling.

Till (Layer 1) thickness for the ODAST/SWIFTLOAD model was corrected to reflect that the impacted till is now included in the source term. Since contamination does not change flow properties of the impacted till, for the purposes of HELP model calculations, till thickness remained

the same as in the RI modeling unless the impacted till (above the cleanup level for the alternative) was removed.

The vertical hydraulic conductivity values for Layer 1 were obtained from the geometric average horizontal hydraulic conductivities of 1000-series wells completed in dark gray clay or clayey silt or from the maximum permeability measurements conducted on core samples. The vertical hydraulic conductivity for Layer 2 was obtained by dividing the horizontal hydraulic conductivity of the Great Miami Aquifer by 10. The factor of 10 represents a typical horizontal to vertical hydraulic conductivity ratio. Results of the recent South Plume pump test calculated aquifer values for vertical to horizontal hydraulic conductivity ratios from 0.07 to 10.7 (i.e., over a range which includes this value) (Parsons, 1993). The vertical hydraulic conductivity was estimated to be 2.4×10^{-6} to 1.4×10^{-7} centimeter per second (cm/sec) for Layer 1. The vertical hydraulic conductivity of Layer 2 was estimated to be 1.6×10^{-2} cm/sec for all of the Operable Unit 2 subunits/disposal cell.

D.3.2.4 Vadose Zone Modeling

Vadose zone modeling was performed by using the leachate concentrations as input into one-dimensional unsaturated flow model to simulate transport through the vadose zone to the Great Miami Aquifer. The One-Dimensional Analytical Solute Transport (ODAST) model was used to simulate dispersion, retardation, and decay through unsaturated materials. The HELP model was used to estimate infiltration rates. For estimating infiltration rate, it was assumed that the geomembrane water barrier will deteriorate and that the leachate collection system in the liner will be ineffective. Waste above each SWIFT III grid cell was modeled separately with individual stratigraphy, contaminant type and concentration, and infiltration rate parameters.

D.3.2.5 Great Miami Aquifer Modeling

The improved and calibrated groundwater flow model for the FEMP site was used to simulate the solute transport of COCs in the Great Miami Aquifer. The Operable Unit 2 fate and transport modeling involved incorporating the vadose zone modeling results (for the vadose zone and perched water infiltration pathways) to determine loading rates to the Great Miami Aquifer from the subunits or disposal areas. The model then simulated the transport of constituents away from these source areas. Dispersion, retardation, and decay were factored into the contaminant transport process. SWIFT III simulations of COC transport in the Great Miami Aquifer were run for up to 1000 years. Great Miami Aquifer modeling was performed only if COC concentrations at point of entry into the

Great Miami Aquifer, as predicted by ODAST/SWIFTLOAD, exceeded 10^{-7} lifetime cancer risk level.

The loading from each grid cell impacted by the subunit was entered into the SWIFT III model as a discrete source, making multiple sources for each constituent. Due to the proximity of the Inactive Flyash Pile to the South Field, sources from the Inactive Flyash Pile and South Field were combined into one SWIFT III run. The modeling runs produced simulations of the aggregate effects of loading from these two subunits for the COCs.

D.3.3 MODEL DESCRIPTIONS

A description of each of the models used in the groundwater fate and transport modeling is contained in the following sections.

D.3.3.1 HELP Model

Infiltration rates (seepage rate) through the waste to the Great Miami Aquifer for various conceptual models were calculated using the Hydraulic Evaluation of Landfill Performance (HELP) model. The HELP model (Schroeder, et al., 1988) is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of a waste unit. The model accepts climatologic, soil, and design data and simulates a number of hydraulic processes including surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage, and lateral drainage. The systems that can be modeled by the HELP model include various combinations of vegetation, cover soils, waste cells, drainage layers, and relatively impermeable barrier soils.

The HELP model is designed to perform water budget calculations for a system having as many as twelve layers. Each layer must be identified as either a vertical percolation, lateral drainage, barrier soil layer, or barrier soil layer with a geomembrane. Two barrier layers with or without geomembrane next to each other cannot be simulated in the HELP model. The identification of each layer used in the model is critical because the program models water flow through various types of layers in different ways. Runoff is calculated using the Soil Conservation Service (SCS) runoff curve number method by considering daily precipitation. Percolation and vertical water routing are modeled using Darcy's Law for saturated flow with modifications for unsaturated conditions. Evapotranspiration is estimated by a modified Penman method adjusted for limiting soil moisture conditions.

The HELP model output consists of input data echo, optional simulation details, and a summary of results. The input data echo includes all the information used for input including the values chosen from the model's built-in data base and manually input data. Following the input data echo, the program produces a table of daily results, monthly totals, and annual totals for each year if the option for detailed output was used. The summary includes average monthly totals, average annual totals, peak daily values on any day during the simulation period, and final moisture contents in all layers modeled. The average totals include precipitation, runoff, evapotranspiration, percolation, and lateral drainage for appropriate layers.

D.3.3.2 ODAST/SWIFTLOAD Model

The ODAST/SWIFTLOAD model was used in the Operable Unit 2 analysis to define vertical contaminant transport from contaminated soil or perched water to the Great Miami Aquifer. ODAST, which is a subroutine of SWIFTLOAD, evaluates the basic one-dimensional analytical solute transport equation as a function of seepage velocity, dispersion coefficient, source decay, retardation factor, depletion time, and source rate. SWIFTLOAD has been developed as a data processing program to create an appropriate input file for the SWIFT model and runs ODAST as a subroutine on a cell by cell basis (SWIFTLOAD used the same 120 by 112 grid as the SWIFT Great Miami Aquifer model). SWIFTLOAD reads an external file defining the layer thickness for each model cell and hydraulic and transport properties for each block.

The ODAST computer code is based on the solution originally developed by Ogata and Banks (1961) and calculates the normalized concentrations of a given constituent in a uniform flow field from a source having a constant or varying concentration in the initial layer. ODAST has been extensively verified against STRIP1B (Batu 1989).

The ODAST model implements an analytical solution to the partial differential equation

$$D\frac{\partial^2 C}{\partial x^2} - V\frac{\partial C}{\partial x} - \lambda RC = R\frac{\partial C}{\partial t}$$

where

C = solute concentration (mass/volume)
and with the constant coefficients
D = dispersion coefficient (length^2/time)

V = seepage velocity (length/time)
R = retardation factor (dimensionless)
λ = solute decay factor (time^{-1})

The solution must satisfy the initial and boundary conditions

$$C(x,0) = 0$$

$$-D\frac{\partial C}{\partial x} + VC\,|_{x=0} = \begin{cases} VC_0\, e^{-\alpha t}, & 0 \le t \le \tau_0 \\ 0, & t > \tau_0 \end{cases}$$

$$\frac{\partial C}{\partial x}\Big|_{x\to\infty} = 0$$

where the constants

C_o = initial source concentration (mass/vol)
α = source depletion factor (time^{-1})
τ_o = source depletion time (time)

The solution is obtained using a Laplace transform technique and involves products of exponential and complementary error functions (Javandel et al. 1984). The solution for C is divided by C_0 to yield normalized concentrations.

Because the coefficients in the governing equation are constant and the solution must satisfy a zero concentration gradient condition as x approaches infinity, ODAST is only strictly applicable to one-dimensional transport in homogeneous, semi-infinite media. However, the present application of ODAST is intended only to provide conservative estimates of aquifer mass loading histories.

ODAST model runs can be executed for only one constituent at a time, and the solution may be applied over any arbitrary segment of a waste area that is judged to contain an unchanging subsurface. A superposition technique is used to combine calculations for the two homogeneous layers comprising the vadose zone conceptual model. The ODAST solution at the bottom of layer 1 is divided into 1000 small time steps and a layer 2 run is performed for each of these steps. Each of these layer 2 runs assumes no source decay, a recharge period 1/1000 of the total modeling time, and a source concentration equal to the averaged layer 1 solution for that time period. The solution at the bottom

of layer 2 is obtained by summing the results of the 1000 layer 2 runs at specified time steps. For RI/FS modeling, concentrations are calculated for up to 1000 years, typically in steps of 20 years. Constituents that migrate quickly, such as technetium-99, require smaller time steps for accurate representation of loading curves.

Input parameters for ODAST are the dispersion coefficient, seepage velocity, retardation factor, source depletion time, solute decay factor, and source depletion factor. These are discussed below:

- Seepage velocity and the dispersion coefficient depend upon the characteristics of the waste area and the vadose zone medium. Seepage velocity is calculated as an empirical function of the percolation rate obtained from the HELP model, saturated hydraulic conductivity, and porosity (US EPA 1988). The dispersion coefficient is obtained as an empirical function of seepage velocity (Biggar and Nielsen 1976).

- The retardation factor accounts for transport delays due to reversible reactions between the chemical constituent and the vadose zone solid matrix. It is thus dependent on both solute and medium characteristics, and is calculated as a function of the constituent's partitioning coefficient and the vadose zone bulk density and moisture content (Walton 1984 and Mills et al. 1985).

- The solute decay factor is constituent dependent. This parameter accounts for biodegradation in organics and radioactive decay in radionuclides, and is zero for stable inorganics.

- Source depletion time and factor control the mass flux history of the constituent at the top of the modeled layer. Based on the upstream boundary condition, source mass flux decays exponentially. To calculate depletion time and factor for the waste at the top of layer 1, the time dependent expression for mass flow from the source is integrated from zero to the source depletion time. This integral is equated to the depleted mass of the constituent to provide a single equation in two unknowns. A second equation is obtained by arbitrarily specifying a mass depletion fraction. This is the level (very close to, but less than one) at which the source is declared depleted; technically, the source is depleted only as time approaches infinity. As stated previously, depletion factor is zero and depletion time is 1/1000 of the total modeling time for the layer 2 runs.

D.3.3.3 SWIFT Model

The SWIFT model is used for simulating three dimensional contaminant transport in the Great Miami Aquifer. The SWIFT code is a fully coupled, transient, 3-dimensional finite-difference model for groundwater flow and transport through both porous and fractured media. The mass transport equations solved include terms for convection, dispersion, retardation by sorption, and decay or degradation of the contaminant. The SWIFT code, originally developed by Sandia National Laboratory in the late 1970s for the High Level Waste Program, has been revised several times to

increase its capability and to change computer platforms. These revisions include the addition of fractured media, a free water surface, extended boundary conditions, conversion to Fortran 77, extended options for matrix solutions and post processing. GEOTRANS (1991) has converted SWIFT for use on 386 and 486 Personal Computers (PCs) and made additional changes to improve user friendliness and input and output control, the most recent version being SWIFT 2.52 (GEOTRANS 1992).

SWIFT was selected from among several codes for use in developing a flow and transport model of the Great Miami Aquifer in the vicinity of the FEMP. Subsequent to selection of the code, SWIFT code was specifically verified for use at the FEMP (IT 1990). A model of the Great Miami Aquifer (using SWIFT) was originally developed and calibrated from 1988 through 1990 (DOE 1993a). This model building effort consisted of

- Development and calibration of 2-D and 3-D regional flow models
- Development and calibration on a telescoped and more refined grid of a 3-D flow model of the FEMP and its adjacent areas
- Development and calibration of 2-D and 3-D solute transport models on the more refined grid.

The original model consisted of five layers. The two uppermost layers represented the upper and lower parts of the upper Great Miami Aquifer, the middle layer includes a clay interbed that is present beneath the FEMP site and the lower two layers represent the lower Great Miami Aquifer. The layers extended laterally into bedrock at the edges of the buried valley that contains the aquifer. This original FEMP steady-state flow model was calibrated to 1986 water elevation data.

Since that time, additional data have been collected, new wells have been installed, and a large scale pumping test (South Plume Pumping Test) has been conducted. Based on these factors and agency comments, a model improvement program was initiated (DOE 1993b). The essential elements of this model improvement program were completed in March 1994 (DOE 1994c). The Operable Unit 2 Feasibility Study modeling makes use of this "improved" model.

The model improvement program consisted of:

- The model grid for steady-state flow and solute transport was expanded. The previous solute transport grid of 78 cells by 102 cells was enlarged by adding a band of

approximately 5250 feet wide along the eastern side and a band approximately 1250 feet wide along the northern side. The new grid contains 120 x 112 cells, each 125 feet square. The layering of the model also has been refined. The five layers of the original model have been replaced with six layers to better match existing well screen elevations. This allowed field data to be more accurately depicted and provided better vertical control over contaminant dispersion.

- Geostatistical analysis has been conducted to understand and correlate the spatial distribution of key data sets. These data sets include the water elevation data and the uranium analytical data from the 2000-, 3000- and 4000-series monitoring wells. Calculations included the sample semivariogram, and kriging and cokriging estimators along with their estimation variance. This analysis was used to help determine calibration criteria and to identify areas of the site where lower confidence exists in the analyzed data sets.

- A transient flow calibration was performed using the South Plume Pumping Test results. Parameter values for porosity and rock compressibility were developed from this calibration. Because of the scale and orientation of the pumping test wells, a telescoped grid (25 foot cell size) was created in the south plume area to effectively simulate the results of the pumping test.

- A steady-state flow calibration was conducted using the expanded and reconstructed steady-state grid. Steady-state heads were matched to the established calibration criteria. This recalibrated steady-state model is the primary model used for flow and solute transport simulations.

- The solute transport model was recalibrated to determine reasonable values of K_d (for uranium) and dispersivity for a representative source loading. The range of acceptable uranium K_d values has been established by reviewing site data related to K_d and by reviewing sensitivity runs of previously utilized K_d values corresponding to retardation factors of 9 and 12.

- The historical source loading terms were decoupled from the model and monitoring data are used to define initial conditions of uranium concentrations. Results from the glacial overburden and Paddys Run models are used to define future loading terms.

- Sensitivity analysis was performed on horizontal hydraulic conductivity (K_h), ratio between horizontal hydraulic conductivity and vertical hydraulic conductivity (K_h/K_v), porosity, uranium distribution coefficient, dispersivity (α) in order to understand the effect of variation of these parameters on the maximum concentration and transport of a normalized plume.

- Quality assurance/quality control procedures for modeling were defined to control and confirm the quality of the modeling effort.

New data sets have been used in the construction and calibration of the model. In summary, new data sets include:

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- Monitoring data from the 1990 to 1993 time period;
- Monitoring data from new wells installed since original calibration;
- Results of additional aquifer analysis to define K_d;
- Geostatistical analysis of data sets;
- Results from the South Plume Pumping Test;
- Results from construction and operation of the South Plume Recovery Well System; and
- Output from additional models (glacial overburden, surface water) to define hydraulic and solute loading terms.

Model simulations of the improved site SWIFT model were performed using a Silicon Graphics Computer (Unix based). Simulation execution times for 1000 year solute transport runs varied between 30 and 40 hours. These 1000 year simulations generated extremely large output files and require peripheral hardware. Output was written to files from which relevant data was extracted using data manipulation programs written for that purpose. Contour plots were made using SURFER for selected constituents at different simulation times. Report graphics were imported into Intergraph Work Stations for preparation of final graphics.

D.3.4 Modeling Results

D.3.4.1 Solid Waste Landfill

The alternative modeled was the consolidation/containment with off-site disposal. Only a small quantity of soil was considered for off-site disposal. Therefore, for the purposes of fate and transport modeling, it was assumed that all the waste will remain on-site. Figure D.3-3 shows the SWIFT III grid blocks directly beneath the waste at the Solid Waste Landfill after consolidation and containment. The only COC for groundwater was technetium-99. Technetium-99 was not detected in the till, therefore, no till was included in the source term. Technetium-99 was not detected in the perched water, therefore, the perched water infiltration pathway was not considered for this alternative.

The vadose zone model depicting flow in the subsurface soils at the Solid Waste Landfill considers two layers. Layer 1 soils consist of tills, 31 to 38 feet thick. Within the till is interbedded sand and gravel stringers with thicknesses of 0.5 to 6 feet containing perched water were not considered as a

part of Layer 1 of the vadose zone pathway. Beneath the till layer at the Solid Waste Landfill is the 19 to 25 feet thick unsaturated sand and gravel layer (Layer 2). Table D.3-1 provides the physical parameters of various layers for each of the blocks modeled. The HELP model was used to estimate infiltration through the clay cap. Output from the HELP model is included in Attachment 1. Infiltration through the cap was estimated to be 1.14 inch/year. Infiltration is controlled by the cap and glacial overburden properties have negligible influence on the infiltration rate.

Table D.3-2 lists the COC inventory in waste, predicted maximum leachate concentration, predicted maximum concentration from vadose zone Layer 2 (maximum loading concentration to the Great Miami Aquifer), seepage rates, and screening concentrations. Screening levels have been developed based on a 10^{-7} lifetime risk of cancer and provide a basis for understanding the risk to human health from the ingestion of water from the Great Miami Aquifer at the hypothetical receptor location. Figure D.3-4 shows the loading curve for technetium-99 to the Great Miami Aquifer. The predicted maximum loading concentration was 29.9 pCi/L. Mass loading to the Great Miami Aquifer remains constant after 500 years.

The groundwater fate and transport modeling results for Operable Unit 2 Feasibility Study are summarized in Table D.3-3. The table presents the maximum loading concentration, the maximum concentrations of the COC that would be expected in the aquifer within 1000 years and the time required for the COC to reach the maximum value. It also presents the predicted maximum concentration at the FEMP fence line. The maximum predicted technetium-99 concentration was 0.18 pCi/L. This concentration is below the screening level, i.e., the maximum cancer risk due technetium-99 in groundwater is less than 10^{-7}. Contour plot for projected increases in the concentrations of technetium-99, at the time of on-site maximum concentrations (660 years) is shown in Figure D.3-5. These figures shows that technetium-99 migration is towards the east. Due to constant loading from 660 years to 1000 years, Figure D.3-5 also represents technetium-99 concentrations from 660 years to 1000 years.

D.3.4.2 Lime Sludge Ponds

No groundwater COCs were determined from the Baseline Risk Assessment for Lime Sludge Ponds. Therefore, no groundwater modeling was performed for the Lime Sludge Ponds.

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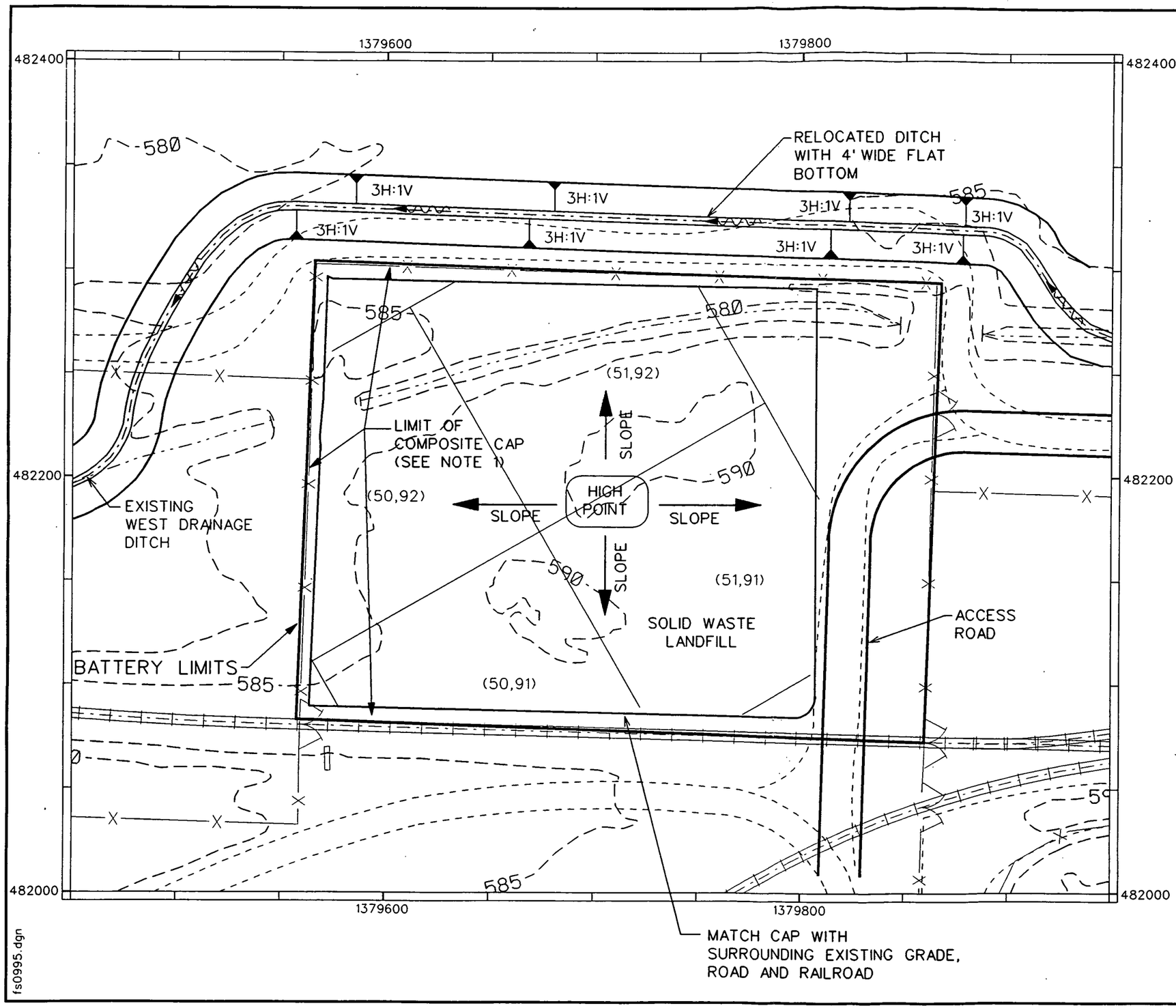


LEGEND

- ELEVATION CONTOURS
- ROADS
- STREAM
- DRAINAGE WAY
- BATTERY LIMITS
- FENCE
- RAILROAD
- (51,91) SWIFT GRID (COLUMN,ROW)

NOTE 1

FOR COMPOSITE CAP DETAIL, REFER TO APPENDIX E.

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

SCALE (FT)
0 25 50 100

SCALE (METER)
0 6 12 24

FIGURE D.3-3
SWIFT GRID AT
SOLID WASTE LANDFILL
CONSOLIDATION/CONTAINMENT

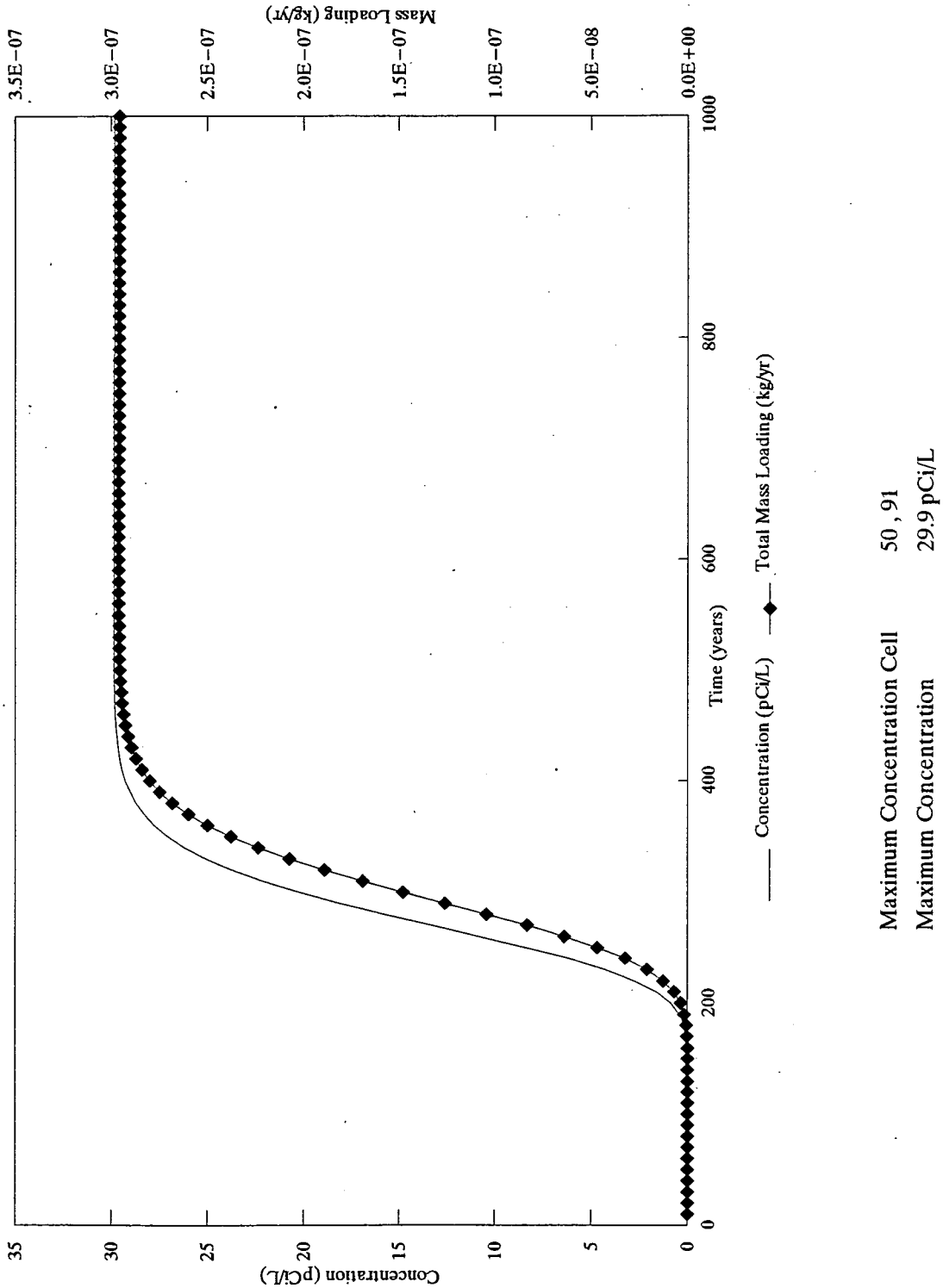
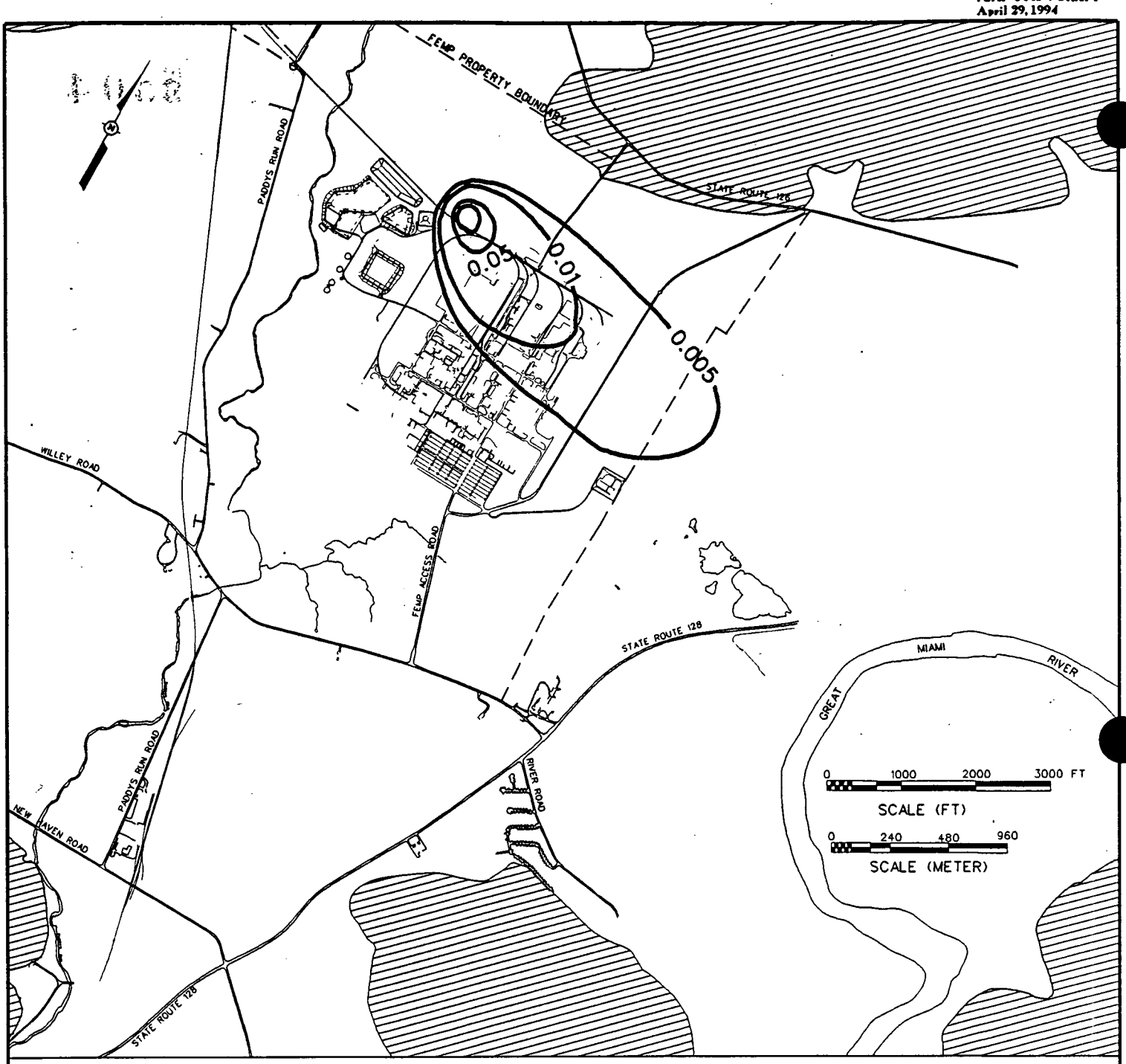


Figure D.3 – 4 Technetium – 99 loading to the Great Miami Aquifer from the Solid Waste Landfill after consolidation/containment



LEGEND:

0.1 CONCENTRATION CONTOUR (pCi/L)

BEDROCK

FIGURE D.3-5
PROJECTED INCREASE IN TECHNETIUM-99 CONCENTRATIONS IN THE GREAT MIAMI AQUIFER FROM 660 TO 1000 YEARS DUE TO LOADING FROM THE SOLID WASTE LANDFILL

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TABLE D.3-1

PARAMETERS FOR SWIFT CELLS IMPACTED
BY SOLID WASTE LANDFILL WASTE AFTER CONSOLIDATION/CONTAINMENT AND
OFF-SITE DISPOSAL

Row	Column	Waste Volume (ft^3)	TC-99 Concentration (pCi/g)	TC-99 Waste Inventory (Kg)	TC-99 Leachate Concentration (pCi/L)	Waste Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration Rate (in/year)
50	91	85200	0.754	3.33	30.0	9.8	31.1	21.7	1.14
50	92	73100	0.754	2.86	30.0	7.8	32.9	19.4	1.14
51	91	126300	0.754	4.94	30.0	9.0	33.8	23.5	1.14
51	92	105200	0.754	4.11	30.0	13.3	34.5	20.6	1.14

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TABLE D.3-2

SUMMARY OF VADOSE ZONE RESULTS FOR OPERABLE UNIT 2

Subunit or Disposal Area	Alterative	COC[a]	Screening Concentration (pCi/L)	Initial Waste Inventory (Kg)	Initial Maximum Leachate Concentration (pCi/L)	Time of Max. (years)	Loading Concentration from ODAST (pCi/L)	Max. Infiltration Rate in Waste Area	Max. Seepage Velocity in Layer 1 (in/yr)	Max. Seepage Velocity in Layer 2 (in/yr)
Solid Waste Landfill	Consolidation/containment and off-site disposal	Tc-99	0.27	15	30	520	29.9	1.14	3.1	60.2
Active Flyash Pile	Consolidation/containment	U-238	0.17	190	0.04	1000	4.0E-29	1.14	2.8	25.8
South Field/Inactive Flyash Pile	Perched water subsurface seep pathway	U-238	0.17	10,240	1,880	60	1,709	93.6	NA[c]	478
South Field/Inactive Flyash Pile	Removal to 60 pCi/g on terrace and to background elsewhere	U-238	0.17	2,100	207	1000	1.6E-48	2.60	6.2	18.3
South Field/ Inactive Flyash Pile	No removal on terrace and removal to background elsewhere	U-238	0.17	3,000	226	1000	1.6E-48	2.60	6.2	18.3
South Field/ Inactive Flyash Pile	Removal to 60 pCi/g on terrace and to 5 pCi/g elsewhere (on-site disposal alternatives)	U-238	0.17	3,400	207	760	25.1	9.61	21.9	60.2
South Field/Inactive Flyash Pile	Consolidation/containment with residual soils at 5 pCi/g	U-238	0.17	12,700	5880	740	25.1	9.61	21.9	60.2
Disposal Cell	On-site disposal without soil treatment	U-238	0.17	24,300	5980	NB[b]	0	3.06	7.3	21.3

[a]COC - Containment of Concern

[b]NB - No breakthrough

[c]NA - Not applicable

TABLE D.3-3

SUMMARY OF MODELING RESULTS FOR OPERABLE UNIT 2

Subunit or Disposal Area	Alterative	COC[a]	Concentration Unit	Maximum Loading Concentration to GMA	On-Site Maximum		FEMP Fenceline Maximum		Maximum Concentration at 1000 years
					Time (Years)	Concentration	Time (Years)	Concentration	
Solid Waste Landfill	Consolidation/ containment and off-site disposal	Technetium-99	pCi/L	29.9	660	0.18	720	0.006	0.18
Active Flyash Pile	Consolidation/ Containment	Uranium-234	pCi/L	3.7E-29	-[a]	-	-	-	-
		Uranium-235/236	pCi/L	1.9E-30	-	-	-	-	-
		Uranium-238	pCi/L	4.0E-29	-	-	-	-	-
		Uranium-total	ug/L	1.2E-28	-	-	-	-	-
South Field/Inactive Flyash Pile	Perched water subsurface seep pathway	Uranium-234	pCi/L	1555	80	275	160	14.2	-
		Uranium-235/236	pCi/L	82	80	14.5	160	0.75	-
		Uranium-238	pCi/L	1709	80	303	160	15.6	-
		Uranium-total	ug/L	5125	80	909	160	46.8	-
South Field/Inactive Flyash Pile	Removal to 60 pCi/g on terrace and to background elsewhere	Uranium-234	pCi/L	1.5E-48	-	-	-	-	-
		Uranium-235/236	pCi/L	7.8E-50	-	-	-	-	-
		Uranium-238	pCi/L	1.6E-48	-	-	-	-	-
		Uranium-total	ug/L	4.9E-48	-	-	-	-	-
South Field/Inactive Flyash Pile	No removal on terrace and removal to background elsewhere	Uranium-234	pCi/L	1.5E-48	-	-	-	-	-
		Uranium-235/236	pCi/L	7.8E-50	-	-	-	-	-
		Uranium-238	pCi/L	1.6E-48	-	-	-	-	-
		Uranium-total	ug/L	4.9E-48	-	-	-	-	-
South Field/Inactive Flyash Pile	Removal to 60 pCi/g on terrace and to 6 pCi/g elsewhere (on-site disposal alternatives)	Uranium-234	pCi/L	22.8	460	0.87	460	0.14	0.79
		Uranium-235/236	pCi/L	1.2	460	0.05	460	0.01	0.04
		Uranium-238	pCi/L	25.1	460	0.96	460	0.15	0.86
		Uranium-total	ug/L	75.2	460	2.87	460	0.46	2.59

See footnotes at end of table

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TABLE D.3-3
(Continued)

Subunit or Disposal Area	Alterative	COC[a]	Concentration Unit	Maximum Loading Concentration to GMA	On-Site Maximum		FEMP Fenceline Maximum		Maximum Concentration at 1000 years
					Time (Years)	Concentration	Time (Years)	Concentration	
South Field/Inactive Flyash Pile	Consolidation/ Containment with residual soils at 5 pCi/g	Uranium-234	pCi/L	22.8	460	0.94	460	0.17	0.84
		Uranium-235/236	pCi/L	1.2	460	0.05	460	0.01	0.04
		Uranium-238	pCi/L	25.1	460	1.03	460	0.18	0.93
		Uranium-total	ug/L	75.2	460	3.08	460	0.54	2.78
OU-2 Disposal Cell	On-site disposal without soil treatment	Uranium-234	pCi/L	0.0	-	-	-	-	-
		Uranium-235/236	pCi/L	0.0	-	-	-	-	-
		Uranium-238	pCi/L	0.0	-	-	-	-	-
		Uranium-total	ug/L	0.0	-	-	-	-	-

[a]COC - Containment of Concern

[b]NB - No breakthrough

D.3.4.3 Active Flyash Pile

The alternative modeled was the consolidation/containment. Figure D.3-6 shows the SWIFT III grid blocks directly beneath the flyash from the Active Flyash Pile after consolidation and containment. The only COCs for groundwater were uranium isotopes. Impacted till was included in the source term. Only the vadose zone pathway was applicable for this alternative.

The vadose zone model depicting flow in the subsurface soils at the Active Flyash Pile containment area considers two layers. Layer 1 soils consist of tills, 11 to 13 feet thick. Interbedded sand and gravel stringers containing perched water within the till were not considered as a part of Layer 1 of the vadose zone pathway. Beneath the till layer is the 30 to 33 feet thick unsaturated sand and gravel layer (Layer 2). Table D.3-4 provides the physical parameters of various layers for each of the blocks modeled. The HELP model was used to estimate infiltration through the clay cap. Output from the HELP model is included in Attachment 1. Infiltration through the cap was estimated to be 1.14 inch/year.

Table D.3-2 lists the COC inventory in waste, predicted maximum leachate concentration, predicted maximum concentration from vadose zone Layer 2 (maximum loading concentration to the Great Miami Aquifer), seepage rates, and screening concentrations. The predicted maximum uranium-238 loading concentration was 4×10^{-29} pCi/L. Due to very low loading concentration, further modeling was not performed. Table D.3-3 shows predicted results for other uranium isotopes. These results were scaled form the uranium-238 results.

D.3.4.4 Inactive Flyash Pile/South Field

Figure D.3-7 shows the areal extent of the waste in the South Field/Inactive Flyash Pile and the SWIFT III grid cells impacted by direct loading from these subunits. Impact of the perched water subsurface seeps on the Great Miami Aquifer and three alternatives were modeled for the South Field/Inactive Flyash Pile. The lithology of the South Field/Inactive Flyash Pile area is variable with the southwestern portion containing virtually no tills, while the till thicknesses increases to 22 feet towards the northeastern side. The thickness of the unsaturated zone in the Great Miami Aquifer (Layer 2) ranges from 16 to 33 feet. Therefore, the vadose zone model depicting flow in the subsurface soils at the South Field/Inactive Flyash Pile used two layers in the area where till is present and used one layer (unsaturated Great Miami Aquifer) where till is not present. The HELP

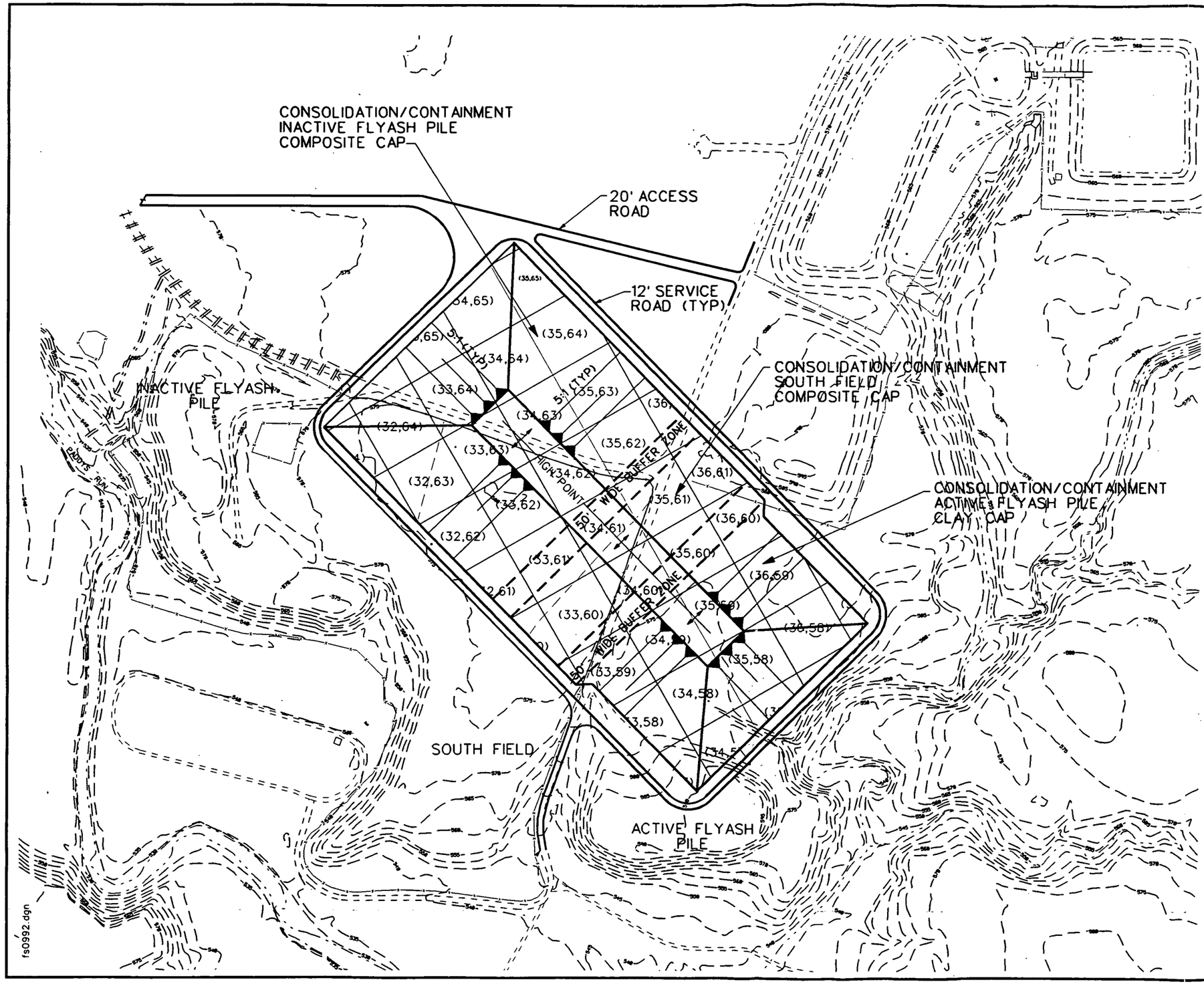
model was used to estimate infiltration through the residual soils and the composite cap. Results from the HELP are presented in Attachment 1.

D.3.4.4.1 Impact of the Perched Water Subsurface Seep Pathway

Fate and transport modeling for the Operable Unit 2 RI indicated that the perched water subsurface seep pathway has a major impact on the Great Miami Aquifer. This modeling scenario quantifies the impact of the perched water subsurface seep pathway on the Great Miami Aquifer. Figure D.3-7 identifies eight grid cells that may receive perched water from the subsurface seep pathways. Figure D.3-8 shows the conceptual model for perched water subsurface seeps. Perched water has been observed in 0 to 3 - feet. (0 to 1 - meter) thick sand and gravel layers in the glacial overburden. Perched water not only represents a source for vertical infiltration, but it also serves as a source for the surface seeps and subsurface seeps. As shown in Figure D.3-8, perched water moves laterally in the sand/gravel layer until it is intercepted at the sand/gravel and waste interface. At that point, perched water moves along the slope of waste and till interface until it comes in contact with the unsaturated Great Miami Aquifer. The subsurface seep water then vertically infiltrates to the aquifer. The travel time for lateral movement of the perched water was assumed to be small compared to the travel time for the vertical movement of the perched water.

The source term for the perched water subsurface seep pathways included uranium-238 in perched water as well as uranium-238 adsorbed in the sand and gravel in the glacial overburden underneath the Inactive Flyash Pile and South Field. Table D.3-5 shows the physical parameters for this simulation. Table D.3-2 shows that the predicted maximum uranium-238 loading concentration for the Great Miami Aquifer was 1670 pCi/L. Figure D.3-9 shows the loading curve for uranium-238 to the Great Miami Aquifer due to perched water subsurface seep pathway.

The groundwater fate and transport modeling results for Operable Unit 2 Feasibility Study are summarized in Table D.3-3. The maximum predicted uranium-238 concentration in the Great Miami Aquifer was 303 pCi/L, and maximum concentration at the FEMP fence line was 15.6 pCi/L. The maximum uranium-238 concentration on-site and at the FEMP fence line were predicted to occur at 80 and 160 years, respectively. Figures D.3-10 and D.3-11 show the projected increase in uranium-238 concentrations due the perched water subsurface seep pathways at 80 and 160 years, respectively. As noted earlier, total uranium, uranium-234, and uranium 235/236 concentrations were estimated from the results of uranium-238 modeling.



LEGEND

- 575 ELEVATION CONTOURS
- 575 PROPOSED CONTOURS
- ROADS
- PROPOSED ROADS
- STREAM
- FENCE
- RAILROAD
- (35,64) SWIFT GRID (COLUMN,ROW)

NOTE:
Surface contours based on 1992 flyover.

SCALE (FT)
0 100 200 400

SCALE (METER)
0 24 48 96

FIGURE D.3-6
SITE RESTORATION
CONSOLIDATION/CONTAINMENT
SWIFT MODEL GRID
FOR INACTIVE
FLYASH PILE, SOUTH FIELD,
AND ACTIVE FLYASH PILE

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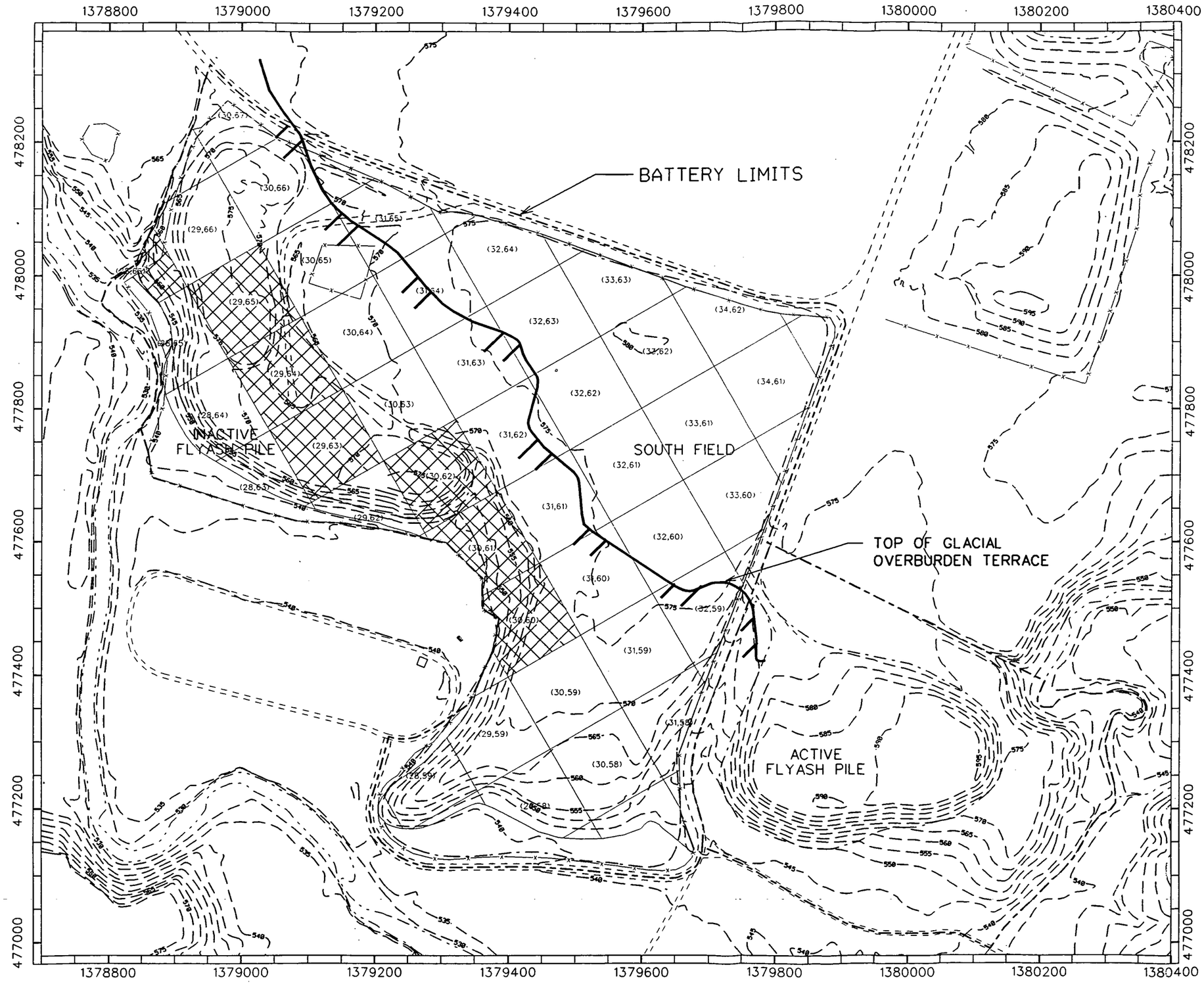

LEGEND

- 575 — ELEVATION CONTOURS
- ROADS
- STREAM
- FENCE
- TOP OF GLACIAL OVERBURDEN TERRACE
- SWIFT MODEL CELL (COLUMN, ROW)
- SWIFT MODEL CELL RECEIVING PERCHED WATER SUBSURFACE SEEPS.

NOTE:
Coordinates are in State Planar NAD 1927.
Surface contours based on 1992 flyover.

N

SCALE (FT)
0 150 300

SCALE (METER)
0 36 72

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FIGURE D.3-7
SWIFT MODEL GRID
AT INACTIVE FLYASH PILE
AND SOUTH FIELD

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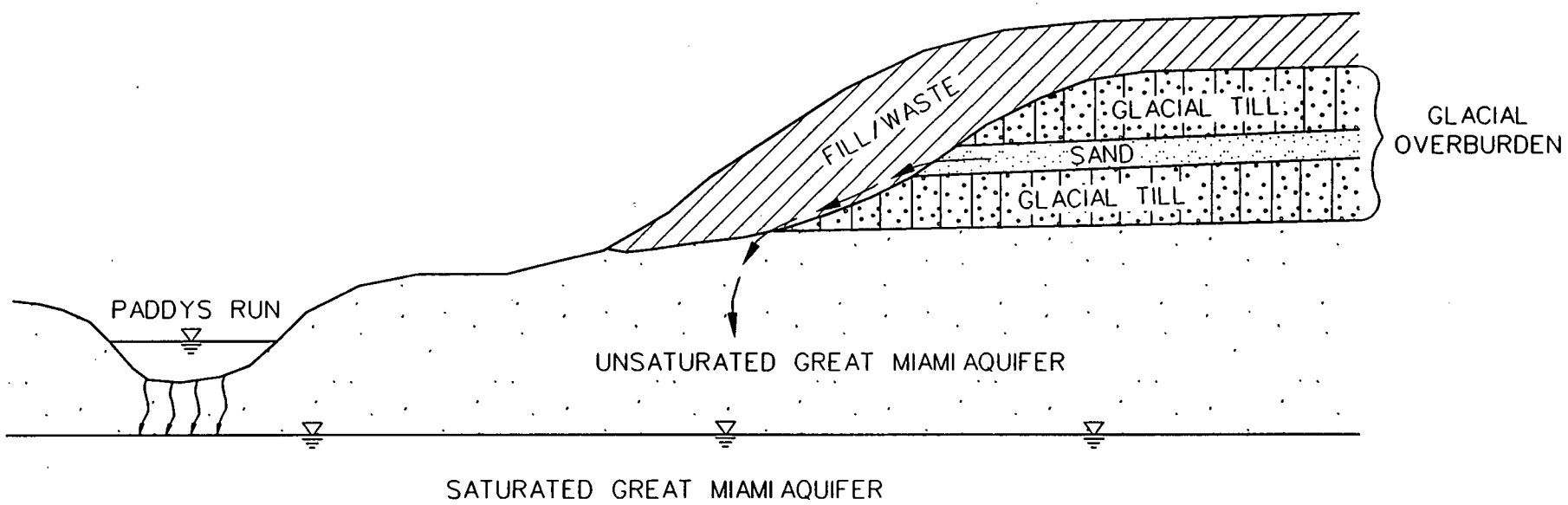

FIGURE D.3-8
CONCEPTUAL MODEL FOR PERCHED WATER SUBSURFACE SEEPS

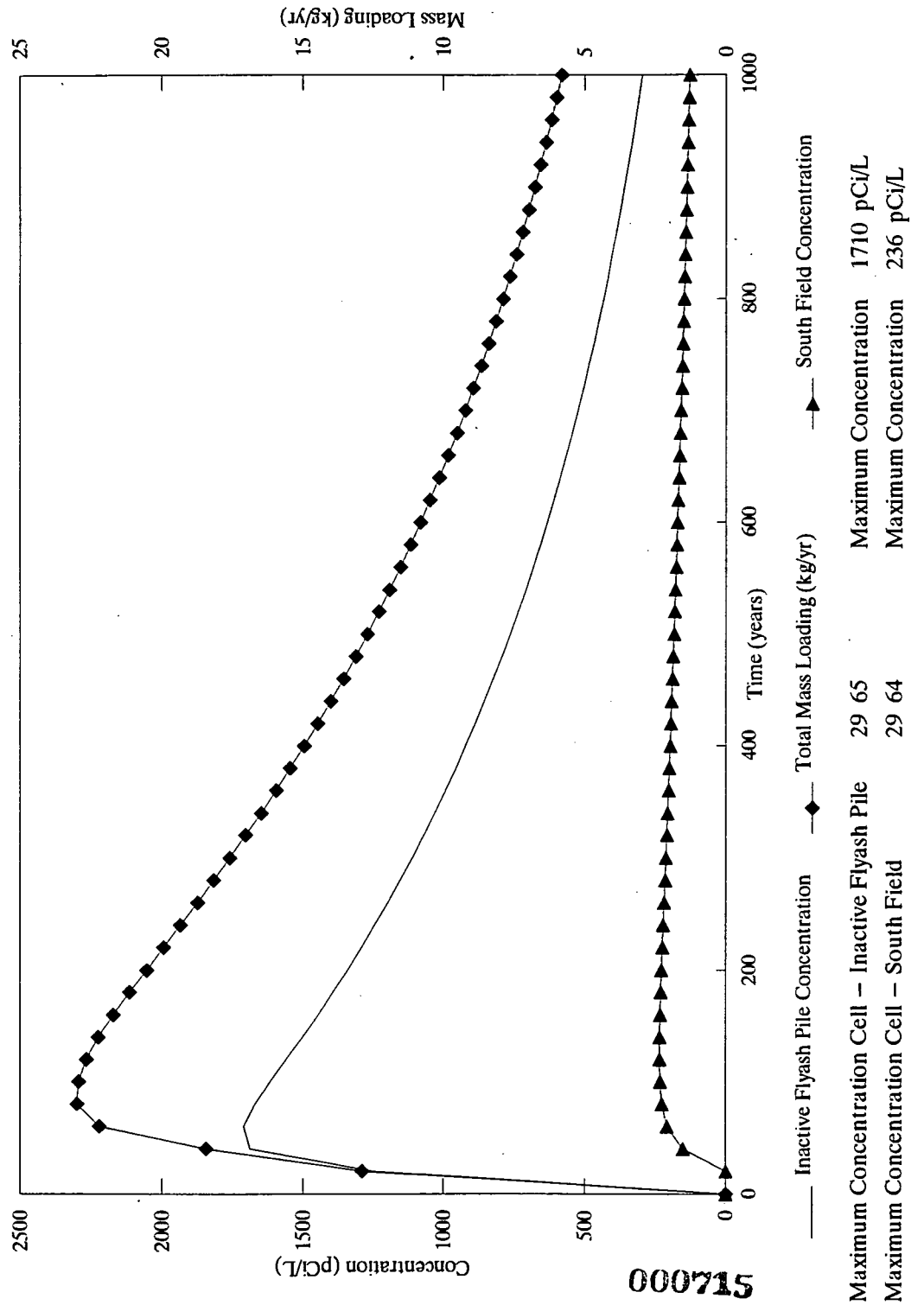

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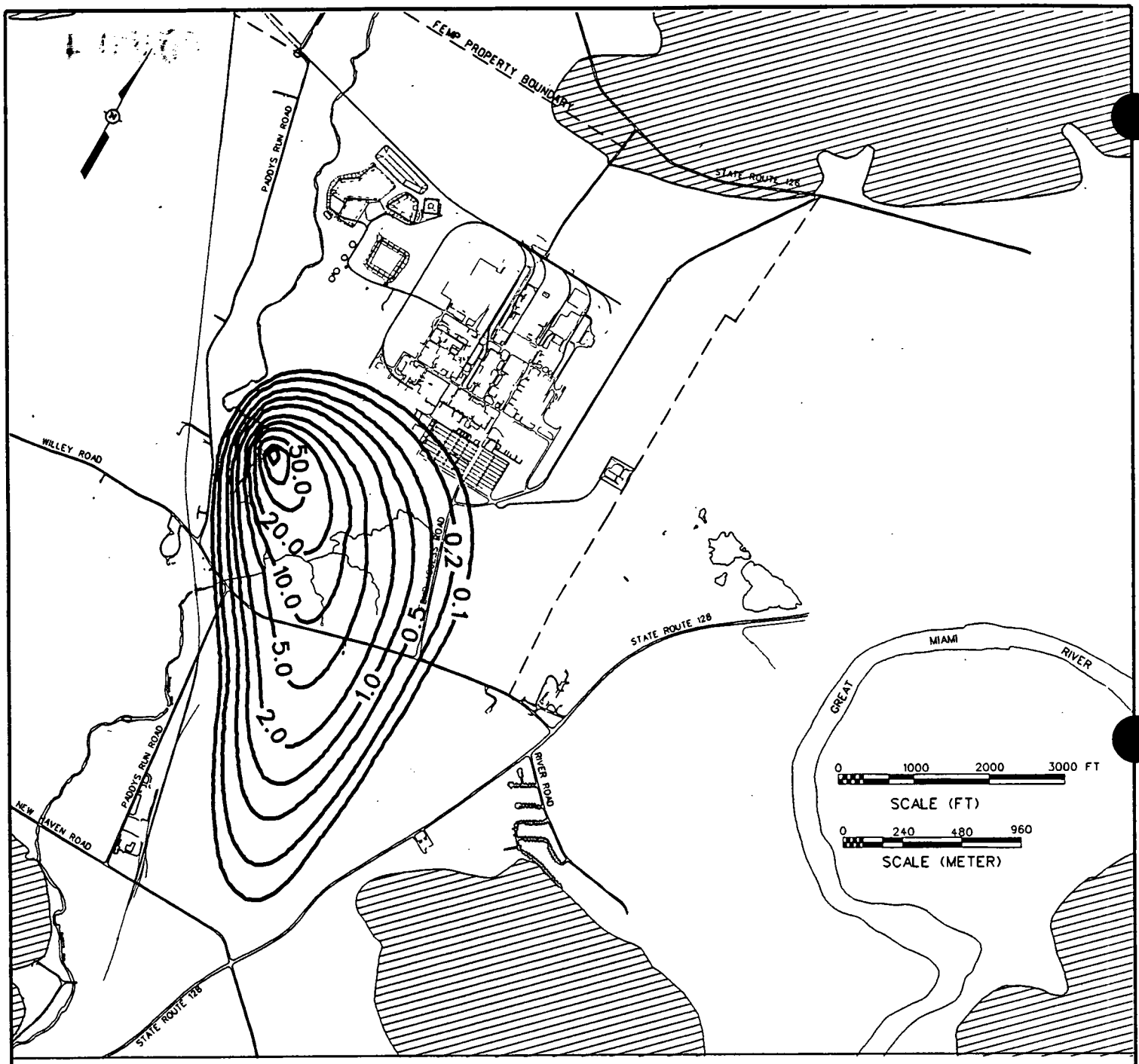
Figure D.3–9 Uranium–238 Loading to the Great Miami Aquifer from the South Field / Inactive Flyash Pile for Perched Water Subsurface Seep Pathway



LEGEND:

0.1 CONCENTRATION CONTOUR (pCi/L)

BEDROCK

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FIGURE D.3-10
PROJECTED INCREASE IN URANIUM-238 CONCENTRATIONS IN THE GREAT MIAMI AQUIFER AT 80 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE/SOUTH FIELD VIA SUBSURFACE PATHWAY

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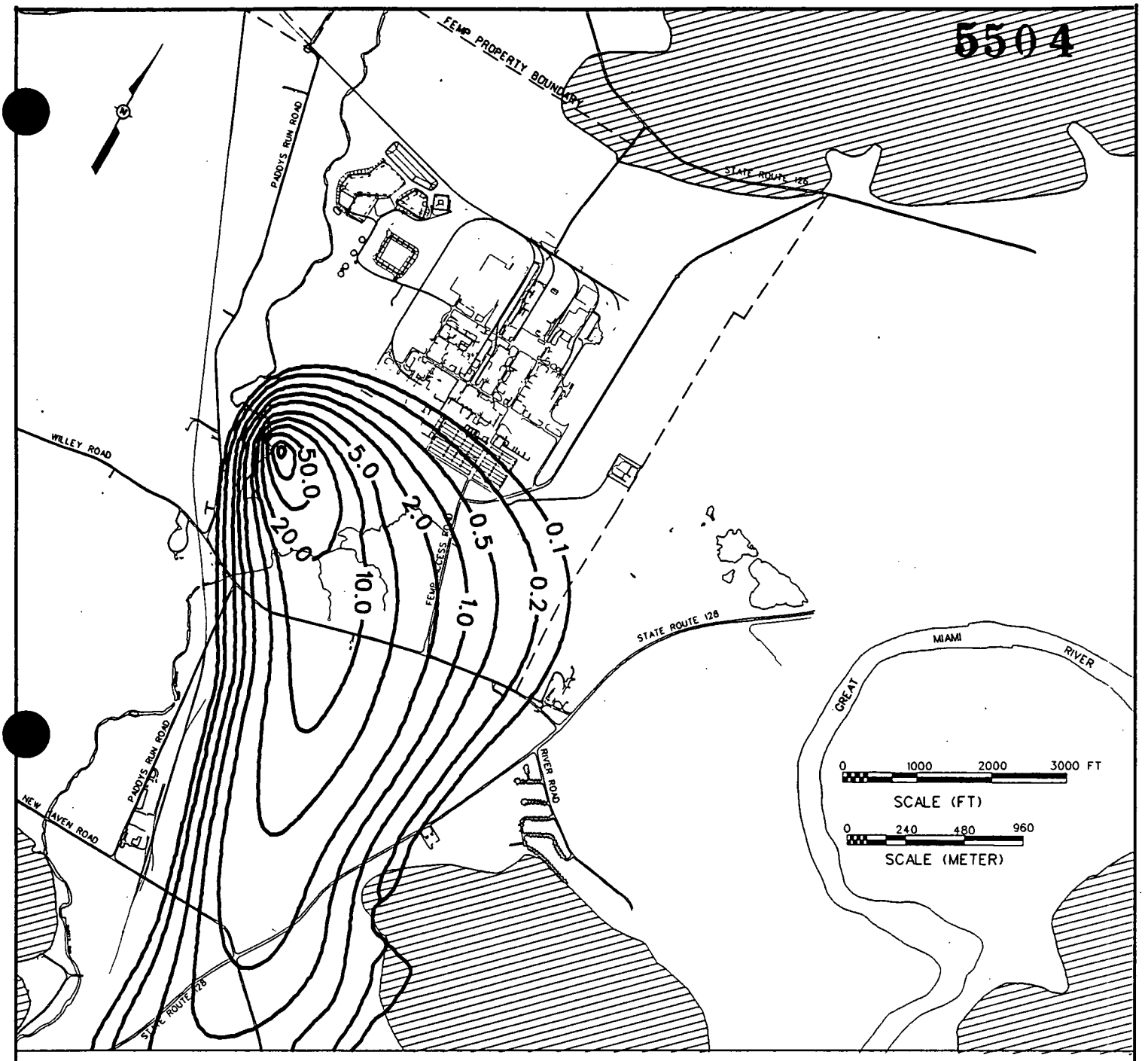

LEGEND:

0.1 CONCENTRATION CONTOUR (pCi/L)

BEDROCK

FIGURE D.3-11
PROJECTED INCREASE IN URANIUM-238 CONCENTRATIONS IN THE GREAT MIAMI AQUIFER AT 160 YEARS DUE TO LOADING FROM THE INACTIVE FLYASH PILE/SOUTH FIELD VIA SUBSURFACE PATHWAY

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TABLE D.3-4

PARAMETERS FOR THE SWIFT CELLS IMPACTED BY THE ACTIVE FLYASH PILE WASTE AFTER CONSOLIDATION/CONTAINMENT OPERABLE UNIT 2 REMEDIAL INVESTIGATION

Row	Column	U-238 Concentration (pCi/L)	U-238 Leachate Concentration (pCi/L)	U-238 Waste Inventory (Kg)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration Rate (in/year)
33	58	8.0	4.44E-02	188	11.0	30.8	1.14
34	57	8.0	4.44E-02	188	13.0	30.5	1.14
34	58	8.0	4.44E-02	188	13.0	32.5	1.14
34	59	8.0	4.44E-02	188	13.0	32.5	1.14
35	57	8.0	4.44E-02	188	12.0	30.5	1.14
35	58	8.0	4.44E-02	188	12.5	31.5	1.14
35	59	8.0	4.44E-02	188	12.5	32.5	1.14
36	58	8.0	4.44E-02	188	11.0	32.0	1.14
36	59	8.0	4.44E-02	188	12.5	32.0	1.14

TABLE D.3-5

PARAMETERS FOR THE SWIFT CELLS AFTER REMOVAL OF WASTE TO 60 pCi/g ON TOP OF TERRACE AND TO BACKGROUND ELSEWHERE, SOUTH FIELD AND INACTIVE FLYASH PILE

Row	Column	Perched Water Concentration (pCi/L)	Flow Rate		Unsaturated GMA Thickness (H)
			Gallons/Minute	Inch/Year	
28	66	1880	0.44	23.6	21.3
29	62	257	0.15	8.1	18.5
29	63	257	0.45	24.4	20.8
29	64	257	0.77	41.8	25.5
29	65	1880	1.73	93.6	24.8
30	60	257	0.20	10.9	29.0
30	61	257	0.40	21.7	24.8
30	62	257	0.40	21.7	24.1

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Table D.3-3 and Figures D.3-9 through D.3-11 indicate that uranium-238 concentrations due to perched water subsurface seeps alone may exceed 10^{-5} cancer risk level and total uranium concentration may exceed MCL (20 ug/l). Therefore, perched water lateral migration should be controlled. For the remaining alternatives it will be assumed that perched water lateral migration engineering control will be used and therefore, the perched water subsurface seep pathway and seep pathway will not be included in the modeling. However, the perched water still represents a source for vertical infiltration, and was modeled.

D.3.4.4.2 Removal to 60 pCi/g on the Top of Terrace and Removal to Background Elsewhere

Figure D.3.7 shows the areal extent of the waste in the South Field/Inactive Flyash Pile and the SWIFT III grid cells impacted by direct loading from these subunits. For this alternative, waste containing uranium-238 at concentrations greater than 60 pCi/g on the top of the terrace was assumed to be removed. Furthermore, all sources directly on the Great Miami Aquifer or on the terrace face was assumed to removed. It was assumed that the perched water lateral migration will be controlled and therefore will not require seepage modeling. However, the perched water still represents a source for vertical infiltration and was modeled. Table D.3-6 shows the physical parameters for this alternative. Table D.3-2 shows that the predicted maximum uranium-238 loading concentration to the Great Miami Aquifer was 1.6×10^{-48} pCi/L. Due to very low loading concentration, further modeling was not performed. Table D.3-3 shows predicted results for other uranium isotopes. These results were scaled from the uranium-238 results. Fate and transport modeling indicates that impact to the Great Miami Aquifer from waste on the top of the terrace is negligible in 1000 years.

D.3.4.4.3 No Removal on Top of Terrace and Removal to Background Elsewhere

Figure D.3-7 shows the areal extent of the waste in the South Field/Inactive Flyash Pile and the SWIFT III grid cells impacted by direct loading from these subunits. For this alternative, only the waste and impacted till on the sloping face of the glacial till (terrace) and the waste directly on the Great Miami Aquifer were assumed to be removed. The fate and transport modeling assumed that the lateral migration of the perched water will be controlled and therefore will not require seepage modeling. However, the perched water still represents a source for vertical infiltration, and was modeled. Table D.3-7 shows the physical parameters for this alternative. Table D.3-2 shows that the predicted maximum uranium-238 loading concentration to the Great Miami Aquifer was 1.6×10^{-48} pCi/L. Due to very low loading concentration, further modeling was not performed. Table D.3-3 shows predicted results for other uranium isotopes. These results were scaled from the uranium-238

TABLE D.3-6

PARAMETERS FOR THE SWIFT CELLS AFTER REMOVAL OF WASTE TO 60 pCi/g ON TOP OF TERRACE AND TO BACKGROUND ELSEWHERE, SOUTH FIELD AND INACTIVE FLYASH PILE

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 1 - ALL SOURCE MATERIAL REMOVED										
28	59	No	0	0.00	0.0	0	0.0	0.0	16.7	
28	63	No	0	0.00	0.0	0	0.0	0.0	18.9	
28	64	No	0	0.00	0.0	0	0.0	0.0	19.7	
28	65	No	0	0.00	0.0	0	0.0	0.0	19.6	
28	66	No	0	0.00	0.0	0	0.0	0.0	21.3	
29	58	No	0	0.00	0.0	0	0.0	0.0	18.2	
29	59	No	0	0.00	0.0	0	0.0	0.0	20.2	
29	60	No	0	0.00	0.0	0	0.0	0.0	25.4	
29	62	No	0	0.00	0.0	0	0.0	0.0	18.5	
29	63	No	0	0.00	0.0	0	0.0	0.0	20.8	
29	64	No	0	0.00	0.0	0	0.0	0.0	25.5	
29	65	No	0	0.00	0.0	0	0.0	0.0	24.8	
29	66	No	0	0.00	0.0	0	0.0	2.0	32.0	
29	67	No	0	0.00	0.0	0	0.0	3.5	32.5	
30	57	No	0	0.00	0.0	0	0.0	0.0	21.3	
30	58	No	0	0.00	0.0	0	0.0	0.0	21.7	
30	59	No	0	0.00	0.0	0	0.0	2.5	28.2	
30	60	No	0	0.00	0.0	0	0.0	3.0	29.0	
30	61	No	0	0.00	0.0	0	0.0	0.0	24.8	

See footnote at end of table

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TABLE D.3-6
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 1 - ALL SOURCE MATERIAL REMOVED (Continued)										
30	62	No	0	0.00	0.0	0	0.0	0.0	24.1	
30	63	No	0	0.00	0.0	0	0.0	0.0	24.8	
30	64	No	0	0.00	0.0	0	0.0	0.4	26.4	
30	65	No	0	0.00	0.0	0	0.0	6.1	27.3	
30	66	No	0	0.00	0.0	0	0.0	7.1	28.6	
30	67	No	0	0.00	0.0	0	0.0	3.9	29.7	
31	58	No	0	0.00	0.0	0	0.0	2.0	29.6	
31	59	No	0	0.00	0.0	0	0.0	7.8	31.4	
31	60	No	0	0.00	0.0	0	0.0	8.6	31.6	
31	61	No	0	0.00	0.0	0	0.0	6.8	30.8	
31	62	No	0	0.00	0.0	0	0.0	7.5	30.1	
31	63	No	0	0.00	0.0	0	0.0	8.2	29.5	
ZONE 2 - 16 TO 18 FEET OF NOT IMPACTED TILL, LESS THAN 3.5 FEET OF SOURCE										
34	62	Yes	31242	37.19	181.2	207	2.0	16.9	31.5	
35	61	Yes	4687	23.18	16.9	129	2.2	17.9	32.2	
34	60	Yes	9374	3.19	4.7	18	2.3	16.6	32.7	
33	63	Yes	46872	23.70	173.2	132	3.0	17.7	30.6	
33	62	Yes	51562	28.49	229.0	158	3.3	16.1	31.1	
Zone 2 Average			28747	23.15	-[a]	-	2.6	17.0	31.6	1.04

See footnote at end of table

TABLE D.3-6
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 3 - 10 TO 12 FEET OF TILL, 8 TO 11 FEET OF SOURCE										
32	59	Yes	110938	2.28	37.6	13	8.9	10.2	32.5	
32	60	Yes	121875	2.81	51.1	16	8.5	11.1	32.3	
31	64	Yes	162502	6.18	148.6	34	10.7	11.1	29.1	
32	61	Yes	126563	3.30	62.3	18	8.3	12.3	31.4	
32	62	Yes	157812	9.75	228.1	54	10.2	12.3	30.7	
Zone 3 Average			135938	4.86	-	-	9.3	11.4	31.2	2.60
ZONE 4 - 12 TO 16 FEET OF TILL, 6 TO 10 FEET OF SOURCE										
31	65	Yes	89062	13.02	175.5	72	6.3	12.5	28.6	
33	59	Yes	9377	2.37	3.4	13	6.0	13.0	33.0	
31	66	Yes	93749	19.25	273.8	107	6.0	13.7	28.7	
32	63	Yes	154688	7.84	179.8	44	10.1	13.7	30.1	
33	60	Yes	85936	2.09	27.4	12	5.7	14.4	32.7	
33	61	Yes	95313	3.45	49.6	19	6.5	15.9	31.8	
34	61	Yes	104687	10.80	170.7	60	6.6	16.1	32.1	
32	64	Yes	96876	2.64	38.5	15	7.0	16.2	29.6	
Zone 4 Average			91211	7.68	-	-	6.8	14.4	30.8	2.18

[a]Not calculated and not required.

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TABLE D.3-7

PARAMETERS FOR THE SWIFT CELLS WITH NO REMOVAL OF WASTE ON THE TOP OF TERRACE AND TO BACKGROUND ELSEWHERE, SOUTH FIELD AND INACTIVE FLYASH PILE

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 1 - ALL SOURCE MATERIAL REMOVED										
28	59	No	15.6	0.00	0	0	0.0	0.0	16.7	
28	63	No	15.2	0.00	0	0	0.0	0.0	18.9	
28	64	No	21.3	0.00	0	0	0.0	0.0	19.7	
28	65	No	15.2	0.00	0	0	0.0	0.0	19.6	
28	66	No	3.5	0.00	0	0	0.0	0.0	21.3	
29	58	No	11.0	0.00	0	0	0.0	0.0	18.2	
29	59	No	20.7	0.00	0	0	0.0	0.0	20.2	
29	60	No	1.4	0.00	0	0	0.0	0.0	25.4	
29	62	No	16.2	0.00	0	0	0.0	0.0	18.5	
29	63	No	24.5	0.00	0	0	0.0	0.0	20.8	
29	64	No	18.3	0.00	0	0	0.0	0.0	25.5	
29	65	No	25.5	0.00	0	0	0.0	0.0	24.8	
29	66	No	15.2	0.00	0	0	0.0	2.0	32.0	
29	67	No	3.6	0.00	0	0	0.0	3.5	32.5	
30	57	No	0.1	0.00	0	0	0.0	0.0	21.3	
30	58	No	10.5	0.00	0	0	0.0	0.0	21.7	
30	59	No	14.8	0.00	0	0	0.0	2.5	28.2	
30	60	No	6.4	0.00	0	0	0.0	3.0	29.0	

See footnote at end of table

TABLE D.3-7
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 1 - ALL SOURCE MATERIAL REMOVED (Continued)										
30	61	No	1.6	0.00	0	0	0.0	0.0	24.8	
30	62	No	18.7	0.00	0	0	0.0	0.0	24.1	
30	63	No	18.9	0.00	0	0	0.0	0.0	24.8	
30	64	No	15.7	0.00	0	0	0.0	0.4	26.4	
30	65	No	7.5	0.00	0	0	0.0	6.1	27.3	
30	66	No	9.9	0.00	0	0	0.0	7.1	28.6	
30	67	No	8.9	0.00	0	0	0.0	3.9	29.7	
31	58	No	5.7	0.00	0	0	0.0	2.0	29.6	
31	59	No	8.4	0.00	0	0	0.0	7.8	31.4	
31	60	No	7.8	0.00	0	0	0.0	8.6	31.6	
31	61	No	9.6	0.00	0	0	0.0	6.8	30.8	
31	62	No	8.6	0.00	0	0	0.0	7.5	30.1	
31	63	No	10.4	0.00	0	0	0.0	8.2	29.5	
ZONE 2 - ZERO TILL, LESS THAN 5 FEET OF SOURCE										
35	61	Yes	0.2	23.18	16.9	129	4.2	17.9	32.2	
34	60	Yes	0.3	3.19	4.7	18	4.3	16.6	32.7	
31	66	Yes	0.9	19.25	277.3	107	4.9	13.7	28.7	
Zone 2 Average			0.5	15.21	-[a]	-	4.5	16.1	31.2	1.92

See footnote at end of table

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TABLE D.3-7
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 3 - 6 to 9 FEET OF SOURCE										
32	59	Yes	4.9	2.28	37.6	13	8.9	10.2	32.5	
32	60	Yes	4.5	2.81	51.1	16	8.5	11.1	32.3	
32	63	Yes	6.2	7.84	179.8	44	10.2	13.7	30.1	
31	64	Yes	6.7	6.18	148.6	34	10.7	11.1	29.1	
32	61	Yes	4.3	3.30	62.3	18	8.3	12.3	31.4	
32	62	Yes	6.2	9.75	228.1	54	10.2	12.3	30.7	
Zone 3 Average			5.5	5.36	-	-	9.5	11.8	31.0	2.60
ZONE 4 - 4 to 6 FEET OF SOURCE										
31	65	Yes	2.3	13.02	175.5	72	6.3	12.5	28.6	
33	59	Yes	2.0	2.37	3.4	13	6.0	13.0	33.0	
33	63	Yes	2.4	28.14	342.8	156	6.4	17.7	30.6	
33	62	Yes	4.1	40.65	812.0	226	8.1	16.1	31.1	
34	62	Yes	2.8	37.19	371.5	207	6.8	16.9	31.5	
33	60	Yes	1.8	2.09	27.4	12	5.8	14.4	32.7	
33	61	Yes	2.5	3.45	49.6	19	6.5	15.9	31.8	
34	61	Yes	2.6	10.80	170.7	60	6.6	16.1	32.1	
32	64	Yes	3.0	2.64	38.5	15	7.0	16.2	29.6	
Zone 4 Average			2.6	15.60	-	-	6.6	15.4	31.2	21.13

[a]Not Calculated and not required.

results. Fate and transport modeling indicates that impact to the Great Miami Aquifer from waste on the top of the terrace is negligible in 1000 years.

D.3.4.4.4 Removal to 60 pCi/g on Top of Terrace and to 5 pCi/g Elsewhere

Figure D.3-7 shows the areal extent of the waste in the South Field/Inactive Flyash Pile and the SWIFT III grid cells impacted by direct loading from these subunits. For this alternative, waste containing uranium-238 at concentrations greater than 60 pCi/g on the top of the terrace was assumed to removed and disposed at the Operable Unit 2 disposal cell. Furthermore, any waste or impacted till on the sloping face of the glacial till (face of the terrace) or waste directly on the Great Miami Aquifer at concentrations exceeding 5 pCi/g were also assumed to be removed. The fate and transport modeling assumed that the lateral migration of the perched water will be controlled and therefore will not require seepage modeling. However, the perched water still represents a source for vertical infiltration, and was modeled. Table D.3-8 shows the physical parameters for this alternative. Table D.3-2 shows that the predicted maximum uranium-238 loading concentration to the Great Miami Aquifer was 25 pCi/L. Figure D.3-12 shows the loading curve for uranium-238 to the Great Miami Aquifer. The maximum mass loading rate occurs at 460 years.

The groundwater fate and transport modeling results for Operable Unit 2 Feasibility Study are summarized in Table D.3-3. The maximum predicted uranium-238 concentration in the Great Miami Aquifer was 0.94 pCi/L. Figures D.3-13 and D.3-14 show the projected increase in uranium-238 concentrations due to the South Field and Inactive Flyash Pile at 460 and 1000 years, respectively. The maximum uranium-238 concentrations on-site and at the FEMP fence line were predicted to occur at 460 years. As noted earlier, total uranium, uranium-234, and uranium-235/236 concentrations were estimated from the results of uranium-238 modeling.

D.3.4.4.5 Consolidation/Containment with Residual Soils at 5 pCi/g

Figure D.3-7 shows the areal extent of the South Field/Inactive Flyash Pile waste containment area and the SWIFT III grid cells impacted by direct loading from it. For this alternative, waste containing uranium-238 at concentrations greater than 5 pCi/g was consolidated and contained as shown in Figure D.3-7. The fate and transport modeling assumed that the lateral migration of the perched water will be controlled and therefore will not require seepage modeling. However, the perched water still represents a source for vertical infiltration, and was modeled. Table D.3-9 shows the physical parameters for this alternative. Table D.3-2 shows that the predicted maximum

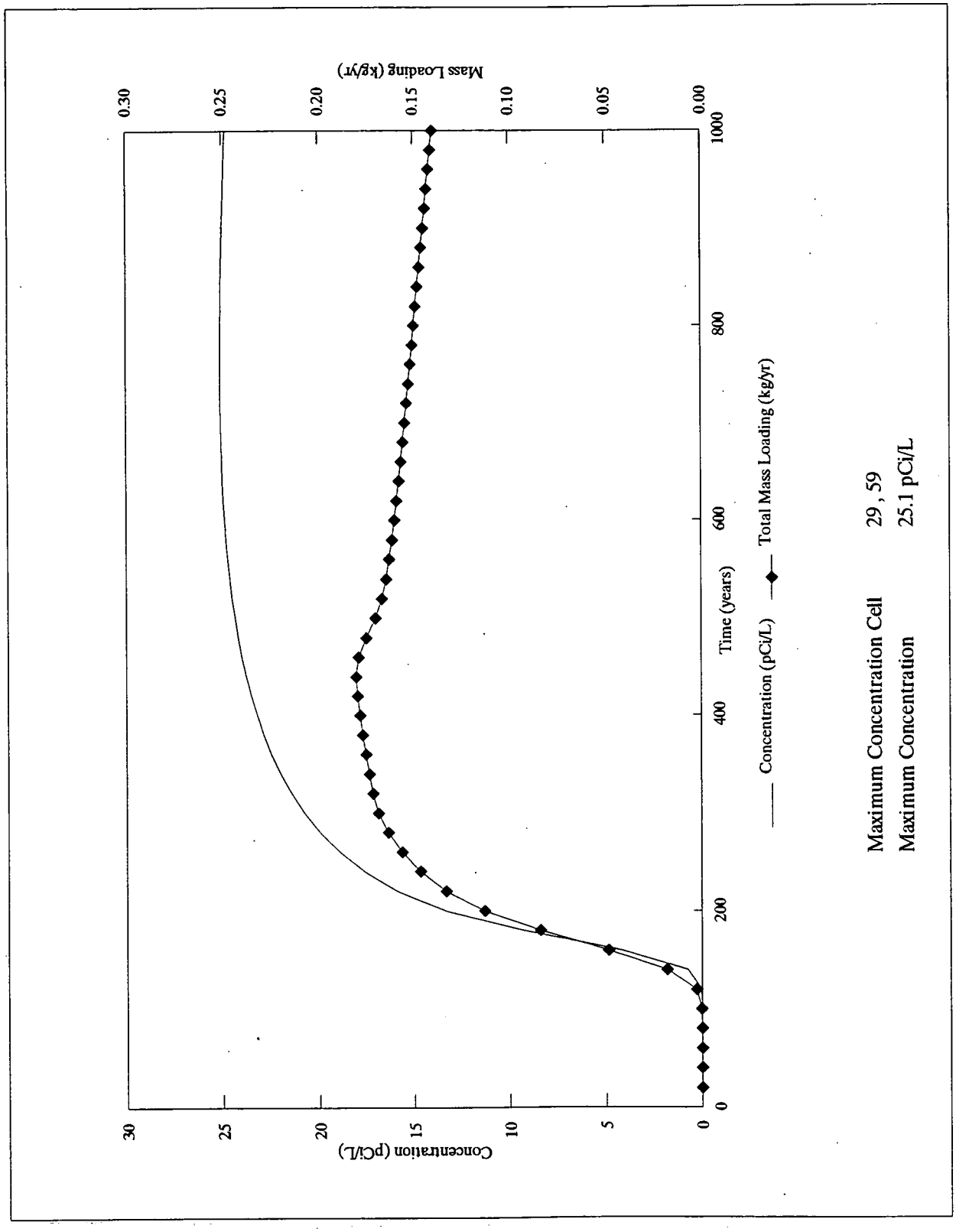

Figure D.3–12 Uranium–238 Loading to the Great Miami Aquifer from the South Field / Inactive Flyash Pile for On–site Disposal Alternative

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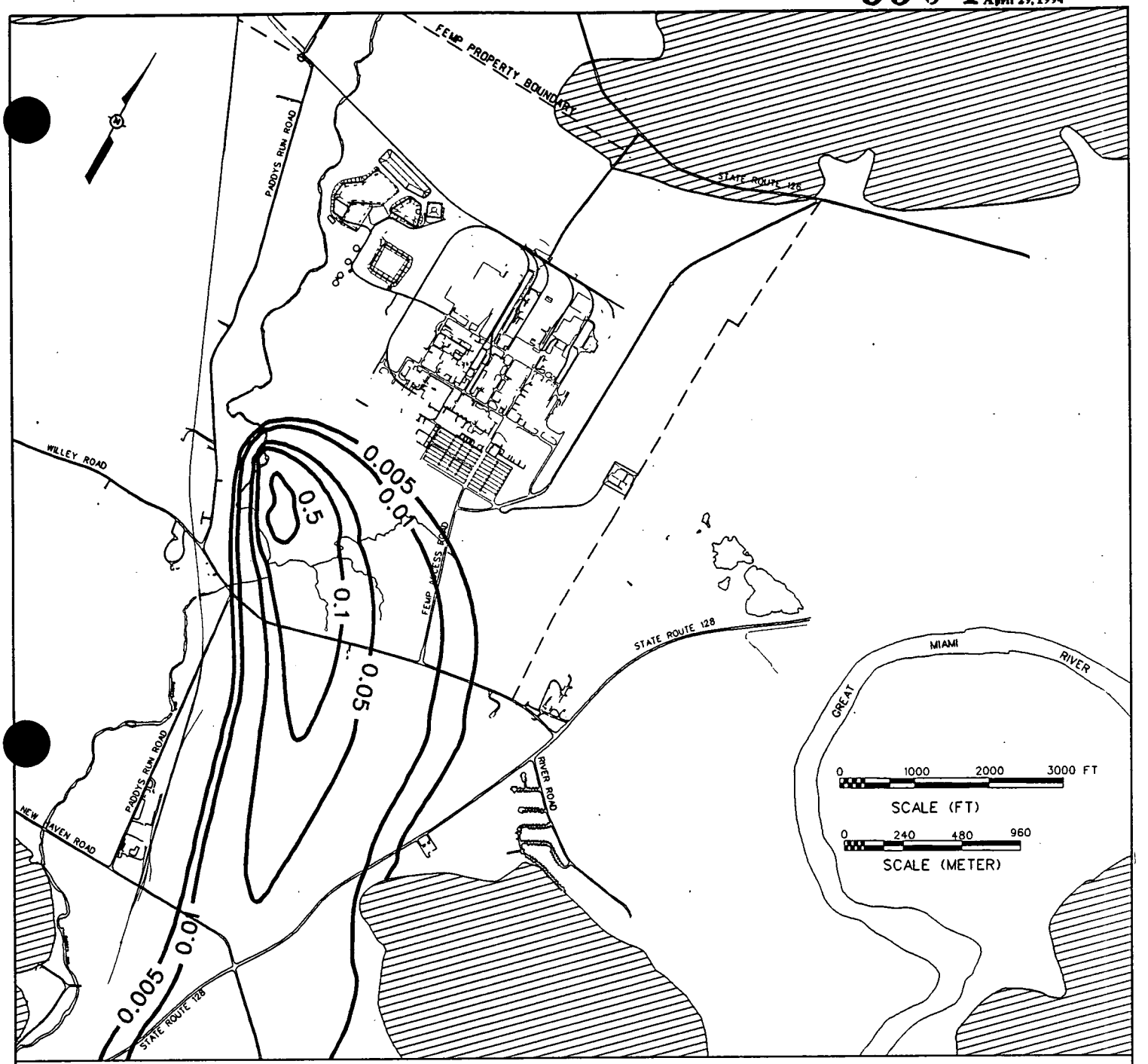

LEGEND:

0.1 CONCENTRATION CONTOUR (pCi/L)

BEDROCK

FIGURE D.3-13
PROJECTED INCREASE IN URANIUM-238 CONCENTRATIONS IN THE GREAT MIAMI AQUIFER AT 460 YEARS DUE TO LOADING FROM THE SOUTH FIELD/INACTIVE FLYASH PILE FOR ON-SITE DISPOSAL ALTERNATIVE

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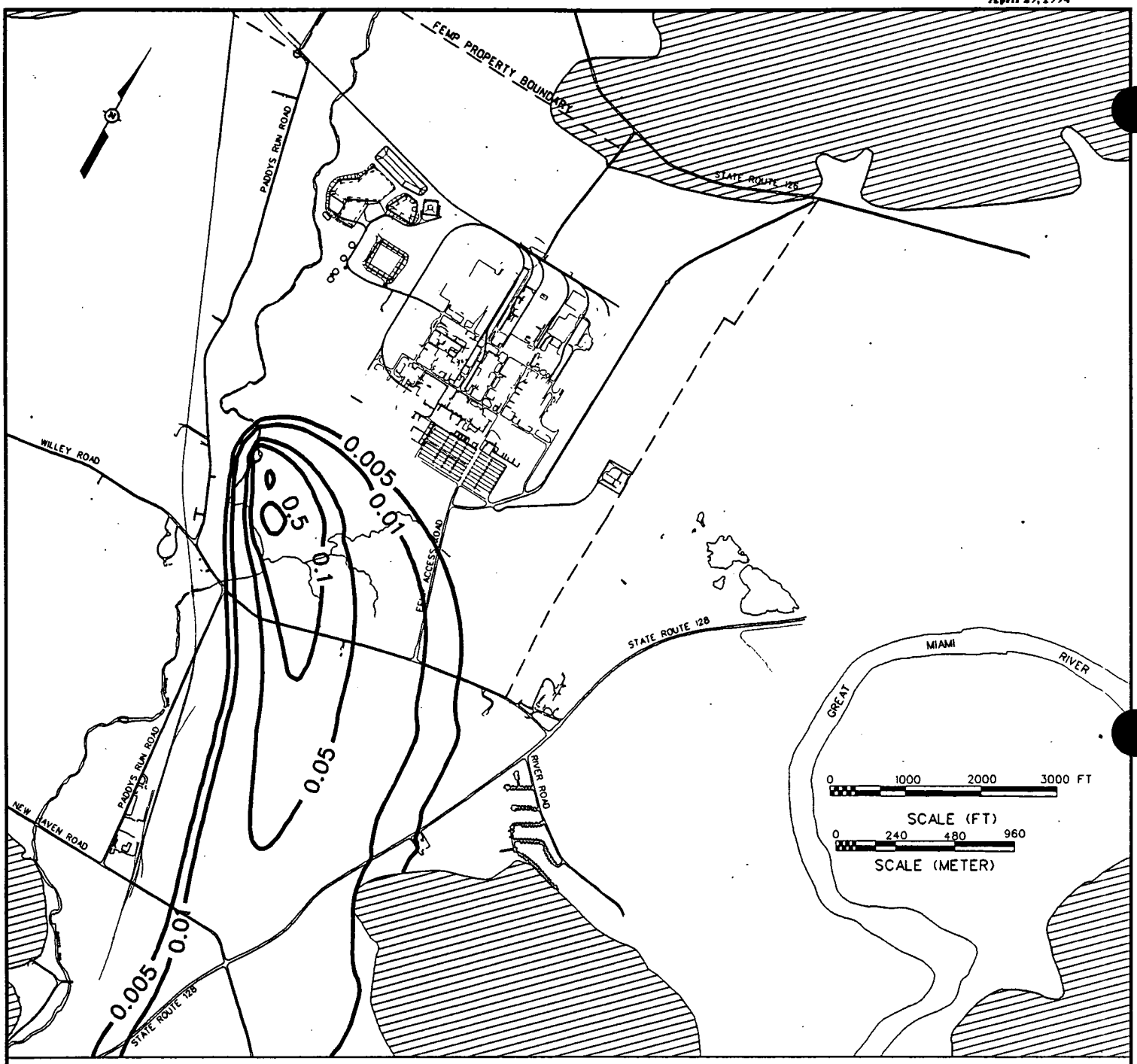

LEGEND:

0.1 CONCENTRATION CONTOUR (pCi/L)

BEDROCK

FIGURE D.3-14
PROJECTED INCREASE IN URANIUM-238 CONCENTRATIONS IN THE GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE SOUTH FIELD/INACTIVE FLYASH PILE FOR ON-SITE DISPOSAL ALTERNATIVE

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TABLE D.3-8

PARAMETERS FOR THE SWIFT CELLS AFTER REMOVAL OF WASTE TO 60 pCi/g ON THE TOP OF TERRACE AND TO 5 pCi/g ELSEWHERE, SOUTH FIELD AND INACTIVE FLYASH PILE

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 1 - ALL SOURCE MATERIAL REMOVED										
28	64	No	0	0.00	0	0	0.0	0.0	19.7	
28	66	No	0	0.00	0	0	0.0	0.0	21.3	
30	57	No	0	0.00	0	0	0.0	0.0	21.3	
28	63	No	0	0.00	0	0	0.0	0.0	18.9	
30	62	No	0	0.00	0	0	0.0	0.0	24.1	
29	64	No	0	0.00	0	0	0.0	0.0	25.5	
29	65	No	0	0.00	0	0	0.0	0.0	24.8	
29	66	No	0	0.00	0	0	0.0	2.0	32.0	
30	65	No	0	0.00	0	0	0.0	6.1	27.3	
30	66	No	0	0.00	0	0	0.0	7.1	28.6	
ZONE 2 - ZERO TILL, LESS THAN 5 FEET OF SOURCE										
30	61	No	10930	5.00	8.5	2.78E+01	0.7	0.0	24.8	
30	58	No	42190	5.00	32.9	2.78E+01	2.7	0.0	21.7	
29	62	No	57823	5.00	45.1	2.78E+01	3.7	0.0	18.5	
29	60	No	4687	1.90	1.4	1.05E+01	4.3	0.0	25.4	
28	65	No	68761	5.00	53.6	2.78E+01	4.4	0.0	19.6	
Zone 2 Average			36878	4.38	-[a]	-	3.2	0.0	22.0	9.61

See footnote at end of table

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TABLE D.3-8
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 3 - ZERO TILL, 10 TO 20 FEET OF SOURCE										
29	58	No	154688	5.00	114.7	2.78E+01	9.9	0.0	18.2	
28	59	No	157812	2.60	60.2	1.45E+01	15.7	0.0	16.7	
29	63	No	278135	5.00	203.1	2.78E+01	17.8	0.0	20.8	
29	59	No	298445	5.00	217.7	2.78E+01	19.1	0.0	20.2	
Zone 3 Average			222270	4.40	-	-	15.6	0.0	19.0	9.61
ZONE 4 - LESS THAN 4 FEET OF TILL, LESS THAN 2 FEET OF SOURCE										
30	64	No	18752	5.00	14.6	2.78E+01	1.2	0.4	26.4	
30	63	No	31263	5.00	24.4	2.78E+01	2.0	0.0	24.8	
29	67	Yes	10949	5.00	8.5	2.78E+01	0.7	3.5	32.5	
30	67	No	9369	5.00	7.3	2.78E+01	0.6	3.9	29.7	
Zone 4 Average			17583	5.00	-	-	1.1	2.0	28.4	1.28
ZONE 5 - 2 to 3 FEET OF NOT IMPACTED TILL										
31	58	No	76561	3.84	45.2	2.14E+01	4.9	2.0	29.6	
30	59	No	135937	4.39	88.9	2.44E+01	8.7	2.5	28.2	
30	60	No	134374	3.45	68.6	1.91E+-1	10.1	3.0	29.0	
Zone 5 Average			115624	3.89	-	-	7.9	2.5	28.9	3.73
ZONE 6 - 16 to 18 FEET OF NOT IMPACTED TILL, 2 to 3 FEET OF SOURCE										
34	62	Yes	31242	37.19	181.1	2.07E+02	2.0	16.9	31.5	
35	61	Yes	4687	23.18	16.9	1.29E+02	2.2	17.9	32.2	

See footnote at end of table

TABLE D.3-8
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 6 - 16 to 18 FEET OF NOT IMPACTED TILL, 2 to 3 FEET OF SOURCE (Continued)										
34	60	Yes	9374	3.19	4.7	1.77E+01	2.3	16.6	32.7	
33	63	Yes	46872	23.70	173.2	1.32E+02	3.0	17.7	30.6	
33	62	Yes	51562	28.49	228.9	1.58E+02	3.3	16.1	31.1	
Zone 6 Average			28747	23.15	-	-	2.6	17.0	31.6	1.04
ZONE 7 - 8 to 10 FEET OF NOT IMPACTED TILL, 3.5 to 4.0 FEET OF SOURCE										
31	63	Yes	54680	5.00	42.6	2.78E+01	3.5	8.2	29.5	
31	61	Yes	56260	5.00	43.8	2.78E+01	3.6	6.8	30.8	
31	62	Yes	60934	5.00	47.5	2.78E+01	3.9	7.5	30.1	
Zone 7 Average			57291	5.00	-	-	3.7	7.5	30.1	1.93
ZONE 8 - 8 to 12 FEET OF NOT IMPACTED TILL, 8 to 11 FEET OF SOURCE										
31	59	No	154680	4.24	97.2	2.35E+01	9.9	7.8	31.4	
31	60	Yes	176558	4.47	116.6	2.48E+01	11.3	8.6	31.6	
32	59	Yes	110938	2.28	37.6	1.27E+01	8.9	10.2	32.5	
32	60	Yes	121875	2.81	51.1	1.56E+01	8.5	11.1	32.3	
31	64	Yes	162502	6.18	148.5	3.43E+01	10.7	11.1	29.1	
32	61	Yes	126563	3.30	62.3	1.83E+01	8.3	12.3	31.4	
32	62	Yes	157812	9.75	228.0	5.42E+01	10.2	12.3	30.7	
Zone 8 Average			144418	4.72	-	-	9.7	10.5	31.3	2.71

See footnote at end of table

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TABLE D.3-8
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 9 - 12 to 16 FEET OF NOT IMPACTED TILL, 6 to 10 FEET OF SOURCE										
31	65	Yes	89062	13.02	175.5	7.23E+01	6.3	12.5	28.6	
33	59	Yes	9377	2.37	3.4	1.32E+01	6.0	13.0	33.0	
31	66	Yes	93749	19.25	273.8	1.07E+02	6.0	13.7	28.7	
32	63	Yes	154688	7.84	179.8	4.36E+01	10.1	13.7	30.1	
33	60	Yes	85936	2.09	27.4	1.16E+01	5.7	14.4	32.7	
33	61	Yes	95313	3.45	49.6	1.92E+01	6.5	15.9	31.8	
34	61	Yes	104687	10.80	170.6	6.00E+01	6.6	16.1	32.1	
32	64	Yes	96876	2.64	38.5	1.47E+01	7.0	16.2	29.6	
Zone 9 Average			91211	7.68	-	-	6.8	14.4	30.8	2.18

[a]Not calculated and not required.

TABLE D.3-9

PARAMETERS FOR THE SWIFT CELLS AFTER CONSOLIDATION/CONTAINMENT WITH RESIDUAL SOILS AT 5 pCi/g, SOUTH FIELD AND INACTIVE FLYASH PILE

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 1 - ALL SOURCE MATERIAL REMOVED										
28	63	No	0	0.00	0	0	0.0	0.0	18.9	
28	64	No	0	0.00	0	0	0.0	0.0	19.7	
28	66	No	0	0.00	0	0	0.0	0.0	21.3	
29	64	No	0	0.00	0	0	0.0	0.0	25.5	
29	65	No	0	0.00	0	0	0.0	0.0	24.8	
29	66	No	0	0.00	0	0	0.0	2.0	32.0	
30	57	No	0	0.00	0	0	0.0	0.0	21.3	
30	62	No	0	0.00	0	0	0.0	0.0	24.1	
30	65	No	0	0.00	0	0	0.0	6.1	27.3	
30	66	No	0	0.00	0	0	0.0	7.1	28.6	
31	66	No	0	0.00	0	0	0.0	13.7	28.7	
ZONE 2 - ZERO TILL, LESS THAN 5 FEET OF SOURCE										
28	65	No	68761	5.00	49.3	27.8	4.4	0.0	19.6	
29	60	No	4687	1.90	1.4	10.5	0.3	0.0	25.4	
29	62	No	57823	5.00	45.1	27.8	3.7	0.0	18.5	
30	58	No	42190	5.00	32.9	27.8	2.7	0.0	21.7	
30	61	No	10930	5.00	8.5	27.8	0.7	0.0	24.8	
Zone 2 Average			36878	4.38	-[a]	-	2.4	0.0	22.0	9.61

See footnote at end of table

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TABLE D.3-9
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 3 - ZERO TILL, 10 TO 20 FEET OF SOURCE										
28	59	No	157812	2.60	60.2	14.5	10.1	0.0	16.7	
29	58	No	154688	5.00	114.8	27.8	9.9	0.0	18.2	
29	59	No	298445	5.00	217.8	27.8	19.1	0.0	20.2	
29	63	No	278135	5.00	203.2	27.8	17.8	0.0	20.8	
Zone 3 Average			222270	4.40	-	-	14.2	0.0	19.0	9.61
ZONE 4 - LESS THAN 4 FEET OF TILL, LESS THAN 2 FEET OF SOURCE										
29	67	Yes	10949	5.00	8.5	27.8	0.7	3.5	32.5	
30	63	No	31263	5.00	24.4	27.8	2.0	0.0	24.8	
30	64	No	18752	5.00	14.6	27.8	1.2	0.4	26.4	
30	67	No	9369	5.00	7.3	27.8	0.6	3.9	29.7	
Zone 4 Average			17583	5.00	-	-	1.1	2.0	28.4	1.28
ZONE 5 - 2 to 3 FEET OF NOT IMPACTED TILL										
30	59	No	135937	4.39	89.0	24.4	8.7	2.5	28.2	
30	60	No	134374	3.45	68.7	19.1	8.6	3.0	29.0	
31	58	No	76561	3.84	45.2	21.4	4.9	2.0	29.6	
Zone 5 Average			115624	3.89	-	-	7.4	2.5	28.9	3.73
ZONE 6 - 16 to 18 FEET OF NOT IMPACTED TILL, 2 to 3 FEET OF SOURCE										
31	59	No	31242	1059.00	19.6	5883	2.0	7.8	31.4	
31	60	Yes	31242	1059.00	20.6	5883	2.0	8.6	31.6	
32	63	Yes	31242	1059.00	36.3	5883	2.0	13.7	30.1	

See footnote at end of table

TABLE D.3-9
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 6 - 16 to 18 FEET OF NOT IMPACTED TILL, 2 to 3 FEET OF SOURCE (Continued)										
33	59	Yes	31242	1059.00	11.3	5883	2.0	13.0	33.0	
33	60	Yes	31242	1059.00	10.0	5883	2.0	14.4	32.7	
33	61	Yes	31242	1059.00	16.3	5883	2.0	15.9	31.8	
33	62	Yes	31242	1059.00	198.0	5883	2.0	16.1	31.1	
33	63	Yes	31242	1059.00	137.1	5883	2.0	17.7	30.6	
34	60	Yes	31242	1059.00	15.5	5883	2.0	16.6	32.7	
34	61	Yes	31242	1059.00	50.9	5883	2.0	16.1	32.1	
34	62	Yes	31242	1059.00	5158.6	5883	2.0	16.9	31.5	
34	63	No	31242	1059.00	0.0	5883	2.0	18	31	
34	64	No	31242	1059.00	0.0	5883	2.0	18	32	
35	60	No	31242	1059.00	0.0	5883	2.0	16	32	
35	61	Yes	31242	1059.00	5158.6	5883	2.0	17.9	32.2	
35	62	No	31242	1059.00	0.0	5883	2.0	17	32	
35	63	No	31242	1059.00	0.0	5883	2.0	18	32	
36	60	No	31242	1059.00	0.0	5883	2.0	14	32	
Zone 6 Average			31242	1059.00	-	-	2.0	15.3	31.8	1.22
ZONE 7 - 8 to 10 FEET OF NOT IMPACTED TILL, 3.5 to 4.0 FEET OF SOURCE										
31	61	Yes	56260	5.00	43.9	27.8	3.6	6.8	30.8	
31	62	Yes	60934	5.00	47.5	27.8	3.9	7.5	30.1	
31	63	Yes	54680	5.00	42.6	27.8	3.5	8.2	29.5	
Zone 7 Average			57291	5.00	-	-	3.7	7.5	30.1	1.93

See footnote at end of table

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TABLE D.3-9
(Continued)

Row	Column	Perched Water Source?	Source Volume (ft^3)	U-238 Concentration (pCi/g)	Source Inventory (Kg)	U-238 Leachate Concentration (pCi/L)	Source Thickness (ft)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 8 - 8 to 12 FEET OF NOT IMPACTED TILL, 8 to 11 FEET OF SOURCE										
31	64	Yes	162502	5.00	126.7	27.8	10.4	11.1	29.1	
31	65	Yes	89062	5.00	69.4	27.8	5.7	12.5	28.6	
32	59	Yes	110938	2.28	39.4	12.7	7.1	10.2	32.5	
32	60	Yes	121875	5.00	95.0	27.8	7.8	11.1	32.3	
32	61	Yes	126563	3.30	62.3	18.3	8.1	12.3	31.4	
32	62	Yes	157812	9.75	228.1	54.2	10.1	12.3	30.7	
32	64	Yes	96876	2.64	38.5	14.7	6.2	16.2	29.6	
Zone 8 Average			142187	4.71	-	-	9.1	12.3	31.1	2.71

[a]Not calculated and not required.

uranium-238 loading concentration to the Great Miami Aquifer was 25 pCi/L. Figure D.3-15 shows the loading curve for uranium-238 to the Great Miami Aquifer. The maximum mass loading occurs at 460 years. The loading curve is similar to Figure D.3-12 because dominant part of mass loading is due to residual soils left on the Great Miami Aquifer.

The groundwater fate and transport modeling results for Operable Unit 2 Feasibility Study are summarized in Table D.3-3. The maximum predicted uranium-238 concentration in the Great Miami Aquifer was 1.03 pCi/L. Figures D.3-16 and D.3-17 show the projected increase in uranium-238 concentrations due to the South Field and Inactive Flyash Pile at 460 and 1000 years, respectively. The maximum uranium-238 concentration on-site and at the FEMP fence line was predicted to occur at 460 years. As noted earlier, total uranium, uranium-234, and uranium-235/236 concentrations were estimated from the results of uranium-238 modeling.

D.3.4.5 Disposal Cell

Figure D.3-18 shows the SWIFT III grid blocks directly beneath the on-site disposal cell considered for the Operable Unit 2 wastes. Wastes from the Lime Sludge Ponds, South Field, Inactive Flyash Pile, and Active Flyash Pile were considered for containment at the disposal cell. The berm material may contains residual soils from the Operable Unit 2 subunits and was included in the source term. The only COCs for groundwater for the waste to be disposed at the disposal cell were uranium isotopes. It was assumed that waste will not be treated before disposal. This represents the worst-case scenario. Only the vadose zone pathway was applicable for the disposal cell.

The vadose zone model depicting flow in the subsurface soils at the disposal cell considers two layers. Layer 1 soils consist of tills with a minimum thickness of 24 feet. Interbedded sand and gravel stringers containing perched water within the till were not considered as a part of Layer 1 of the vadose zone pathway. Beneath the till layer is more than 35 feet thick unsaturated sand and gravel layer (Layer 2). Table D.3-10 provides the physical parameters of various layers for each of the blocks modeled. The HELP model was used to estimate infiltration through the composite cap. Output of HELP model are included in the Attachment D.3.I. Infiltration through the cap and the berm were estimated to be 1.22 and 3.06 inch/year, respectively.

Table D.3-2 lists the COC inventory. In waste, predicted maximum leachate concentration, predicted maximum concentration from vadose zone Layer 2 (maximum loading concentration to the Great

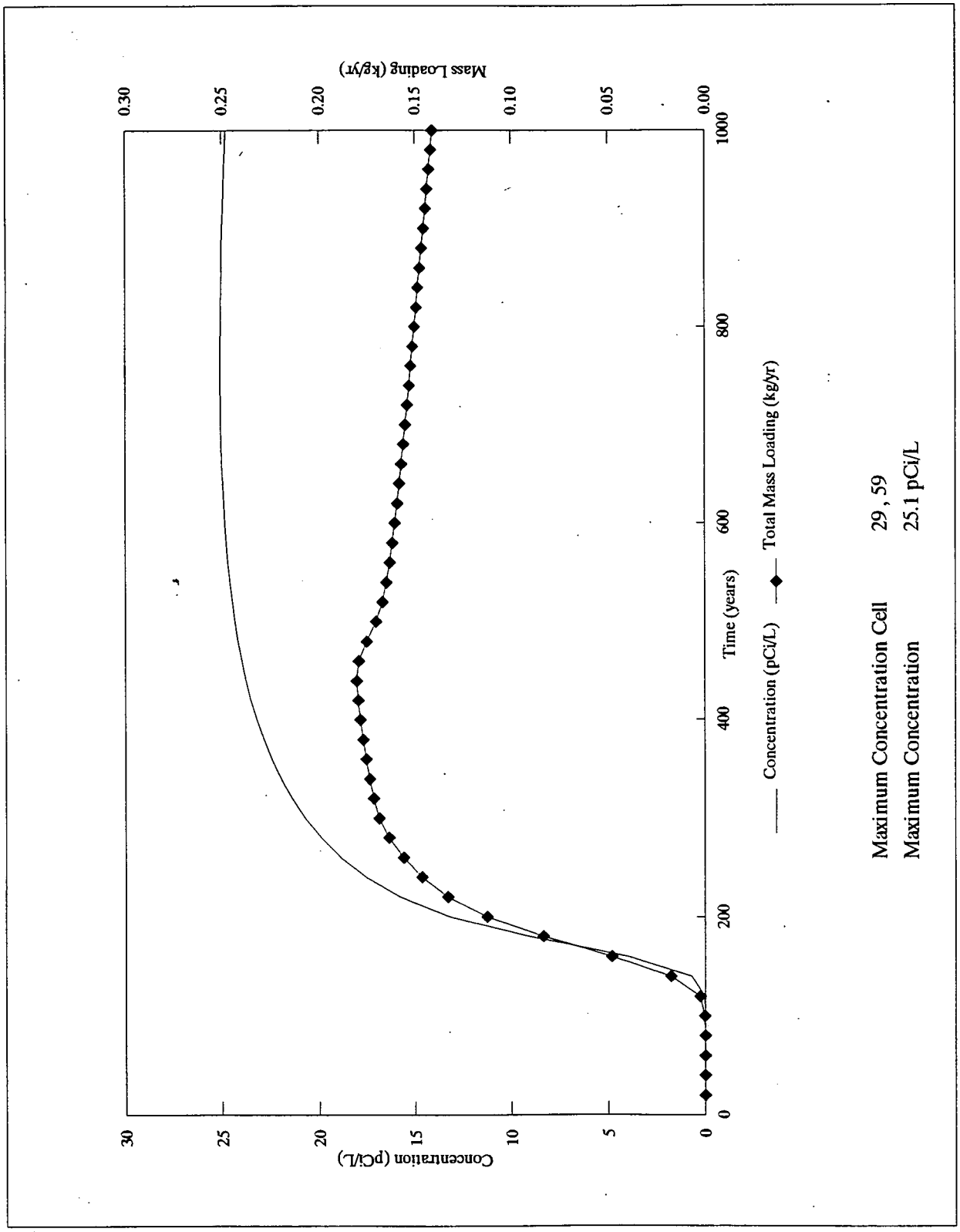

Figure D.3−15 Uranium−238 Loading to the Great Miami Aquifer from the South Field / Inactive Flyash Pile for Consolidation / Containment Alternative

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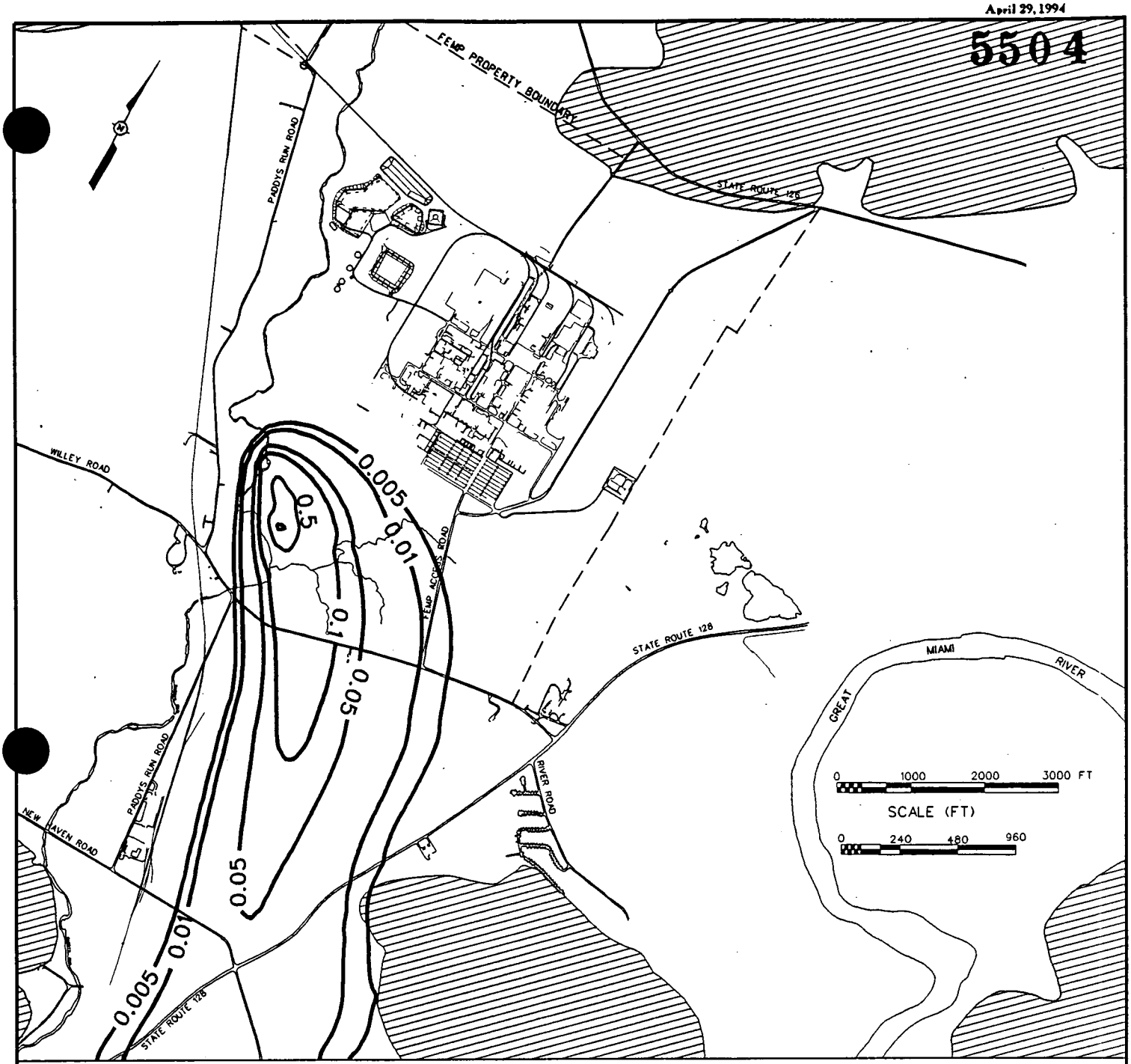

LEGEND:

0.1 CONCENTRATION CONTOUR (pCi/L)

BEDROCK

FIGURE D.3-16
PROJECTED INCREASE IN URANIUM-238 CONCENTRATIONS IN THE GREAT MIAMI AQUIFER AT 460 YEARS DUE TO LOADING FROM THE SOUTH FIELD/INACTIVE FLYASH PILE FOR CONSOLIDATION/CONTAINMENT ALTERNATIVE

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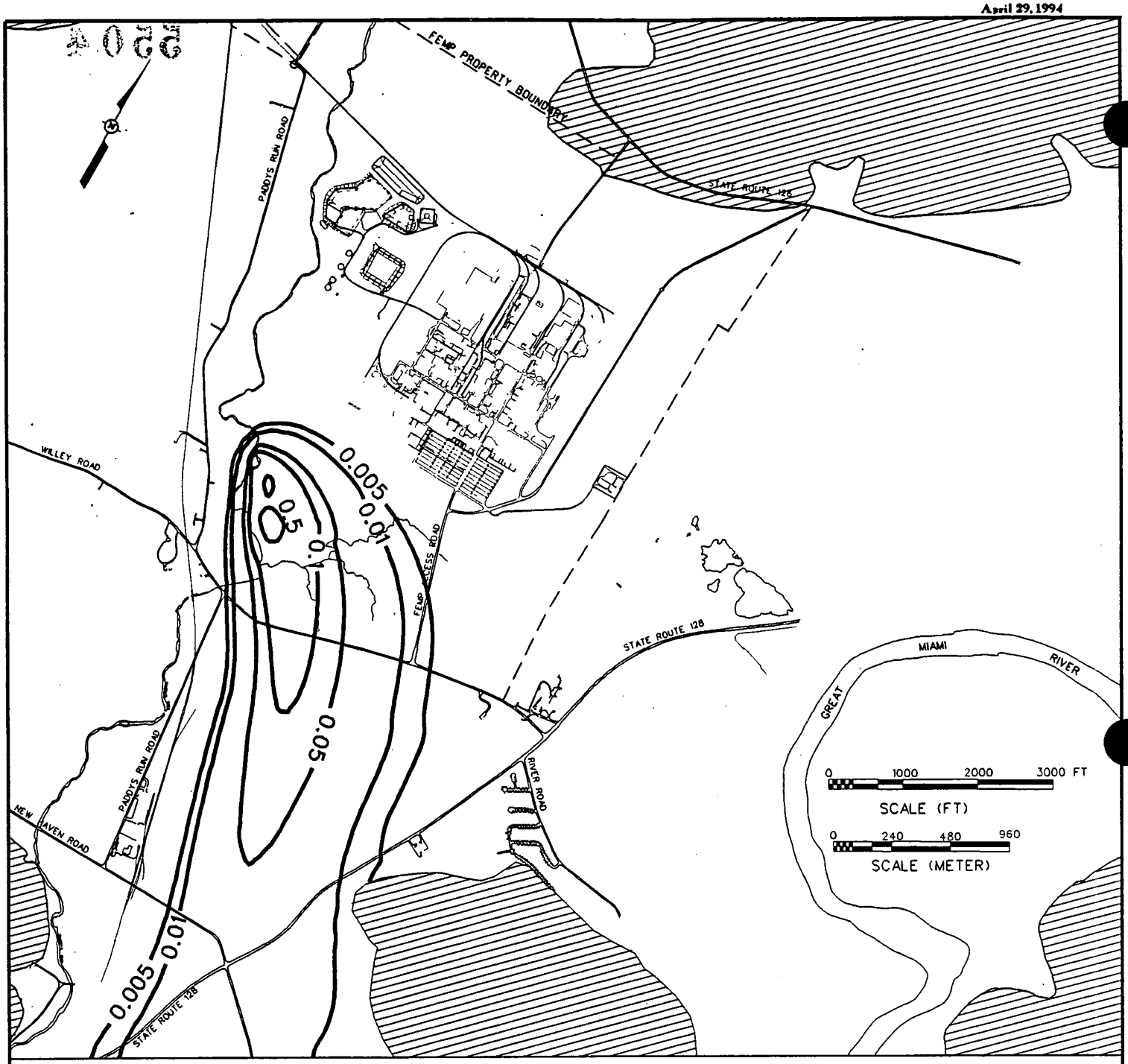

LEGEND:

0.1 CONCENTRATION CONTOUR (pCi/L)

BEDROCK

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FIGURE D.3-17
PROJECTED INCREASE IN URANIUM-238 CONCENTRATIONS IN THE GREAT MIAMI AQUIFER AT 1000 YEARS DUE TO LOADING FROM THE SOUTH FIELD/INACTIVE FLYASH PILE FOR CONSOLIDATION/CONTAINMENT ALTERNATIVE

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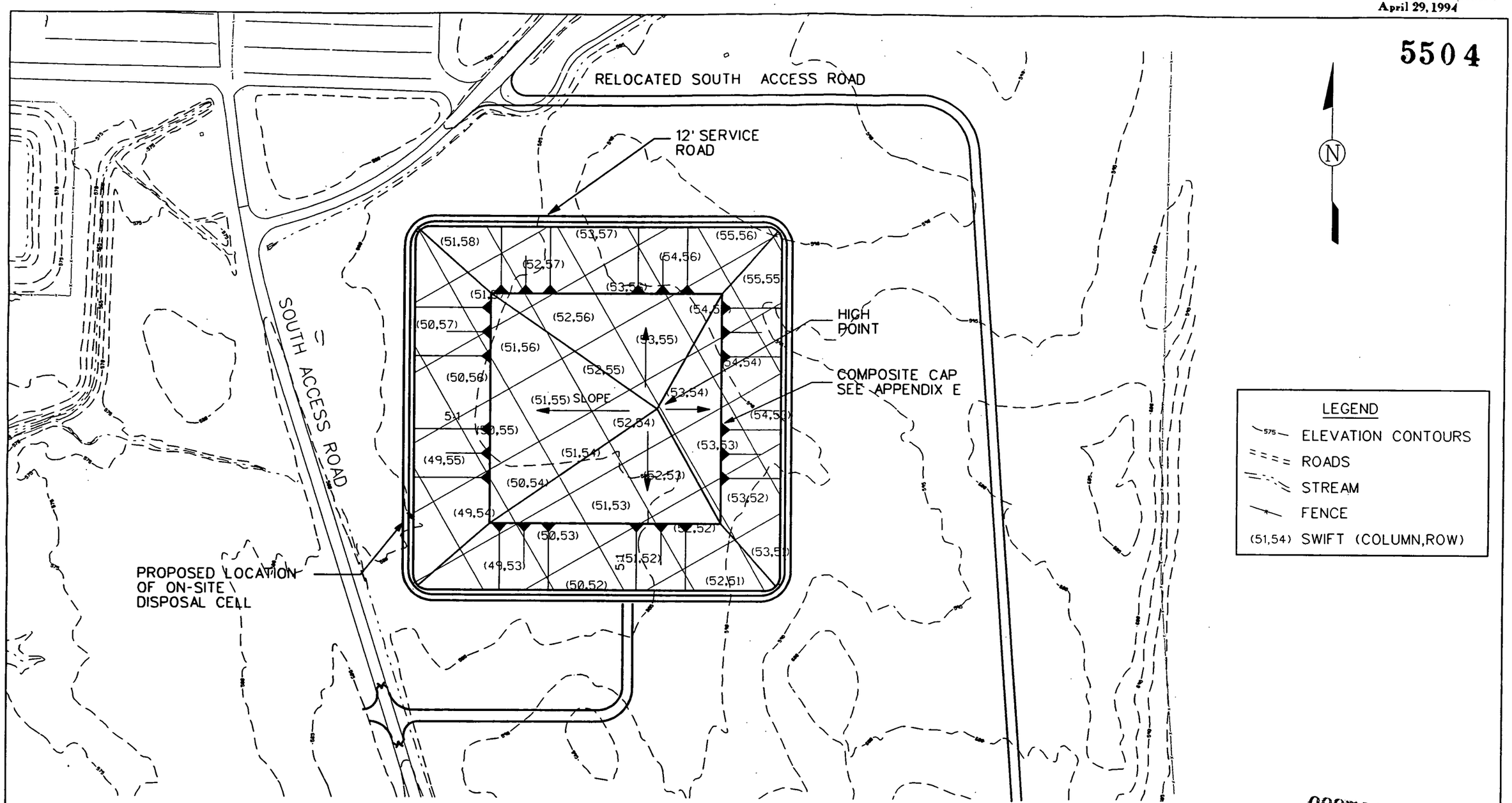

NOTE:
1. Surface contours based on 1992 flyover.

000744

FIGURE D.3-18
SWIFT GRID AT PROPOSED LOCATION OF ON-SITE DISPOSAL CELL

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TABLE D.3-10

PARAMETERS FOR THE SWIFT CELLS IMPACTED BY THE OPERABLE UNIT 2 DISPOSAL CELL

Row	Column	U-238 Concentration (pCi/g)	U-238 Leachate Concentration (pCi/L)	U-238 Waste Inventory (Kg)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 1 - INTERIOR OF THE DISPOSAL CELL							
50	54	1077	5984	13926	28.5	40.9	
50	55	1077	5984	13926	28.5	38.7	
51	53	1077	5984	13926	31.5	39.5	
51	54	1077	5984	13926	31.5	38.0	
51	55	1077	5984	13926	31.5	36.2	
51	56	1077	5984	13926	30.0	36.2	
52	53	1077	5984	13926	34.3	37.1	
52	54	1077	5984	13926	34.2	36.5	
52	55	1077	5984	13926	32.0	37.0	
52	56	1077	5984	13926	30.0	40.0	
53	54	1077	5984	13926	34.0	38.0	
53	55	1077	5984	13926	31.1	40.0	
WORST CASE		1077	5984	13926	28.5	36.2	1.22
ZONE 2 - CENTER OF DIKE OF THE DISPOSAL CELL							
49	54	565	3136	8072	25.7	42.0	
50	53	565	3136	8072	28.9	41.5	
50	56	565	3136	8072	29.0	36.0	
51	57	565	3136	8072	28.0	38.5	
52	52	565	3136	8072	33.7	39.0	
53	53	565	3136	8072	35.5	37.0	

5504

000725

TABLE D.3-10
(Continued)

Row	Column	U-238 Concentration (pCi/g)	U-238 Leachate Concentration (pCi/L)	U-238 Waste Inventory (Kg)	Till Thickness (ft)	Unsaturated GMA Thickness (ft)	Infiltration (in/year)
ZONE 2 - CENTER OF DIKE OF THE DISPOSAL CELL (Continued)							
53	56	565	3136	8072	29.4	42.5	
54	55	565	3136	8072	30.0	42.0	
WORST CASE		565	3136	8072	25.7	36.0	3.06
ZONE 3 - EDGE OF DIKE OF THE DISPOSAL CELL							
48	54	52	289	739	23.8	40.6	
49	53	52	289	985	26.2	42.5	
49	55	52	289	1724	26.0	41.0	
49	56	52	289	739	27.5	37.9	
50	52	52	289	1478	28.9	42.5	
50	57	52	289	1478	29.0	35.0	
51	52	52	289	1355	31.5	41.0	
51	58	52	289	985	27.0	39.6	
52	51	52	289	1478	32.2	40.2	
52	57	52	289	2217	27.8	42.5	
53	52	52	289	1724	33.9	37.5	
53	57	52	289	369	27.9	44.7	
54	53	52	289	246	34.7	38.9	
54	54	52	289	1724	32.0	40.0	
54	56	52	289	1724	29.4	44.0	
55	55	52	289	246	29.7	43.9	
WORST CASE		52	289	2217	23.8	35.0	3.06

Miami Aquifer), seepage rates and screening concentrations. Leachate concentrations were estimated from the waste containing highest uranium-238 concentrations. Table D.3-2 show that uranium-238 does not reach the Great Miami Aquifer in 1000 years. This result makes it impractical to attempt to estimate differences that might be caused by treating any of the waste prior to placement in the cell. Any treatment would reduce the leachate concentration. However, uranium-238 would not reach the aquifer in any case and all treatment methods would yield identical results - no impact on the Great Miami Aquifer.

D.3.5 ECTran Confirmation Modeling with ODAST/SWIFT

Conformation modeling was conducted using the ODAST/SWIFT Model to verify that the modified PRGs developed using the ECTran Model are protective of the Great Miami Aquifer at the designated risk based criteria. Results of this modeling are provided in Section D.3.4.4. Conformation modeling was conducted for the South Field/Inactive Flyash Pile area. This conformation modeling evaluated removing all contaminated material from the area directly on the Great Miami Aquifer and on the sloping face of the glacial overburden (terrace face) and left all contaminated material on the top of the terrace. The results of this evaluation indicated that the maximum uranium-238 concentration in the Great Miami Aquifer is predicted to be 1.6×10^{-48} pCi/L. The predicted result is significantly less than 10^{-6} criteria for uranium-238 which is 0.62 pCi/L. This indicates that the ECTran model overestimates the impact on the Great Miami Aquifer.

Additional ODAST/SWIFT modeling was conducted to evaluate the concentration of uranium-238 which could be left in the South Field/Inactive Flyash Pile, and be protective of the Great Miami Aquifer. This evaluation assumes that lateral groundwater migration is prevented with source controls. A concentration of 5 pCi/g of uranium-238 was evaluated for the area directly above the Great Miami Aquifer or on the terrace face and 60 pCi/g of uranium-238 was evaluated for the top of the terrace. The results of this analysis indicated that the 60 pCi/g concentration on the top of the terrace resulted in a maximum concentration of 1.6×10^{-48} pCi/L in the Great Miami Aquifer, which is considered negligible. The 5 pCi/g concentration direct on the Great Miami Aquifer resulted in a maximum uranium-238 concentration at the FEMP fence line of 0.153 pCi/L, which is less than the 0.62 pCi/L risk criteria for the off-property farmer. These confirmation results indicate that ECTran model is very conservative and underestimates the PRGs and PRLs.

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FEMP-OU02-4 DRAFT
April 29, 1994

APPENDIX D.3

ATTACHMENT D.3.I

INFILTRATION CALCULATIONS FOR ODAST/SWIFT MODELING

D.3.I INFILTRATION CALCULATIONS FOR ODAST/SWIFT MODELING

MODELING APPROACH

Infiltration rates (seepage rate) through the waste to the Great Miami Aquifer for various conceptual models were calculated using the Hydraulic Evaluation of Landfill Performance (HELP) model. The HELP model (Schroeder, et al., 1988) is a quasi-two-dimensional hydrologic model of water movement across, into, through, and out of a waste unit. The model accepts climatologic, soil, and design data and simulates a number of hydraulic processes including surface storage, runoff, infiltration, percolation, evapotranspiration, soil moisture storage, and lateral drainage. The systems that can be modeled by the HELP model include various combinations of vegetation, cover soils, waste cells, drainage layers, and relatively impermeable barrier soils.

The HELP model was run in 5-year steps using the climatologic data (precipitation and mean monthly temperatures) from 1974 to 1978 for Cincinnati, Ohio. These data were obtained from the HELP model database. The HELP model was run to "steady state", that is, until successive simulations showed less than 0.005 change between initial and final year soil moisture content in any of the layers. A successive substitution procedure was used to reach steady state conditions.

Physical properties of waste, glacial till, and the Great Miami Aquifer soils were the same as properties used in the Operable Unit 2 Remedial Investigation fate and transport modeling (Appendix A-2 of the Final RI Report). These values were defined based upon RI sampling activities.

Figure D.3.I-1 shows a typical section for the composite cap and liner. Figure D.3.I-2 shows a typical section for the clay cap. Design data for conceptual models available on February 28, 1994 were used for infiltration calculations. Topsoil, vegetative soil support, sand filter, cobbles, pea gravel, bentonite geocomposite, clay liner with bentonite, and compacted structural fill were simulated as HELP soil texture no. 6, 5, 2, 1, 1, 18, 18, and 17, respectively. HELP default hydraulic conductivities were modified to match the design. Hydraulic conductivities for these layers were 1×10^{-3}, 5×10^{-4}, 1×10^{-3}, 10.0, 1×10^{-2}, 1×10^{-8}, 1×10^{-7}, and 2.6×10^{-5} cm/sec, respectively. Grass cover was assumed to be fair and the evaporative zone depth was conservatively estimated to be 18 inches.

The bentonite geocomposite was assumed to be 0.25 inch thick with properties of recompacted clay. The HDPE geomembrane was assumed to have deteriorated and the drainage layer in the liner was assumed to be ineffective. The bentonite geocomposite (a barrier layer) is on top of clay soil liner with bentonite layer (another barrier layer) (see Figure D.3.I-1). However, the HELP model cannot simulate two barrier layers next to each other. Therefore, a vertical percolation (sand) layer with hydraulic conductivity of 10.0 cm/sec was inserted in between the two barrier layers.

For conceptual models with cap, the HELP model simulation showed that the infiltration rate is not sensitive to the thicknesses of waste, glacial overburden, or the unsaturated Great Miami Aquifer. This may be because infiltration through these caps is very small and is within the transmissive capability of the glacial overburden under gravity drainage.

The remaining conceptual models were simulated with typical thicknesses of waste, glacial till, and unsaturated Great Miami Aquifer obtained during field activities for the Remedial Investigation and were modified to account for any source removal considered. It was assumed that the top 12 inches will be reworked, fertilized and seeded. Sand/gravel layers within the Glacial Overburden and weathered till were ignored while calculating glacial till thickness. An attempt was made to estimate worst-case infiltration rates.

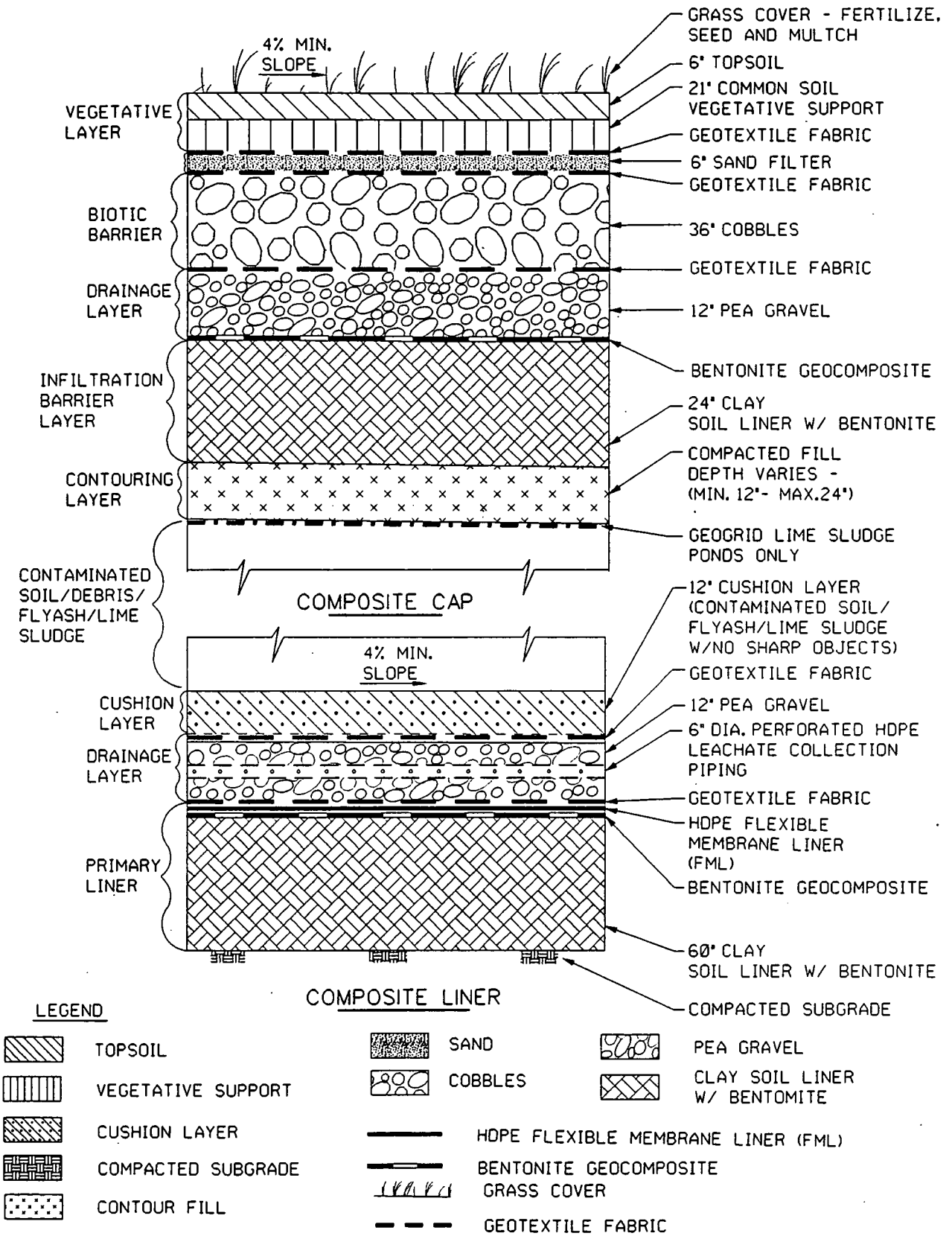

FIGURE D.3.1-1
TYPICAL DETAIL
COMPOSITE CAP AND LINER

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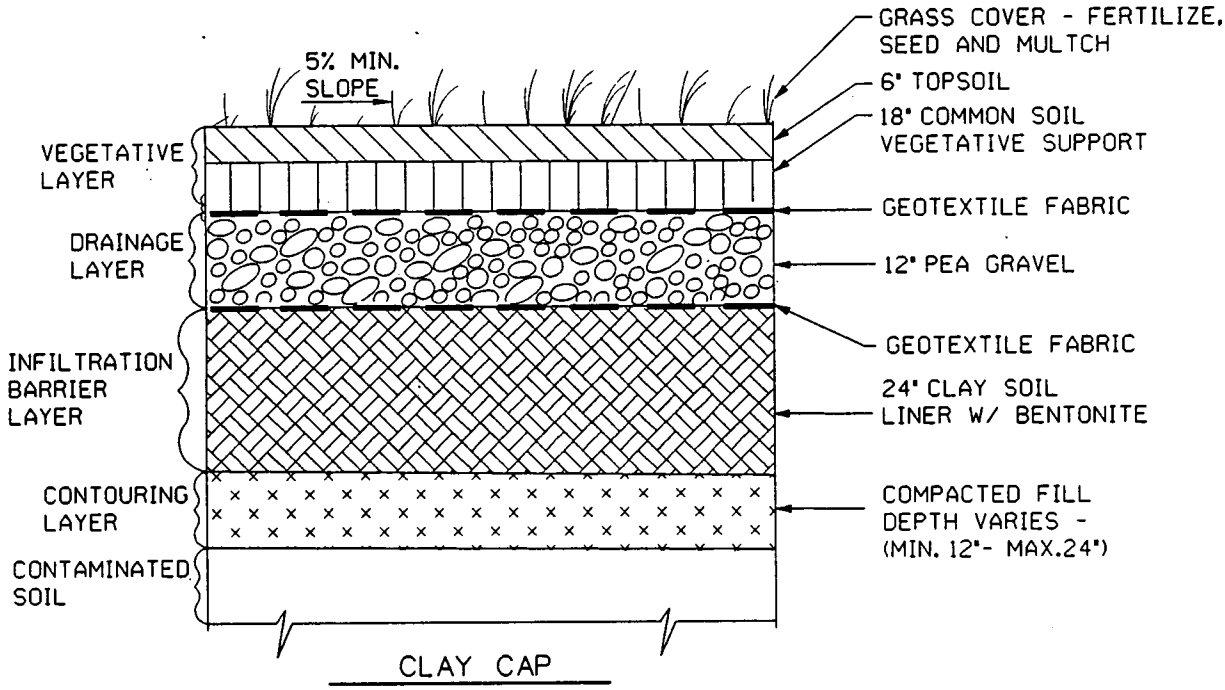
(NOT TO SCALE)



LEGEND

- TOPSOIL
- VEGETATIVE SUPPORT
- PEA GRAVEL
- CLAY SOIL LINER W/ BENTONITE
- CONTOUR FILL
- GRASS COVER
- GEOTEXTILE FABRIC

FIGURE D.3.1-2
TYPICAL SECTION
CLAY CAP

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(NOT TO SCALE)

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*************************************************************************
*************************************************************************

 CLAY CAP
                                March 11, 1994

*************************************************************************
*************************************************************************

                              FAIR GRASS

                              LAYER  1
                              --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                          =      6.00 INCHES
   POROSITY                           =      0.4530 VOL/VOL
   FIELD CAPACITY                     =      0.1901 VOL/VOL
   WILTING POINT                      =      0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.3207 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.001000000047 CM/SEC


                              LAYER  2
                              --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                          =     18.00 INCHES
   POROSITY                           =      0.4570 VOL/VOL
   FIELD CAPACITY                     =      0.1309 VOL/VOL
   WILTING POINT                      =      0.0580 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.2426 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000500000024 CM/SEC


                              LAYER  3
                              --------

                       LATERAL DRAINAGE LAYER
   THICKNESS                          =     12.00 INCHES
   POROSITY                           =      0.4170 VOL/VOL
   FIELD CAPACITY                     =      0.0454 VOL/VOL
   WILTING POINT                      =      0.0200 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.2732 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.009999999776 CM/SEC
   SLOPE                              =      5.00 PERCENT
   DRAINAGE LENGTH                    =    175.0 FEET
```

000754

LAYER 4

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	18.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.2020 INCHES
INITIAL VEG. STORAGE	=	4.8354 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	19.8894 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

000755

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	0.000	0.006	0.000	0.000	0.000	0.000
	0.000	0.000	0.001	0.000	0.000	0.005
STD. DEVIATIONS	0.000	0.013	0.000	0.000	0.000	0.000
	0.000	0.000	0.001	0.000	0.000	0.011
EVAPOTRANSPIRATION						
TOTALS	0.844	1.518	2.382	2.794	2.983	4.954
	4.536	4.351	2.312	1.978	1.646	0.890
STD. DEVIATIONS	0.189	0.322	0.148	0.391	1.564	1.091
	1.395	1.298	1.628	0.510	0.152	0.188
LATERAL DRAINAGE FROM LAYER 3						
TOTALS	1.1922	1.2683	1.2703	1.3076	0.8941	0.4875
	0.4083	0.1525	0.1772	0.2426	0.2446	0.6608
STD. DEVIATIONS	0.7559	0.7180	0.8252	0.7979	0.6691	0.4991
	0.3918	0.1662	0.3461	0.4287	0.3280	0.6145
PERCOLATION FROM LAYER 4						
TOTALS	0.1068	0.1109	0.1273	0.1242	0.1191	0.1071
	0.0831	0.0757	0.0681	0.0532	0.0683	0.0937
STD. DEVIATIONS	0.0540	0.0299	0.0156	0.0198	0.0131	0.0104
	0.0405	0.0438	0.0440	0.0414	0.0457	0.0467

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	0.011	(0.014)	43.	0.03
EVAPOTRANSPIRATION	31.187	(2.864)	119551.	76.74
LATERAL DRAINAGE FROM LAYER 3	8.3060	(3.7580)	31840.	20.44
PERCOLATION FROM LAYER 4	1.1375	(0.2501)	4360.	2.80
CHANGE IN WATER STORAGE	0.000	(3.670)	0.	0.00

****

****

PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	0.028	107.7
LATERAL DRAINAGE FROM LAYER 3	0.0940	360.5
PERCOLATION FROM LAYER 4	0.0057	21.9
HEAD ON LAYER 4	16.3	
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3405

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0667

****

****

FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.92	0.3207
2	4.37	0.2426
3	3.28	0.2732
4	10.32	0.4300
SNOW WATER	0.00	

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****

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LOW LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY FOR OPERABLE UNIT 2
GEOCOMPOSITE CAP AND LINER - NO HDPE LINER AND FAILED LEACHATE COLLECTION SY
MINIMUM WASTE THICKNESS February 28, 1994

****
****

FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4530 VOL/VOL
FIELD CAPACITY	=	0.1901 VOL/VOL
WILTING POINT	=	0.0848 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3243 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001000000047 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	21.00 INCHES
POROSITY	=	0.4570 VOL/VOL
FIELD CAPACITY	=	0.1309 VOL/VOL
WILTING POINT	=	0.0580 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2440 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000500000024 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4370 VOL/VOL
FIELD CAPACITY	=	0.0624 VOL/VOL
WILTING POINT	=	0.0245 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1581 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001000000047 CM/SEC

```
                    LAYER  4
                    --------

              VERTICAL PERCOLATION LAYER
THICKNESS                          =     36.00 INCHES
POROSITY                           =      0.4170 VOL/VOL
FIELD CAPACITY                     =      0.0454 VOL/VOL
WILTING POINT                      =      0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =     10.000000000000 CM/SEC


                    LAYER  5
                    --------

               LATERAL DRAINAGE LAYER
THICKNESS                          =     12.00 INCHES
POROSITY                           =      0.4170 VOL/VOL
FIELD CAPACITY                     =      0.0454 VOL/VOL
WILTING POINT                      =      0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.4170 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.009999999776 CM/SEC
SLOPE                              =      4.00 PERCENT
DRAINAGE LENGTH                    =    800.0 FEET


                    LAYER  6
                    --------

                 BARRIER SOIL LINER
THICKNESS                          =      0.25 INCHES
POROSITY                           =      0.4000 VOL/VOL
FIELD CAPACITY                     =      0.3560 VOL/VOL
WILTING POINT                      =      0.2899 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.4000 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000010000 CM/SEC


                    LAYER  7
                    --------

              VERTICAL PERCOLATION LAYER
THICKNESS                          =      2.00 INCHES
POROSITY                           =      0.4170 VOL/VOL
FIELD CAPACITY                     =      0.0454 VOL/VOL
WILTING POINT                      =      0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.0564 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =     10.000000000000 CM/SEC
```

000760

LAYER 8

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

LAYER 9

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3808 VOL/VOL
FIELD CAPACITY	=	0.1924 VOL/VOL
WILTING POINT	=	0.1043 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2523 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000026000000 CM/SEC

LAYER 10

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2794 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 11

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.009999999776 CM/SEC

LAYER 12

BARRIER SOIL LINER

THICKNESS	=	60.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	1102500. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	5.4600 INCHES
INITIAL VEG. STORAGE	=	3.4098 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	58.2148 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	0.000	0.004	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.001	0.000	0.005
STD. DEVIATIONS	0.000	0.009	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.002	0.000	0.011
EVAPOTRANSPIRATION						
TOTALS	0.853	1.535	2.424	2.871	2.814	4.791
	3.826	4.116	2.198	1.959	1.683	0.905
STD. DEVIATIONS	0.188	0.312	0.120	0.265	1.712	1.202
	1.451	0.997	1.704	0.567	0.120	0.179
LATERAL DRAINAGE FROM LAYER 5						
TOTALS	1.3155	1.4678	1.1784	0.9902	0.6175	0.5255
	0.5178	0.4965	0.6843	0.4741	0.4245	0.7490
STD. DEVIATIONS	0.6603	1.2556	1.1494	0.6790	0.1245	0.0628
	0.0694	0.0626	0.4737	0.1049	0.1121	0.7123
PERCOLATION FROM LAYER 6						
TOTALS	0.1141	0.1071	0.1175	0.1157	0.1173	0.1063
	0.1024	0.0937	0.0851	0.0842	0.0811	0.0921
STD. DEVIATIONS	0.0405	0.0405	0.0441	0.0333	0.0261	0.0272
	0.0269	0.0232	0.0273	0.0336	0.0341	0.0355

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PERCOLATION FROM LAYER 8

TOTALS	0.1077	0.0983	0.1082	0.1048	0.1084	0.0978
	0.1012	0.1018	0.0970	0.0983	0.0918	0.1010
STD. DEVIATIONS	0.0025	0.0034	0.0023	0.0024	0.0026	0.0179
	0.0184	0.0169	0.0194	0.0236	0.0257	0.0161

PERCOLATION FROM LAYER 12

TOTALS	0.1050	0.0919	0.0998	0.0975	0.1018	0.0994
	0.1035	0.1042	0.1013	0.1050	0.1017	0.1051
STD. DEVIATIONS	0.0016	0.0088	0.0120	0.0100	0.0084	0.0064
	0.0050	0.0036	0.0024	0.0017	0.0013	0.0014

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	3733984.	100.00
RUNOFF	0.010	(0.014)	920.	0.02
EVAPOTRANSPIRATION	29.974	(2.728)	2753890.	73.75
LATERAL DRAINAGE FROM LAYER 5	9.4411	(3.7889)	867399.	23.23
PERCOLATION FROM LAYER 6	1.2163	(0.3337)	111743.	2.99
PERCOLATION FROM LAYER 8	1.2162	(0.1433)	111743.	2.99
PERCOLATION FROM LAYER 12	1.2162	(0.0607)	111741.	2.99
CHANGE IN WATER STORAGE	0.000	(3.907)	34.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	220500.0
RUNOFF	0.025	2269.9
LATERAL DRAINAGE FROM LAYER 5	0.5774	53045.4
PERCOLATION FROM LAYER 6	0.0045	415.1
HEAD ON LAYER 6	12.2	
PERCOLATION FROM LAYER 8	0.0036	331.4
HEAD ON LAYER 8	1.4	
PERCOLATION FROM LAYER 12	0.0034	314.4
HEAD ON LAYER 12	0.4	
SNOW WATER	1.18	108843.8

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3497

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0711

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	1.95	0.3243
2	5.12	0.2440
3	0.95	0.1581
4	1.64	0.0454
5	5.00	0.4170
6	0.40	0.4000
7	0.11	0.0564
8	10.32	0.4300
9	3.03	0.2523
10	3.35	0.2794
11	0.55	0.0454
12	25.80	0.4300
SNOW WATER	0.00	

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 LOW LEVEL RADIOACTIVE WASTE DISPOSAL FACILITY FOR OPERABLE UNIT 2

 BERM WITH VEGETATIVE COVER AND LINER
 INEFFECTIVE HDPE LINER AND GEOCOMPOSITE                March 10, 1994

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                              FAIR GRASS

                              LAYER  1
                              --------

                     VERTICAL PERCOLATION LAYER
   THICKNESS                          =      6.00 INCHES
   POROSITY                           =      0.4530 VOL/VOL
   FIELD CAPACITY                     =      0.1901 VOL/VOL
   WILTING POINT                      =      0.0848 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4530 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.001000000047 CM/SEC


                              LAYER  2
                              --------

                     VERTICAL PERCOLATION LAYER
   THICKNESS                          =     21.00 INCHES
   POROSITY                           =      0.4570 VOL/VOL
   FIELD CAPACITY                     =      0.1309 VOL/VOL
   WILTING POINT                      =      0.0580 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4570 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000500000024 CM/SEC


                              LAYER  3
                              --------

                     VERTICAL PERCOLATION LAYER
   THICKNESS                          =     60.00 INCHES
   POROSITY                           =      0.4100 VOL/VOL
   FIELD CAPACITY                     =      0.3710 VOL/VOL
   WILTING POINT                      =      0.2510 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000002400000 CM/SEC
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                    LAYER  4
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              VERTICAL PERCOLATION LAYER
THICKNESS                          =     12.00 INCHES
POROSITY                           =      0.4170 VOL/VOL
FIELD CAPACITY                     =      0.0454 VOL/VOL
WILTING POINT                      =      0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.4170 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.009999999776 CM/SEC


                    LAYER  5
                    --------

                 BARRIER SOIL LINER
THICKNESS                          =     60.00 INCHES
POROSITY                           =      0.4300 VOL/VOL
FIELD CAPACITY                     =      0.3663 VOL/VOL
WILTING POINT                      =      0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000100000 CM/SEC


                    LAYER  6
                    --------

              VERTICAL PERCOLATION LAYER
THICKNESS                          =      6.00 INCHES
POROSITY                           =      0.4100 VOL/VOL
FIELD CAPACITY                     =      0.3710 VOL/VOL
WILTING POINT                      =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.3712 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.100000001490 CM/SEC


                    LAYER  7
                    --------

                 BARRIER SOIL LINER
THICKNESS                          =    286.00 INCHES
POROSITY                           =      0.4100 VOL/VOL
FIELD CAPACITY                     =      0.3710 VOL/VOL
WILTING POINT                      =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.000002400000 CM/SEC
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LAYER 8

VERTICAL PERCOLATION LAYER

THICKNESS	=	420.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0646 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	1102500. SQ FT
EVAPORATIVE ZONE DEPTH	=	18.00 INCHES
UPPER LIMIT VEG. STORAGE	=	8.2020 INCHES
INITIAL VEG. STORAGE	=	8.2020 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	214.3382 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.004	0.738	1.050	0.391	0.051	0.071
	0.000	0.000	0.001	0.000	0.000	0.318
STD. DEVIATIONS	0.751	1.649	1.633	0.558	0.114	0.158
	0.001	0.000	0.003	0.000	0.000	0.711
EVAPOTRANSPIRATION						
TOTALS	0.841	1.511	2.375	2.765	2.913	5.005
	6.763	4.989	2.364	1.932	1.614	0.885
STD. DEVIATIONS	0.188	0.320	0.150	0.227	1.618	1.000
	0.793	1.126	1.599	0.477	0.141	0.180
PERCOLATION FROM LAYER 5						
TOTALS	0.2689	0.2451	0.2680	0.2590	0.2666	0.2565
	0.2585	0.2480	0.2407	0.2484	0.2411	0.2583
STD. DEVIATIONS	0.0161	0.0164	0.0155	0.0096	0.0085	0.0087
	0.0049	0.0014	0.0059	0.0067	0.0074	0.0146
PERCOLATION FROM LAYER 7						
TOTALS	0.2689	0.2451	0.2680	0.2590	0.2666	0.2566
	0.2586	0.2480	0.2407	0.2484	0.2411	0.2583
STD. DEVIATIONS	0.0161	0.0164	0.0155	0.0096	0.0085	0.0087
	0.0049	0.0014	0.0058	0.0067	0.0074	0.0145
PERCOLATION FROM LAYER 8						
TOTALS	0.2584	0.2358	0.2598	0.2519	0.2608	0.2528
	0.2613	0.2606	0.2514	0.2590	0.2500	0.2579
STD. DEVIATIONS	0.0041	0.0063	0.0046	0.0048	0.0051	0.0051
	0.0053	0.0050	0.0045	0.0045	0.0042	0.0042

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	3733984.	100.00
RUNOFF	3.624	(3.979)	332956.	8.92
EVAPOTRANSPIRATION	33.959	(3.628)	3119962.	83.56
PERCOLATION FROM LAYER 5	3.0592	(0.0929)	281066.	7.53
PERCOLATION FROM LAYER 7	3.0592	(0.0929)	281067.	7.53
PERCOLATION FROM LAYER 8	3.0597	(0.0540)	281108.	7.53
CHANGE IN WATER STORAGE	0.000	(4.065)	-43.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	220500.0
RUNOFF	2.224	204345.6
PERCOLATION FROM LAYER 5	0.0090	829.3
HEAD ON LAYER 5	99.4	
PERCOLATION FROM LAYER 7	0.0090	826.7
HEAD ON LAYER 7	0.0	
PERCOLATION FROM LAYER 8	0.0086	791.5
SNOW WATER	1.18	108843.8

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4557

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0667

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	2.72	0.4530
2	9.60	0.4570
3	24.60	0.4100
4	5.00	0.4170
5	25.80	0.4300
6	2.23	0.3712
7	117.26	0.4100
8	27.13	0.0646
SNOW WATER	0.00	

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 SOUTH FIELD AND INACTIVE FLYASH PILE
 10 TO 12 FEET OF NOT IMPACTED TILL, 8 TO 11 FEET OF SOURCE
                                                   March 2, 1994

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                              FAIR GRASS

                              LAYER  1
                              --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                          =     12.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC

                              LAYER  2
                              --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                          =     76.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                              LAYER  3
                              --------

                         BARRIER SOIL LINER
   THICKNESS                          =    161.00 INCHES
   POROSITY                           =      0.4100 VOL/VOL
   FIELD CAPACITY                     =      0.3710 VOL/VOL
   WILTING POINT                      =      0.2510 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000140000 CM/SEC
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LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	376.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0633 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	135.5708 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.813	0.750	1.074	0.381	0.000	0.033
	0.020	0.043	0.184	0.027	0.000	1.271
STD. DEVIATIONS	1.124	1.660	1.658	0.535	0.000	0.061
	0.045	0.097	0.394	0.046	0.000	1.597
EVAPOTRANSPIRATION						
TOTALS	0.848	1.533	2.472	2.865	3.168	5.021
	5.456	4.290	2.263	1.965	1.663	0.901
STD. DEVIATIONS	0.186	0.308	0.123	0.279	1.635	1.285
	1.267	1.226	1.781	0.509	0.155	0.169
PERCOLATION FROM LAYER 3						
TOTALS	0.2245	0.2040	0.2235	0.2162	0.2224	0.2143
	0.2188	0.2167	0.2105	0.2173	0.2112	0.2225
STD. DEVIATIONS	0.0067	0.0071	0.0055	0.0020	0.0019	0.0025
	0.0009	0.0003	0.0035	0.0034	0.0047	0.0063
PERCOLATION FROM LAYER 4						
TOTALS	0.2208	0.2011	0.2212	0.2142	0.2215	0.2143
	0.2214	0.2211	0.2137	0.2206	0.2133	0.2204
STD. DEVIATIONS	0.0016	0.0040	0.0019	0.0020	0.0020	0.0019
	0.0019	0.0018	0.0016	0.0016	0.0015	0.0016

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

000775

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	5.595	(3.786)	21449.	13.77
EVAPOTRANSPIRATION	32.445	(3.105)	124371.	79.83
PERCOLATION FROM LAYER 3	2.6019	(0.0297)	9974.	6.40
PERCOLATION FROM LAYER 4	2.6036	(0.0213)	9981.	6.41
CHANGE IN WATER STORAGE	-0.002	(3.468)	-7.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.240	8588.5
PERCOLATION FROM LAYER 3	0.0074	28.3
HEAD ON LAYER 3	88.4	
PERCOLATION FROM LAYER 4	0.0072	27.7
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	39.52	0.5200
3	66.01	0.4100
4	23.79	0.0633
SNOW WATER	0.00	

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 REMOVE FILL EVERYWHERE EXCEPT ON TERRACE (PRG CONFIRMATION)
 SOUTH FIELD AND INACTIVE FLYASH PILE
 ZONE 2                                        March 4, 1994

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                          FAIR GRASS

                           LAYER  1
                           --------

                     VERTICAL PERCOLATION LAYER
   THICKNESS                          =     12.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                           LAYER  2
                           --------

                     VERTICAL PERCOLATION LAYER
   THICKNESS                          =     18.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                           LAYER  3
                           --------

                       BARRIER SOIL LINER
   THICKNESS                          =    217.00 INCHES
   POROSITY                           =      0.4100 VOL/VOL
   FIELD CAPACITY                     =      0.3710 VOL/VOL
   WILTING POINT                      =      0.2510 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000140000 CM/SEC
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000778

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	374.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0608 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	127.3092 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

000779

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.855	0.767	1.107	0.399	0.000	0.094
	0.020	0.043	0.204	0.026	0.000	1.451
STD. DEVIATIONS	1.143	1.676	1.692	0.554	0.000	0.159
	0.045	0.097	0.439	0.046	0.000	1.646
EVAPOTRANSPIRATION						
TOTALS	0.848	1.532	2.471	2.864	3.167	4.981
	5.767	4.304	2.278	1.986	1.658	0.900
STD. DEVIATIONS	0.186	0.308	0.124	0.279	1.634	1.311
	1.416	1.243	1.805	0.496	0.156	0.169
PERCOLATION FROM LAYER 3						
TOTALS	0.1654	0.1504	0.1648	0.1594	0.1641	0.1583
	0.1614	0.1596	0.1551	0.1602	0.1559	0.1643
STD. DEVIATIONS	0.0046	0.0049	0.0035	0.0011	0.0010	0.0014
	0.0007	0.0002	0.0025	0.0022	0.0033	0.0042
PERCOLATION FROM LAYER 4						
TOTALS	0.1627	0.1481	0.1630	0.1578	0.1631	0.1579
	0.1631	0.1630	0.1576	0.1627	0.1573	0.1626
STD. DEVIATIONS	0.0008	0.0028	0.0010	0.0010	0.0010	0.0010
	0.0009	0.0009	0.0008	0.0008	0.0008	0.0008

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	5.967	(3.853)	22872.	14.68
EVAPOTRANSPIRATION	32.756	(3.092)	125566.	80.60
PERCOLATION FROM LAYER 3	1.9189	(0.0186)	7356.	4.72
PERCOLATION FROM LAYER 4	1.9189	(0.0111)	7356.	4.72
CHANGE IN WATER STORAGE	0.000	(3.238)	0.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.252	8634.2
PERCOLATION FROM LAYER 3	0.0054	20.8
HEAD ON LAYER 3	30.4	
PERCOLATION FROM LAYER 4	0.0053	20.3
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	9.36	0.5200
3	88.97	0.4100
4	22.74	0.0608
SNOW WATER	0.00	

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REMOVE FILL EVERYWHERE EXCEPT ON TERRACE (PRG CONFIRMATION)
SOUTH FIELD AND INACTIVE FLYASH PILE
ZONE 3 March 4, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	78.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 3

BARRIER SOIL LINER

THICKNESS	=	166.00 INCHES
POROSITY	=	0.4100 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000140000 CM/SEC

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	372.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0633 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	138.4076 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX = 2.00
START OF GROWING SEASON (JULIAN DATE) = 133
END OF GROWING SEASON (JULIAN DATE) = 300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.813	0.750	1.075	0.381	0.000	0.033
	0.020	0.043	0.184	0.027	0.000	1.273
STD. DEVIATIONS	1.125	1.660	1.658	0.535	0.000	0.061
	0.045	0.097	0.394	0.046	0.000	1.598
EVAPOTRANSPIRATION						
TOTALS	0.848	1.533	2.472	2.865	3.168	5.021
	5.458	4.290	2.263	1.965	1.663	0.901
STD. DEVIATIONS	0.186	0.308	0.123	0.279	1.635	1.285
	1.267	1.226	1.781	0.509	0.155	0.169

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PERCOLATION FROM LAYER  3
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  TOTALS              0.2239  0.2035  0.2230  0.2157  0.2219  0.2139
                      0.2184  0.2164  0.2102  0.2170  0.2109  0.2220

  STD. DEVIATIONS     0.0065  0.0070  0.0053  0.0020  0.0018  0.0024
                      0.0009  0.0003  0.0034  0.0033  0.0046  0.0061

PERCOLATION FROM LAYER  4
-------------------------
  TOTALS              0.2205  0.2008  0.2209  0.2139  0.2211  0.2140
                      0.2211  0.2208  0.2134  0.2203  0.2130  0.2201

  STD. DEVIATIONS     0.0016  0.0040  0.0020  0.0020  0.0020  0.0019
                      0.0019  0.0018  0.0016  0.0017  0.0016  0.0016
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 AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS   74 THROUGH   78
-----------------------------------------------------------------------
                                (INCHES)          (CU. FT.)    PERCENT
                              ----------------   -----------   -------
 PRECIPITATION                40.64   ( 6.929)     155794.     100.00

 RUNOFF                        5.598  ( 3.788)      21461.      13.77

 EVAPOTRANSPIRATION           32.447  ( 3.104)     124379.      79.84

 PERCOLATION FROM LAYER  3     2.5968 ( 0.0288)      9955.       6.39

 PERCOLATION FROM LAYER  4     2.5997 ( 0.0216)      9966.       6.40

 CHANGE IN WATER STORAGE      -0.003  ( 3.467)        -11.      -0.01
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000785

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.241	8589.4
PERCOLATION FROM LAYER 3	0.0073	28.2
HEAD ON LAYER 3	90.4	
PERCOLATION FROM LAYER 4	0.0072	27.6
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	40.56	0.5200
3	68.06	0.4100
4	23.53	0.0633
SNOW WATER	0.00	

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 REMOVE FILL EVERYWHERE EXCEPT ON TERRACE (PRG CONFIRMATION)
 SOUTH FIELD AND INACTIVE FLYASH PILE
 ZONE 4                                        March 4, 1994

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                          FAIR GRASS

                           LAYER  1
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                    VERTICAL PERCOLATION LAYER
   THICKNESS                          =     12.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                           LAYER  2
                           --------

                    VERTICAL PERCOLATION LAYER
   THICKNESS                          =     43.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                           LAYER  3
                           --------

                      BARRIER SOIL LINER
   THICKNESS                          =    209.00 INCHES
   POROSITY                           =      0.4100 VOL/VOL
   FIELD CAPACITY                     =      0.3710 VOL/VOL
   WILTING POINT                      =      0.2510 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000140000 CM/SEC
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000787

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	374.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0616 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	137.3284 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

000788

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.841	0.762	1.097	0.393	0.000	0.048
	0.020	0.043	0.198	0.026	0.000	1.384
STD. DEVIATIONS	1.136	1.671	1.682	0.548	0.000	0.071
	0.045	0.097	0.425	0.046	0.000	1.631
EVAPOTRANSPIRATION						
TOTALS	0.848	1.533	2.471	2.865	3.167	4.981
	5.710	4.300	2.278	1.987	1.659	0.900
STD. DEVIATIONS	0.186	0.308	0.124	0.279	1.634	1.311
	1.412	1.238	1.805	0.496	0.157	0.169
PERCOLATION FROM LAYER 3						
TOTALS	0.1837	0.1670	0.1830	0.1770	0.1822	0.1757
	0.1795	0.1776	0.1726	0.1782	0.1733	0.1824
STD. DEVIATIONS	0.0049	0.0053	0.0038	0.0013	0.0012	0.0016
	0.0008	0.0002	0.0026	0.0023	0.0034	0.0045
PERCOLATION FROM LAYER 4						
TOTALS	0.1804	0.1643	0.1808	0.1751	0.1810	0.1752
	0.1810	0.1809	0.1749	0.1806	0.1746	0.1805
STD. DEVIATIONS	0.0008	0.0031	0.0010	0.0010	0.0010	0.0010
	0.0010	0.0009	0.0008	0.0008	0.0008	0.0008

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	5.813	(3.864)	22282.	14.30
EVAPOTRANSPIRATION	32.697	(3.077)	125339.	80.45
PERCOLATION FROM LAYER 3	2.1323	(0.0202)	8174.	5.25
PERCOLATION FROM LAYER 4	2.1292	(0.0115)	8162.	5.24
CHANGE IN WATER STORAGE	0.003	(3.310)	12.	0.01

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.252	8632.0
PERCOLATION FROM LAYER 3	0.0060	23.1
HEAD ON LAYER 3	55.4	
PERCOLATION FROM LAYER 4	0.0059	22.5
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	22.36	0.5200
3	85.69	0.4100
4	23.05	0.0616
SNOW WATER	0.00	

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 REMOVE FILL TO 60 PCI/G ABOVE TERRACE AND 5 PCI/G ELSEWHERE
 SOUTH FIELD AND INACTIVE FLYASH PILE
 ZONE 2                                        March 1, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3970 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	26.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3435 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	264.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0800 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	4.7640 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	34.8150 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	0.000	0.020	0.000	0.019	0.000	0.027
	0.022	0.043	0.008	0.027	0.000	0.016
STD. DEVIATIONS	0.000	0.044	0.000	0.042	0.000	0.061
	0.048	0.096	0.014	0.046	0.000	0.036
EVAPOTRANSPIRATION						
TOTALS	0.848	1.534	2.470	2.879	3.165	4.809
	4.073	4.272	2.250	1.983	1.672	0.893
STD. DEVIATIONS	0.189	0.311	0.129	0.331	1.635	1.381
	1.402	1.207	1.767	0.526	0.138	0.170
PERCOLATION FROM LAYER 3						
TOTALS	0.8352	1.0329	1.2453	1.2758	1.0715	0.8111
	0.6842	0.5754	0.5131	0.5287	0.4737	0.5658
STD. DEVIATIONS	0.3779	0.4749	0.7002	0.9397	0.6703	0.4254
	0.2926	0.1962	0.1774	0.2619	0.2075	0.2471

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	0.181	(0.096)	694.	0.45
EVAPOTRANSPIRATION	30.847	(2.970)	118245.	75.90
PERCOLATION FROM LAYER 3	9.6130	(4.3239)	36850.	23.65
CHANGE IN WATER STORAGE	0.001	(4.506)	5.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	0.214	819.0
PERCOLATION FROM LAYER 3	0.1001	383.7
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4810

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	4.76	0.3970
2	8.93	0.3435
3	21.13	0.0800
SNOW WATER	0.00	

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REMOVE FILL TO 60 PCI/G ABOVE TERRACE AND 5 PCI/G ELSEWHERE
SOUTH FIELD AND INACTIVE FLYASH PILE
ZONE 3 March 1, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3970 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	175.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3367 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	228.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0734 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	4.7640 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	80.4217 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	0.000	0.020	0.000	0.019	0.000	0.027
	0.022	0.043	0.008	0.027	0.000	0.016
STD. DEVIATIONS	0.000	0.044	0.000	0.042	0.000	0.061
	0.048	0.096	0.014	0.046	0.000	0.036
EVAPOTRANSPIRATION						
TOTALS	0.848	1.534	2.470	2.879	3.165	4.809
	4.073	4.272	2.250	1.984	1.672	0.892
STD. DEVIATIONS	0.189	0.311	0.128	0.332	1.635	1.381
	1.402	1.207	1.767	0.527	0.138	0.170
PERCOLATION FROM LAYER 3						
TOTALS	0.6821	0.7043	0.8792	0.9673	1.0362	0.9456
	0.8909	0.8049	0.7156	0.7010	0.6432	0.6438
STD. DEVIATIONS	0.2027	0.2250	0.3254	0.4649	0.5470	0.4802
	0.4131	0.3318	0.2646	0.2509	0.2215	0.2043

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	0.181	(0.096)	694.	0.45
EVAPOTRANSPIRATION	30.847	(2.971)	118247.	75.90
PERCOLATION FROM LAYER 3	9.6141	(3.7773)	36854.	23.66
CHANGE IN WATER STORAGE	0.000	(4.878)	-1.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	0.214	819.0
PERCOLATION FROM LAYER 3	0.0604	231.4
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4811

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	4.76	0.3970
2	58.92	0.3367
3	16.74	0.0734
SNOW WATER	0.00	

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 REMOVE FILL TO 60 PCI/G ABOVE TERRACE AND 5 PCI/G ELSEWHERE
 SOUTH FIELD/INACTIVE FLYASH PILE
 ZONE 4                                   March 1, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4100 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 2

BARRIER SOIL LINER

THICKNESS	=	25.00 INCHES
POROSITY	=	0.4100 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000140000 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	341.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0572 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	77900. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	4.9200 INCHES
INITIAL VEG. STORAGE	=	4.9200 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	34.6752 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.875	0.750	1.254	0.656	0.000	0.481
	0.121	0.701	0.553	0.584	0.362	2.354
STD. DEVIATIONS	1.001	1.660	1.570	0.651	0.000	0.683
	0.166	0.614	1.137	0.879	0.256	1.662
EVAPOTRANSPIRATION						
TOTALS	0.857	1.551	2.466	2.823	2.960	4.617
	3.758	3.898	2.200	1.900	1.732	0.913
STD. DEVIATIONS	0.187	0.306	0.132	0.300	1.680	1.148
	1.313	0.869	1.728	0.536	0.142	0.183
PERCOLATION FROM LAYER 2						
TOTALS	0.2021	0.1747	0.1588	0.0779	0.0447	0.0749
	0.0344	0.0448	0.0488	0.0816	0.1633	0.1697
STD. DEVIATIONS	0.0241	0.0153	0.0737	0.0370	0.0533	0.0246
	0.0224	0.0205	0.0679	0.0511	0.0284	0.0949
PERCOLATION FROM LAYER 3						
TOTALS	0.1084	0.1023	0.1148	0.1118	0.1130	0.1069
	0.1084	0.1052	0.0996	0.1010	0.0992	0.1052
STD. DEVIATIONS	0.0099	0.0106	0.0109	0.0106	0.0100	0.0094
	0.0087	0.0082	0.0081	0.0092	0.0089	0.0090

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	263834.	100.00
RUNOFF	9.692	(4.146)	62917.	23.85
EVAPOTRANSPIRATION	29.674	(2.752)	192636.	73.01
PERCOLATION FROM LAYER 2	1.2758	(0.2798)	8282.	3.14
PERCOLATION FROM LAYER 3	1.2756	(0.1053)	8281.	3.14
CHANGE IN WATER STORAGE	0.000	(1.207)	1.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	15580.0
RUNOFF	2.244	14569.5
PERCOLATION FROM LAYER 2	0.0071	46.0
HEAD ON LAYER 2	13.0	
PERCOLATION FROM LAYER 3	0.0042	27.3
SNOW WATER	1.18	7690.6

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4100

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2449

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	4.92	0.4100
2	10.25	0.4100
3	19.51	0.0572
SNOW WATER	0.00	

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REMOVE FILL TO 60 PCI/G ABOVE TERRACE AND 5 PCI/G ELSEWHERE
SOUTH FIELD AND INACTIVE FLYASH PILE
ZONE 5 March 1, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	59.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 3

BARRIER SOIL LINER

THICKNESS	=	54.00 INCHES
POROSITY	=	0.4100 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000140000 CM/SEC

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	347.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0664 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	82.1008 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX = 2.00
START OF GROWING SEASON (JULIAN DATE) = 133
END OF GROWING SEASON (JULIAN DATE) = 300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.715	0.727	1.017	0.345	0.000	0.028
	0.021	0.043	0.149	0.027	0.000	0.900
STD. DEVIATIONS	1.076	1.625	1.597	0.493	0.000	0.062
	0.047	0.097	0.317	0.046	0.000	1.516
EVAPOTRANSPIRATION						
TOTALS	0.849	1.535	2.473	2.866	3.168	5.009
	4.967	4.268	2.262	1.971	1.670	0.901
STD. DEVIATIONS	0.186	0.307	0.123	0.279	1.636	1.306
	1.178	1.201	1.782	0.512	0.153	0.173
PERCOLATION FROM LAYER 3						
TOTALS	0.3295	0.2982	0.3248	0.3135	0.3208	0.3072

	0.3104	0.3055	0.2975	0.3059	0.2977	0.3207
STD. DEVIATIONS	0.0233	0.0211	0.0198	0.0097	0.0080	0.0095
	0.0024	0.0011	0.0110	0.0110	0.0149	0.0212

PERCOLATION FROM LAYER 4

TOTALS	0.3154	0.2882	0.3176	0.3080	0.3187	0.3085
	0.3183	0.3172	0.3060	0.3152	0.3043	0.3143
STD. DEVIATIONS	0.0067	0.0092	0.0083	0.0086	0.0088	0.0084
	0.0084	0.0076	0.0068	0.0068	0.0064	0.0067

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	4.972	(3.571)	19058.	12.23
EVAPOTRANSPIRATION	31.939	(3.309)	122431.	78.59
PERCOLATION FROM LAYER 3	3.7318	(0.1118)	14305.	9.18
PERCOLATION FROM LAYER 4	3.7317	(0.0878)	14305.	9.18
CHANGE IN WATER STORAGE	0.000	(3.826)	0.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.200	8434.5
PERCOLATION FROM LAYER 3	0.0111	42.4
HEAD ON LAYER 3	71.6	
PERCOLATION FROM LAYER 4	0.0106	40.6
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	30.68	0.5200
3	22.14	0.4100
4	23.04	0.0664
SNOW WATER	0.00	

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 REMOVE FILL TO 60 PCI/G ABOVE TERRACE, 16 TO 18 FEET OF NOT IMPACTED TILL
 SOUTH FIELD/INACTIVE FLYASH PILE
 ZONE 6                                          March 1, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4100 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 2

BARRIER SOIL LINER

THICKNESS	=	223.00 INCHES
POROSITY	=	0.4100 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000140000 CM/SEC

LAYER 3

VERTICAL PERCOLATION LAYER

THICKNESS	=	379.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0559 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	77900. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	4.9200 INCHES
INITIAL VEG. STORAGE	=	4.9200 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	117.5361 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.925	0.766	1.293	0.670	0.000	0.483
	0.121	0.702	0.557	0.587	0.398	2.399
STD. DEVIATIONS	0.997	1.676	1.593	0.664	0.000	0.687
	0.166	0.615	1.146	0.879	0.266	1.682
EVAPOTRANSPIRATION						
TOTALS	0.857	1.552	2.467	2.828	2.958	4.625
	3.766	3.902	2.202	1.903	1.731	0.913
STD. DEVIATIONS	0.187	0.305	0.131	0.297	1.674	1.157
	1.316	0.871	1.732	0.542	0.142	0.183
PERCOLATION FROM LAYER 2						
TOTALS	0.1486	0.1390	0.1477	0.0645	0.0393	0.0653
	0.0300	0.0386	0.0408	0.0675	0.1332	0.1240
STD. DEVIATIONS	0.0136	0.0031	0.0113	0.0262	0.0483	0.0241
	0.0192	0.0180	0.0567	0.0406	0.0217	0.0693
PERCOLATION FROM LAYER 3						
TOTALS	0.0876	0.0816	0.0916	0.0894	0.0909	0.0866
	0.0884	0.0864	0.0823	0.0838	0.0820	0.0861
STD. DEVIATIONS	0.0057	0.0063	0.0057	0.0055	0.0051	0.0050
	0.0046	0.0045	0.0045	0.0054	0.0052	0.0053

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	263834.	100.00
RUNOFF	9.900	(4.208)	64267.	24.36
EVAPOTRANSPIRATION	29.704	(2.760)	192826.	73.09
PERCOLATION FROM LAYER 2	1.0385	(0.2089)	6742.	2.56
PERCOLATION FROM LAYER 3	1.0366	(0.0578)	6729.	2.55
CHANGE IN WATER STORAGE	0.002	(1.142)	13.	0.00

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	15580.0
RUNOFF	2.253	14624.5
PERCOLATION FROM LAYER 2	0.0050	32.6
HEAD ON LAYER 2	12.9	
PERCOLATION FROM LAYER 3	0.0033	21.1
SNOW WATER	1.18	7690.6

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4100

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2450

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	4.92	0.4100
2	91.43	0.4100
3	21.20	0.0559
SNOW WATER	0.00	

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 REMOVE FILL TO 60 PCI/G ABOVE TERRACE AND 5 PCI/G ELSEWHERE
 SOUTH FIELD AND INACTIVE FLYASH PILE
 ZONE 5                                        March 1, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	8.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

LAYER 3

BARRIER SOIL LINER

THICKNESS	=	114.00 INCHES
POROSITY	=	0.4100 VOL/VOL
FIELD CAPACITY	=	0.3710 VOL/VOL
WILTING POINT	=	0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000140000 CM/SEC

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	361.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0608 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	79.0888 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.851	0.766	1.104	0.397	0.000	0.097
	0.020	0.043	0.204	0.026	0.000	1.452
STD. DEVIATIONS	1.141	1.674	1.689	0.552	0.000	0.168
	0.045	0.097	0.439	0.046	0.000	1.642
EVAPOTRANSPIRATION						
TOTALS	0.848	1.533	2.471	2.865	3.167	4.981
	5.761	4.304	2.278	1.986	1.658	0.900
STD. DEVIATIONS	0.186	0.308	0.124	0.279	1.633	1.311
	1.416	1.243	1.805	0.496	0.157	0.169
PERCOLATION FROM LAYER 3						
TOTALS	0.1689	0.1532	0.1675	0.1619	0.1660	0.1596
	0.1609	0.1574	0.1537	0.1586	0.1552	0.1664
STD. DEVIATIONS	0.0087	0.0078	0.0065	0.0020	0.0019	0.0026
	0.0013	0.0004	0.0048	0.0041	0.0062	0.0080
PERCOLATION FROM LAYER 4						
TOTALS	0.1632	0.1487	0.1637	0.1586	0.1641	0.1588
	0.1641	0.1638	0.1582	0.1632	0.1577	0.1630

STD. DEVIATIONS	0.0015	0.0033	0.0018	0.0019	0.0019	0.0018
	0.0018	0.0017	0.0015	0.0015	0.0014	0.0015

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	5.962	(3.838)	22853.	14.67
EVAPOTRANSPIRATION	32.751	(3.090)	125546.	80.58
PERCOLATION FROM LAYER 3	1.9293	(0.0359)	7396.	4.75
PERCOLATION FROM LAYER 4	1.9272	(0.0198)	7388.	4.74
CHANGE IN WATER STORAGE	0.002	(3.228)	8.	0.01

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.252	8633.5
PERCOLATION FROM LAYER 3	0.0056	21.5
HEAD ON LAYER 3	20.4	
PERCOLATION FROM LAYER 4	0.0054	20.6
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

000818

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	4.16	0.5200
3	46.74	0.4100
4	21.96	0.0608
SNOW WATER	0.00	

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 REMOVE FILL TO 60 PCI/G ABOVE TERRACE AND 5 PCI/G ELSEWHERE
 SOUTH FIELD AND INACTIVE FLYASH PILE
 ZONE 5                                        March 1, 1994

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                          FAIR GRASS

                           LAYER  1
                           --------

                     VERTICAL PERCOLATION LAYER
   THICKNESS                          =     12.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                           LAYER  2
                           --------

                     VERTICAL PERCOLATION LAYER
   THICKNESS                          =      8.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                           LAYER  3
                           --------

                        BARRIER SOIL LINER
   THICKNESS                          =    114.00 INCHES
   POROSITY                           =      0.4100 VOL/VOL
   FIELD CAPACITY                     =      0.3710 VOL/VOL
   WILTING POINT                      =      0.2510 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000140000 CM/SEC
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000820

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	361.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0608 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	79.0888 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.851	0.766	1.104	0.397	0.000	0.097
	0.020	0.043	0.204	0.026	0.000	1.452
STD. DEVIATIONS	1.141	1.674	1.689	0.552	0.000	0.168
	0.045	0.097	0.439	0.046	0.000	1.642
EVAPOTRANSPIRATION						
TOTALS	0.848	1.533	2.471	2.865	3.167	4.981
	5.761	4.304	2.278	1.986	1.658	0.900
STD. DEVIATIONS	0.186	0.308	0.124	0.279	1.633	1.311
	1.416	1.243	1.805	0.496	0.157	0.169
PERCOLATION FROM LAYER 3						
TOTALS	0.1689	0.1532	0.1675	0.1619	0.1660	0.1596
	0.1609	0.1574	0.1537	0.1586	0.1552	0.1664
STD. DEVIATIONS	0.0087	0.0078	0.0065	0.0020	0.0019	0.0026
	0.0013	0.0004	0.0048	0.0041	0.0062	0.0080
PERCOLATION FROM LAYER 4						
TOTALS	0.1632	0.1487	0.1637	0.1586	0.1641	0.1588
	0.1641	0.1638	0.1582	0.1632	0.1577	0.1630
STD. DEVIATIONS	0.0015	0.0033	0.0018	0.0019	0.0019	0.0018
	0.0018	0.0017	0.0015	0.0015	0.0014	0.0015

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	5.962	(3.838)	22853.	14.67
EVAPOTRANSPIRATION	32.751	(3.090)	125546.	80.58
PERCOLATION FROM LAYER 3	1.9293	(0.0359)	7396.	4.75
PERCOLATION FROM LAYER 4	1.9272	(0.0198)	7388.	4.74
CHANGE IN WATER STORAGE	0.002	(3.228)	8.	0.01

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.252	8633.5
PERCOLATION FROM LAYER 3	0.0056	21.5
HEAD ON LAYER 3	20.4	
PERCOLATION FROM LAYER 4	0.0054	20.6
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	4.16	0.5200
3	46.74	0.4100
4	21.96	0.0608
SNOW WATER	0.00	

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REMOVE FILL TO 60 PCI/G ABOVE TERRACE AND 5 PCI/G ELSEWHERE
SOUTH FIELD AND INACTIVE FLYASH PILE
ZONE 8 March 1, 1994

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.5200 VOL/VOL
FIELD CAPACITY	=	0.2942 VOL/VOL
WILTING POINT	=	0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000199999995 CM/SEC

000824

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                    LAYER  2
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              VERTICAL PERCOLATION LAYER
THICKNESS                          =     80.00 INCHES
POROSITY                           =      0.5200 VOL/VOL
FIELD CAPACITY                     =      0.2942 VOL/VOL
WILTING POINT                      =      0.1400 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                    LAYER  3
                    --------

                BARRIER SOIL LINER
THICKNESS                          =    150.00 INCHES
POROSITY                           =      0.4100 VOL/VOL
FIELD CAPACITY                     =      0.3710 VOL/VOL
WILTING POINT                      =      0.2510 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000140000 CM/SEC


                    LAYER  4
                    --------

              VERTICAL PERCOLATION LAYER
THICKNESS                          =    376.00 INCHES
POROSITY                           =      0.3900 VOL/VOL
FIELD CAPACITY                     =      0.0454 VOL/VOL
WILTING POINT                      =      0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT         =      0.0636 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY   =      0.015900000930 CM/SEC


              GENERAL SIMULATION DATA
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SCS RUNOFF CURVE NUMBER            =      68.00
TOTAL AREA OF COVER                =   46000. SQ FT
EVAPORATIVE ZONE DEPTH             =      12.00 INCHES
UPPER LIMIT VEG. STORAGE           =       6.2400 INCHES
INITIAL VEG. STORAGE               =       6.2400 INCHES
INITIAL SNOW WATER CONTENT         =       0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN
  SOIL AND WASTE LAYERS            =     133.2536 INCHES

        SOIL WATER CONTENT INITIALIZED BY USER.
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000825

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX = 2.00
START OF GROWING SEASON (JULIAN DATE) = 133
END OF GROWING SEASON (JULIAN DATE) = 300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.805	0.747	1.069	0.378	0.000	0.031
	0.021	0.043	0.180	0.027	0.000	1.236
STD. DEVIATIONS	1.120	1.657	1.652	0.532	0.000	0.061
	0.046	0.097	0.387	0.046	0.000	1.591
EVAPOTRANSPIRATION						
TOTALS	0.849	1.533	2.472	2.865	3.168	5.021
	5.407	4.287	2.263	1.966	1.664	0.901
STD. DEVIATIONS	0.186	0.307	0.123	0.279	1.635	1.285
	1.250	1.223	1.781	0.509	0.155	0.169

PERCOLATION FROM LAYER 3

TOTALS	0.2340	0.2126	0.2329	0.2252	0.2317	0.2232
	0.2278	0.2256	0.2192	0.2263	0.2199	0.2318
STD. DEVIATIONS	0.0074	0.0077	0.0060	0.0023	0.0021	0.0028
	0.0009	0.0003	0.0038	0.0036	0.0051	0.0068

PERCOLATION FROM LAYER 4

TOTALS	0.2295	0.2091	0.2301	0.2229	0.2304	0.2230
	0.2304	0.2301	0.2224	0.2296	0.2220	0.2294
STD. DEVIATIONS	0.0016	0.0043	0.0020	0.0020	0.0020	0.0020
	0.0020	0.0018	0.0017	0.0017	0.0016	0.0016

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	5.536	(3.763)	21222.	13.62
EVAPOTRANSPIRATION	32.395	(3.127)	124183.	79.71
PERCOLATION FROM LAYER 3	2.7104	(0.0327)	10390.	6.67
PERCOLATION FROM LAYER 4	2.7090	(0.0217)	10385.	6.67
CHANGE IN WATER STORAGE	0.001	(3.505)	5.	0.00

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000827

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.237	8575.1
PERCOLATION FROM LAYER 3	0.0077	29.5
HEAD ON LAYER 3	92.5	
PERCOLATION FROM LAYER 4	0.0075	28.8
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.5200
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	41.60	0.5200
3	61.50	0.4100
4	23.92	0.0636
SNOW WATER	0.00	

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 SOUTH FIELD AND INACTIVE FLYASH PILE
 12 TO 16 FEET OF NOT IMPACTED TILL, 6 TO 10 FEET OF SOURCE
                                                   March 1, 1994

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                              FAIR GRASS

                              LAYER  1
                              --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                          =     12.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                              LAYER  2
                              --------

                      VERTICAL PERCOLATION LAYER
   THICKNESS                          =     46.00 INCHES
   POROSITY                           =      0.5200 VOL/VOL
   FIELD CAPACITY                     =      0.2942 VOL/VOL
   WILTING POINT                      =      0.1400 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.5200 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000199999995 CM/SEC


                              LAYER  3
                              --------

                        BARRIER SOIL LINER
   THICKNESS                          =    197.00 INCHES
   POROSITY                           =      0.4100 VOL/VOL
   FIELD CAPACITY                     =      0.3710 VOL/VOL
   WILTING POINT                      =      0.2510 VOL/VOL
   INITIAL SOIL WATER CONTENT         =      0.4100 VOL/VOL
   SATURATED HYDRAULIC CONDUCTIVITY   =      0.000000140000 CM/SEC
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000829

LAYER 4

VERTICAL PERCOLATION LAYER

THICKNESS	=	370.00 INCHES
POROSITY	=	0.3900 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0618 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.015900000930 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	68.00
TOTAL AREA OF COVER	=	46000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	6.2400 INCHES
INITIAL VEG. STORAGE	=	6.2400 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	133.7960 INCHES

SOIL WATER CONTENT INITIALIZED BY USER.

CLIMATOLOGICAL DATA

DEFAULT RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR CINCINNATI OHIO

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	133
END OF GROWING SEASON (JULIAN DATE)	=	300

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
28.90	32.10	41.80	53.50	63.00	71.40
75.40	74.10	67.50	55.30	43.40	33.80

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 74 THROUGH 78

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.33	1.59	3.86	3.11	3.36	4.79
	3.54	4.80	2.89	3.33	2.69	3.36
STD. DEVIATIONS	0.56	1.34	1.71	0.63	1.78	1.24
	2.04	1.04	2.17	1.37	1.35	1.99
RUNOFF						
TOTALS	1.837	0.761	1.095	0.392	0.000	0.042
	0.020	0.043	0.196	0.026	0.000	1.369
STD. DEVIATIONS	1.134	1.670	1.679	0.547	0.000	0.062
	0.045	0.097	0.422	0.046	0.000	1.628
EVAPOTRANSPIRATION						
TOTALS	0.848	1.533	2.471	2.865	3.167	4.981
	5.691	4.299	2.277	1.987	1.659	0.900
STD. DEVIATIONS	0.186	0.308	0.124	0.279	1.634	1.311
	1.407	1.237	1.805	0.496	0.157	0.169
PERCOLATION FROM LAYER 3						
TOTALS	0.1881	0.1710	0.1874	0.1813	0.1865	0.1798
	0.1837	0.1817	0.1766	0.1823	0.1773	0.1867
STD. DEVIATIONS	0.0052	0.0056	0.0041	0.0014	0.0013	0.0018
	0.0008	0.0002	0.0028	0.0025	0.0036	0.0048
PERCOLATION FROM LAYER 4						
TOTALS	0.1848	0.1683	0.1851	0.1793	0.1854	0.1794
	0.1854	0.1852	0.1790	0.1848	0.1788	0.1847
STD. DEVIATIONS	0.0009	0.0032	0.0011	0.0012	0.0012	0.0011
	0.0011	0.0010	0.0010	0.0010	0.0009	0.0009

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 74 THROUGH 78

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	40.64	(6.929)	155794.	100.00
RUNOFF	5.781	(3.859)	22162.	14.23
EVAPOTRANSPIRATION	32.678	(3.081)	125267.	80.41
PERCOLATION FROM LAYER 3	2.1823	(0.0217)	8366.	5.37
PERCOLATION FROM LAYER 4	2.1802	(0.0129)	8357.	5.36
CHANGE IN WATER STORAGE	0.002	(3.326)	8.	0.01

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PEAK DAILY VALUES FOR YEARS 74 THROUGH 78

	(INCHES)	(CU. FT.)
PRECIPITATION	2.40	9200.0
RUNOFF	2.252	8631.4
PERCOLATION FROM LAYER 3	0.0062	23.6
HEAD ON LAYER 3	58.4	
PERCOLATION FROM LAYER 4	0.0060	23.1
SNOW WATER	1.18	4541.3

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.5200

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1391

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FINAL WATER STORAGE AT END OF YEAR 78

LAYER	(INCHES)	(VOL/VOL)
1	6.24	0.5200
2	23.92	0.5200
3	80.77	0.4100
4	22.88	0.0618
SNOW WATER	0.00	

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APPENDIX D.4

URANIUM PARTITION COEFFICIENT EVALUATION STUDY

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D.4.0 URANIUM PARTITION COEFFICIENT EVALUATION STUDY

This appendix documents the results of the Uranium Partition Coefficient Evaluation Study carried out in support of the Remedial Investigation/Feasibility Study (RI/FS) for Operable Unit 2 - Other Waste Units at the U.S. Department of Energy (DOE), Fernald Environmental Management Project (FEMP) at Fernald, Ohio. The study consisted of laboratory analyses conducted to determine the partition coefficients (K_d) for waste, soils, and geologic formations in Operable Unit 2 as an input in fate and transport modeling. This appendix will focus on the K_d for total uranium, which is prevalent throughout the Operable Unit 2 waste units. The K_d results are based on both adsorption and desorption tests conducted at the FEMP laboratory.

To identify Operable Unit 2-specific K_d values, a laboratory study was conducted on Operable Unit 2 waste and soil. Waste and soil samples were collected from the waste units and associated geological layers for each of the subunits. These waste or soil samples underwent laboratory tests where they were mixed with a leachate solution in a batch-type reactor. Two separate tests were conducted, one test evaluated the amount of uranium that was leached from the waste and soil and the other test evaluated the amount of uranium that was adsorbed by the waste or soil. The first test was conducted on samples (collected in the subunits where the media was contaminated) that were considered to be contaminated. The second test was conducted on samples whose analysis showed little or no contamination.

D.4.1 Soil Sample Selection

Table D.4-1 is a summary of the samples which were used to develop K_d values and the location where they were sampled. The samples were collected from the ongoing field sampling activities or retrieved from the sample archive. The contaminated samples were identified by the beta-gamma field readings conducted during the field sampling program. Samples with beta-gamma field readings above background were considered contaminated. Once the appropriate sample(s) were located, sample numbers were identified for retrieval from FEMP archives. Since the RI field sampling program was ongoing at the time, some soil samples were collected directly from the field.

The main purpose for collecting samples directly from the field was to assure that samples with significant levels of contamination were used. The field samples included both Trench Nos. 1 and 4 samples in the South Field; Boring No. 1985 in the Solid Waste Landfill; and the sand and gravel

TABLE D.4-1

SUMMARY OF K_d STUDY SAMPLES FOR OPERABLE UNIT 2

Waste Subunits	Waste Material Samples	Glacial Overburden Samples	Sand and Gravel Samples	Great Miami Aquifer Samples
Solid Waste Landfill	Boring 1985 (depth 0-3 ft.) Boring 1986 (depth 5-7.5 ft.)	Boring 1986 (depth 12.5-15 ft.) Boring 11037 (depth 20-22.5 ft.)	Boring 2953 (depth 46 ft.)	Boring 2953 (depth 70 ft.)
Lime Sludge Ponds	LSP-SS-03 (depth 0-12 in.) LSP-SS-05 (depth 0-6 in.) LSP-SS-06 (depth 0-6 in.)	N/S	N/S	N/S
Inactive Flyash Pile	Boring 11001 (depth 0.5-2.5 ft.) Boring 11003 (depth 3.5-5.5 ft.)	N/S	N/S	N/S
Active Flyash Pile	Boring 1980 (depth 4-5.5 ft.)	N/S	N/S	N/S
South Field	Trench No. 1 (depth 2 ft.)	Boring 11187 (depth 6.5-7 ft.) Trench No. 4 (depth 7 ft.)	Boring 2944 (depth 25-51 ft.)	Boring 2944 (depth 50-65 ft.)

N/S - No Sample Collected

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samples from Boring No. 2944 in the South Field and Boring No. 2953 in the Solid Waste Landfill. The samples with the highest contamination based on hand held beta-gamma measurements were found in the South Field trench locations and at Boring No. 1985 in the Solid Waste Landfill. The sand and gravel samples from Boring Nos. 2944 and 2953 were collected because the samples were the last two borings to be drilled in the RI sampling program, and all the previous borings contained low concentrations in the sand and gravel zones. After collection, however, these samples also showed no or little contamination.

The sample volume required for the test was approximately two liters; however, the archive samples were usually in 500 milliliter (mL) jars. Therefore, three to four archive samples were required at slightly different depths to make one K_d sample. However, all of the samples were from the same split spoon interval with the exception of samples from Boring No. 2944. Samples from Boring No. 2944 in the South Field were collected over a 26 foot interval and a 15 foot interval for the unsaturated and saturated sand and gravel, respectively. These samples were composited in the field, whereas the archive samples were combined and homogenized in the FEMP laboratory.

D.4.1.1 Waste Samples

A waste material sample was collected from each subunit. All were identified as containing elevated levels of uranium except the Active Flyash Pile sample. The waste material was considered the flyash for the Active Flyash Pile and the Inactive Flyash Pile. One sample from each pile was collected. A second sample at the Inactive Flyash Pile was collected for the earthen cover material overlying the flyash. The waste material at the Lime Sludge Pond was the lime sludge. Two samples were taken at the north Lime Sludge Pond and composited into one. Another sample of the earthen berm material was also collected.

Two waste samples were collected for the Solid Waste Landfill. Both were in the boundaries of the waste cells and were taken at different depths. One waste material sample was collected for the South Field. The sample was collected during the RI trenching at the South Field; visual inspection identified the sample as fill material.

D.4.1.2 Glacial Overburden Layer

The glacial overburden was characterized using soil samples collected from two separate areas composed of Operable Unit 2 subunits. The areas were the Solid Waste Landfill/Lime Sludge Ponds and the Active Flyash Pile/Inactive Flyash Pile/South Field. This approach was based on similarities in lithologic descriptions taken from boring logs from each collective area. Additionally, the South Field and the Solid Waste Landfill were considered to have the greatest potential for future impact to the Great Miami Aquifer. All of the glacial overburden samples collected for the study were contaminated.

Two samples were collected from Solid Waste Landfill, one in a blue clay just below the bottom of the Solid Waste Landfill at a depth of 12.5-15.0 feet and the other in an olive clay area below the blue clay at a depth of 20-22.5 feet. Two samples were collected from the South Field; one of the samples was collected in a gray olive silty clay at Trench No. 4 at a depth of seven feet and one at Boring No. 1974 in a light olive brown silty clay at a depth of seven feet.

D.4.1.3 Sand and Gravel Layer

The sand and gravel samples were considered to be similar at all the subunits. This approach was based on the Great Miami Aquifer being continuous over the site. All the sand and gravel samples collected for the K_d study were relatively free of contamination. The samples were collected at two locations. One set of samples (saturated and unsaturated) was at the Solid Waste Landfill/Lime Sludge Ponds in an area between the two units. The other set of samples was collected in the South Field.

D.4.2 Laboratory Procedures

Two types of batch tests were used to perform the laboratory K_d studies. One was a desorption test used on the contaminated samples and was based on determining the amount of total uranium that leached into solution. The other was an adsorption test used on the samples which contained low concentrations of total uranium and was based on determining the total uranium adsorbed by the soil/waste from a uranium spiked water solution. The desorption and adsorption tests meet the same objectives but operate in reverse of one another. Both tests will determine the equilibrium uranium concentrations of the soil and liquid solution. The selection of the appropriate K_d test was based on

the soil sample's initial total uranium concentration. A total of 19 tests were performed on the soil samples, which consisted of 11 desorption tests and eight adsorption tests.

The desorption test was performed for all of the samples that had a total uranium concentration above background. The adsorption test was performed on the remaining soil samples. For some samples both the adsorption and desorption tests were performed for comparison purposes. A total uranium analysis on the initial waste/soil samples was performed by both the FEMP and International Technology Corporation Analytical Services (ITAS), which participates in the U.S. Environmental Protection Agency's (EPA) Contract Laboratory Program (CLP).

The ASTM D 4319-83 Standard Test Method for Distribution Ratios by the Short-Term Batch Method was evaluated and used as guidance in the preparation for the procedure used in the K_d evaluation. Where appropriate, specific preparatory procedures of the ASTM were used. The K_d evaluation procedure is provided in Appendix A.

D.4.2.1 Desorption Test

In general, the desorption test consisted of placing a 400 gram portion of the sample into a one gallon Nalgene plastic jar/reactor with 3500 mL of a water solution. This equated to a liquid to soil ratio of 8.75. The soil and liquid mixture was tumbled continuously at approximately 29 revolutions per minute until the total uranium concentration in the water solution reached equilibrium.

Soil preparation started with compositing several archive samples for the same boring and depth (due to the small volumes archived) into a 600 gram sample. The 600 gram sample was then filtered to remove any free liquids. No drying was performed. The only samples requiring filtering were the saturated sand and gravel samples. After filtering, a 400 gram sample was weighed and placed in the reactor with the water.

The remaining portion of the waste/soil sample that was not placed in the jar was prepared for laboratory analysis on total uranium and moisture content. A 200 gram sample was oven-dried at 103°C for 24 hours. The moisture content was calculated by using the weight of the sample before oven-drying and the weight of the sample after oven-drying. A 10 gram portion of the oven-dried sample was used for the FEMP total uranium analysis and a 135 gram portion was used for the off-site laboratory analysis.

In the desorption tests, three different water solutions were used with the soils to determine the K_d and were based on the location/type of the soil sample. For the waste material samples, a distilled water solution adjusted to 5.6 pH with 60/40 mixture of sulfuric acid to nitric acid solution was used. This water solution was used to represent the rainwater percolating through the waste material. The glacial overburden soil samples used a distilled water solution with no pH adjustment. The unsaturated and saturated sand and gravel samples were mixed with FEMP groundwater from a 3000-series background well. The groundwater was considered to have a uranium concentration that was representative of the background level at the site.

The time period for the desorption test samples to reach equilibrium was approximately two weeks. During each test, a sample of the water solution was analyzed periodically for total uranium to verify when the sample reached equilibrium. This was performed by drawing off a 20 mL of leachate and filtering the sample through a 0.45 micron size membrane filter to remove any solids. The sampling frequency for some of the water samples was adjusted on occasion because of holidays or weekends. All of the intermediate water samples were analyzed for total uranium at the FEMP laboratory to allow quick turnaround times which were required during the test. The final samples from each test were split between the ITAS and FEMP laboratory.

Other parameters such as pH, oxidation/reduction potential (E_h), and specific conductivity can effect the "sorption" process and K_d value [(American Society for Testing and Materials) D-4319]. Therefore, during each adsorption/desorption test, periodic measurements were made for temperature, pH, E_h, and specific conductivity. The measurements were made at the same time that samples of the water solutions were collected for total uranium analysis during the test.

All of the subunits' waste samples and glacial overburden samples underwent the desorption test except for the Active Flyash Pile flyash. The Active Flyash Pile flyash was not contaminated above background concentrations. Also, the Inactive Flyash Pile flyash sample did not leach uranium at concentrations which were detectable and therefore was discontinued after ten days. Attachment B-1 provides the laboratory desorption test results.

D.4.2.2 Adsorption Test

In the adsorption tests, the same type of water solutions were prepared as in the desorption tests, depending on the location of the sample. The exception in the preparation activities between the two

tests was that the water solutions were spiked with uranium for the adsorption test. The spiked solution was a 1.0 milligram (mg)/mL concentration of uranium nitrate in two percent nitric acid. The water was spiked with 7 mL of the uranium nitrate solution. The addition of the uranium nitrate solution resulted in a uranium concentration of 2 mg/L for the initial water solution in all of the adsorption tests.

The testing period on the adsorption of non-contaminated samples focused more on the first 72 hours of the test. During this period, a sample was collected each day. Literature review indicates most adsorption tests reach equilibrium within that time period (ASTM D-4319). If equilibrium was not reached, periodic sampling would continue after the 72 hour period, until equilibrium was reached. Equilibrium was determined by evaluating results from two consecutive samples. If the samples were within five percent (+ or -) or less, the sample was considered at equilibrium and the test was stopped.

All of the sand and gravel samples underwent the adsorption test since they were not contaminated. The soil samples from the glacial overburden at Boring No. 1986 in the Solid Waste Landfill, flyash at both the Active Flyash Pile and Inactive Flyash Pile, and Trench No. 4 in the South Field were also tested. These soil samples, except for the Active Flyash Pile flyash, had low total uranium concentrations which were considered too low to leach into solution under the desorption test. The desorption test was performed on these three samples with the adsorption test performed for comparison purposes. The flyash sample from the Inactive Flyash Pile (Sample No. 114068) did not leach any measurable quantity of uranium during the desorption test. The other two glacial overburden samples (Samples Nos. 111457 and 113721) had detectable uranium concentrations in the leachate. Appendix B-2 provides the laboratory adsorption test results.

D.4.2.3 Analytical Methods/Procedures

The total uranium analysis was performed by both the FEMP laboratory and the ITAS. The FEMP analysis was at an analytical support level B and the ITAS analysis was at an analytical support level C. The FEMP laboratory used calorimetric analysis for the soil analysis and laser phosphorimetry for the water analysis. The volume requirements were 5 grams for the soils and 10 mL for the water. The FEMP Analytical Laboratory Services methods used were 3002 and 3062 for soils and water, respectively, which is consistent with the FEMP Site-wide Comprehensive Environmental Response,

Compensation, and Liability Act of 1980 (CERCLA) Quality Assurance Project Plan (SCQ) requirements.

The ITAS used gamma spectrometry for the soil analysis and pulsed laser phosphorimetry for the water analysis. The volume requirements were 135 grams for the soils and 210 mL for the water. The standard operating procedures used were OR7003 and OR7127 for soils and water, respectively, and was consistent with the EPA approved CLP operating procedures.

The pH, E_h, conductivity, and temperature were measured by placing the instrument probe directly into the jar/reactor. The instrument was calibrated each day for E_h, conductivity, and pH. The E_h and conductivity calibration was performed by zeroing the meter. The pH was calibrated by using a 4.0 and 7.0 pH buffer. Also, when using the probe, the jars were organized to be sampled in increasing aqueous uranium concentrations; the probe was also raised with deionized water between samples to avoid cross-contamination of the samples.

D.4.3 Partition Coefficient Calculations

The K_d values for both the adsorption and desorption tests were calculated by dividing the concentration of uranium in the test media or soil (at equilibrium) by the concentration of uranium in the test liquid or groundwater (at equilibrium), as follows:

$$K_d = \frac{C_s'}{C_l}$$

C_s' = concentration of uranium in soil or test media (minus background)

C_l = concentration of uranium in liquid (at equilibrium)

The concentration of uranium in the liquid (at equilibrium) was obtained directly from laboratory analytical results; however, the concentration of uranium in the soil was calculated.

Desorption Calculations:

In order to calculate the concentration of uranium in the soil (at equilibrium), the mass of uranium in the water (at equilibrium) must first be determined. The mass of uranium was calculated by multiplying the concentration of uranium in the liquid (at equilibrium) by the total volume of the test liquid used during the desorption test, as follows:

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$$m_l = C_l \times V$$

m_l = Mass of Uranium in Liquid (at equilibrium)

V = Volume of Liquid used During Desorption Testing

The initial mass of uranium in the soil was calculated by multiplying the initial concentration of uranium in the soil by the mass of the soil, as follows:

$$m_s = C_o \times M$$

m_s = Initial Mass of Uranium in Soil or Test Media

C_o = Initial Concentration of Uranium in Soil or Test Media

M = Mass of Soil or Test Media

Once these two values were determined, the concentration of uranium in the soil (at equilibrium) was calculated by subtracting the mass of uranium in the liquid (at equilibrium) from the initial mass of uranium in the soil and dividing the difference by the mass of the soil, as follows:

$$C_s = \frac{m_s - m_l}{M}$$

C_s = Concentration of Uranium in Soil or Test Media (at equilibrium)

In calculating the K_d values, the liquid source has an impact on determining the total uranium concentration in the soil. The background uranium concentration in soil was assumed to be in equilibrium with groundwater. In tests where groundwater was used as the desorption test liquid, the background uranium concentration was not subtracted from the concentration of uranium in the soil (at equilibrium); therefore, C_s' equals C_s. However, in tests where groundwater was not used as the adsorption test liquid, the background uranium concentration was subtracted from the concentration of uranium in the soil (at equilibrium), as follows:

$$C_s' = C_s - C_b$$

C_b = Background Concentration of Uranium

The background total uranium concentration in soil was calculated to be 3.7 micrograms per gram (μg/g) by using the FEMP background activity for uranium isotopes. The equation used for the

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calculation is found in Data Validation Program, Rev. 0, DOE Oak Ridge Operations Office, 1991, pages D-3 through D-5.

The K_d calculations for the desorption tests were based on the analytical results for the ITAS laboratory and can be found in Attachment C-1. A summary of the off-site analytical results and the K_d values for the desorption tests are provided in Table D.4-2.

Desorption Test Calculation Example:

The following is an example of desorption testing calculations for Sample No. 111457 to determine the K_d value.

C_o = 18.3 μg/g
C_l = 10.6 μg/L
M = 400 g
V = 3.5 L
C_b = 3.7 μg/g
m_l = C_l x V = 10.6 μg/L x 3.5 l = 37.1 μg
m_s = C_o x M = 18.3 μg/g x 400 g = 7,320 μg

$$C_s = \frac{m_s - m_l}{M} = \frac{7{,}320\ \mu g - 37.1\ \mu g}{400\ g} = \frac{7282.9\ \mu g}{400\ g} = 18.2\ \mu g/g$$

$$C_s' = C_s - C_b = 18.2\ \mu g/g - 3.7\ \mu g/g = 14.5\ \mu g/g$$

$$K_d = \frac{C_s'}{C_l} = \frac{14.5\ \mu g/g}{10.6\ \mu g/L} = 1.37\ L/g = 1370\ L/kg$$

Kd = 1370 L/kg

TABLE D.4-2
OPERABLE UNIT 2 K_d VALUES FOR DESORPTION TEST

Sample No.	Location[a]	Total Uranium			K_d Values (L/kg)
		Initial Soil Concentration (μg/g)	Equilibrium Soil Concentration (μg/g)	Equilibrium Water Concentration (μg/L)	
111455	Solid Waste Landfill/1986 - Waste Material	146.0	127.4	1700.0	75
111440	Solid Waste Landfill/1985 - Waste Material	74.0	63.9	726.0	88
111457	Solid Waste Landfill/1986 - Glacial Overburden	18.3	14.5	10.6	1370
115370	Solid Waste Landfill/11037 - Glacial Overburden	9.0/2.65[b]	2.0	10.0	200
114472	Lime Sludge Pond/SS03 - Waste/Berm Material	18.9	14.8	41.6	360
114494	Lime Sludge Pond/SS05&06 - Lime Sludge	14.3	10.6	4.0	2650
114067	Inactive Flyash Pile/11001 - Cover Material	147.0	127.5	1810.0	70
114068	Inactive Flyash Pile/11003 - Flyash	16.9	---[c]	---	---
114070	South Field/11187 - Glacial Overburden	308.0	304	32.5	9350
113717	South Field/Trench No. 1 - Waste Material	278.0	261.4	1480.0	180
113721	South Field/Trench No. 4 - Glacial Overburden	4.34	0.6	2.16	280

[a]Identifies subunit and boring number

[b]Used average of FEMP and IT soil concentration

[c]Concentration below detection limit

Adsorption Calculations:

In order to calculate the concentration of uranium in the soil (at equilibrium), the amount of uranium adsorbed to the soil must first be calculated. The mass of uranium adsorbed was calculated by multiplying the initial concentration of uranium spiked in the liquid by the volume of the liquid used during adsorption testing, as follows:

$m_i = S \times V$
m_i = Initial Mass of Uranium Spiked in Liquid
S = Initial Concentration of Uranium Spiked in Liquid
V = Volume of Liquid used During Adsorption Testing

Then, the mass of uranium in the solution (at equilibrium) was calculated by multiplying the concentration of uranium in the liquid (at equilibrium) by the volume of the liquid used during adsorption testing, as follows:

$m_f = C_l \times V$

m_f = Mass of Uranium in Liquid (at equilibrium)

C_l = Concentration of Uranium in Liquid (at equilibrium)

The concentration of uranium adsorbed in the soil was calculated by subtracting the mass of uranium in the liquid (at equilibrium) from the initial mass of uranium spiked in the liquid and dividing the difference by the total soil mass, as follows:

$$C_a = \frac{m_i - m_f}{M}$$

C_a = Concentration of Uranium Adsorbed in Soil or Test Media

M = Mass of Soil or Test Media

The final concentration of uranium in the soil (at equilibrium) was calculated by adding the concentration of uranium adsorbed in the soil to the initial concentration of uranium in the soil, as follows:

$C_s = C_a + C_o$
C_s = Concentration of Uranium in Soil or Test Media (at equilibrium)
C_o = Initial Concentration of Uranium in Soil or Test Media

The background uranium concentration in the soil was assumed to be in equilibrium with the groundwater concentrations; therefore, in tests where groundwater was used as the adsorption test

liquid, the background uranium concentration was not subtracted from the concentration of uranium in the soil (at equilibrium); therefore, Cs' equals Cs. In tests where groundwater was not used as the adsorption test liquid, the background uranium concentration was subtracted from the concentration of uranium in the soil (at equilibrium), as follows:

$$C_s' = C_s - C_b$$
$$C_b = \text{Background Concentration of Uranium}$$

The K_d calculations for the adsorption tests were based on the analytical results for the ITAS laboratory and can be found in Attachment C-2. A summary of the off-site analytical results and the K_d values for the adsorption test are provided in Table D.4-3.

Adsorption Test Calculation Example:

The following is an example of adsorption testing calculations for Sample No. 11457 to determine the Kd values.

Given:

$C_o = 18.3\ \mu g/g$ $\quad V = 3.5\ L$
$C_l = 357\ \mu g/L$ $\quad S = 2000\ \mu g/L$
$M = 400\ g$

Calculations:

$$m_i = S \times V = 2000\ \mu g/L \times 3.5\ L = 7000\ \mu g$$
$$m_f = C_l \times V = 357\ \mu g/L \times 3.5\ L = 1249.5\ \mu g$$

$$C_a = \frac{m_i - m_f}{M} = \frac{7000\ \mu g - 1249.5\ \mu g}{400\ g} = \frac{5750.5\ \mu g}{400\ g} = 14.4\ \mu g/g$$

$$C_s = C_a + C_o = 14.4\ \mu g/g + 18.3\ \mu g/g = 32.7\ \mu g/g$$
$$C_s' = C_s - C_b = 32.7\ \mu g/g - 3.7\ \mu g/g = 29.0\ \mu g/g$$

$$K_d = \frac{C_s'}{C_l} = \frac{29.0\ \mu g/g}{357\ \mu g/L} = 0.081\ L/g = 81.0\ L/kg$$

$$K_d = 81.0\ L/kg$$

The off-site results were used because they were performed by a laboratory using EPA CLP procedures.

TABLE D.4-3

OPERABLE UNIT 2 K_d VALUES FOR ADSORPTION TEST

Sample No.	Location[a]	Total Uranium			K_d Values (L/kg)
		Initial Soil Concentration (μg/g)	Equilibrium Soil Concentration (μg/g)	Equilibrium Water Concentration (μg/L)	
115445	Solid Waste Landfill/2953 - Unsaturated Sand and Gravel	1.63	11.1	918.0	12.0
115454	Solid Waste Landfill/2953 - Saturated Sand and Gravel	1.17	10.1	982.0	10.0
111457	Solid Waste Landfill/1986 - Glacial Overburden	18.3	29.0	357.0	81
114068	Inactive Flyash Pile/11003 - Flyash	16.9	30.7	3.0[b]	10,230
114069	Active Flyash Pile/1980 - Flyash	12.2	21.1	564.0	37.0
113721	South Field/Trench No. 4 - Glacial Overburden	4.34	10.4	876.0	12.0
113755	South Field/2944 - Unsaturated Sand and Gravel	1.43	11.7	826.0	14.0
113770	South Field/2944 - Saturated Sand and Gravel	2.86	9.9	1190.0	8.0

[a]Identifies subunit and boring number

[b]Used FEMP average water analysis result

D.4.4 Summary and Conclusions

D.4.4.1 Desorption Versus Adsorption

A summary of K_d values for desorption and adsorption tests is provided in Table D.4-4. Two values were provided wherever there were two samples from the same area and for the sand and gravel samples since they were similar. The K_d values, based on desorption values, were significantly higher then the adsorption test based K_d values. Results for the Solid Waste Landfill Sample No. 111457 and South Field Sample No. 113721 provide a direct comparison between the two tests. Measurement of the Solid Waste Landfill sample yielded a K_d of 1370.0 L/kg from the desorption test and a K_d of 81.0 L/kg from the adsorption test. On the South Field sample, the desorption test showed a K_d value of 280.0 L/kg and the adsorption test showed a K_d value of 12.0 L/kg.

The results between the adsorption and desorption tests were different and can be attributed to the difference in the tests. One difference was the generation or presence of uranium in the leachate. In the adsorption test, uranium was added at the beginning of the test to the leachate. In the desorption test, the uranium was leached, during the test, from the soil sample in the leachate. The uranium in the leachate was also different between the test. In the adsorption test, the uranium was in the form of uranium nitrate.

The desorption test, the uranium varied chemically depending on the source and/or chemical changes that may have occurred during its presence in the soil. In addition, the desorption test was different than the adsorption test by the process. The desorption worked on the process of removing absorbed uranium from the soil. The adsorption test used the process of soil particles absorbing uranium from solution.

The desorption test is considered more representative than the adsorption test because it more accurately represents actual site conditions and the chemical form of the uranium. The adsorption values were mainly used in the unsaturated and saturated sand and gravel zones where the desorption test was not practical because the soils were not contaminated or not contaminated to a level that would leach at detectable concentrations.

TABLE D.4-4

SUMMARY OF K_d VALUES FOR OPERABLE UNIT 2

Sample Location	Desorption Test K_d (L/Kg)	Adsorption Test K_d (L/Kg)
Solid Waste Landfill - Waste Material	75.0/88.0	
Solid Waste Landfill - Glacial Overburden	200.0/1370.0	81.0
Inactive Flyash Pile - Cover Material	70.0	
Inactive Flyash Pile/Active Flyash Pile - Flyash		37.0/10,230.0
Lime Sludge Pond - Berm Material	360.0	
Lime Sludge Pond - Lime Sludge	2650.0	
South Field - Waste Material	180.0	
South Field - Glacial Overburden	280.0/9350.0	12.0
South Field/Solid Waste Landfill - Unsaturated Sand and Gravel		12.0/14.0
South Field/Solid Waste Landfill - Saturated Sand and Gravel		8.0/10.0

D.4.4.2 Operable Unit 2 k_d Values Versus Literature Values

Several literature reviews were performed to evaluate the range of K_d values for uranium. One reference (Thibault et al., 1990), provided a range of K_d values from 46 to 395,100 L/kg for clay rich soils and 0.03 to 2,200 L/kg for sandy soils. For agriculture soils or the soil layer where plants and roots uptake nutrients, the K_d value for uranium ranged between 10.5 to 4,400 L/kg (Baes et al., 1984).

Both the waste layer and glacial overburden layer soils at the Solid Waste Landfill and South Field were clay rich soil with K_d values from 75 to 180 L/Kg for the waste layer and 12 to 9350 L/kg for the glacial overburden layer. In comparison with the literature values, the Operable Unit 2 K_d values were on the low end of the range. Likewise, for the sand and gravel at the Solid Waste Landfill and South Field, the K_d values ranged from 8.0 to 14.0 L/kg, which was on the low end of the literature values for sandy soils. No literature values were obtained for the flyash and lime sludge.

D.4.4.3 Operable Unit 2 k_d Values Versus In Situ Values

A final assessment of the Operable Unit 2 K_d values were made by comparison with in situ samples. The in situ K_d determination was conducted by Operable Unit 5 and was determined by analyzing a soil and water sample at the same location in 1000-series wells. Because the perched water flow velocities are low in the glacial overburden, it was assumed the measured soil and liquid phase concentrations were in equilibrium.

Before the in situ K_ds were calculated, the soil concentration was corrected for the uranium contained in the soil moisture. Approximately 25 percent of the soil uranium concentration was subtracted to adjust for the soil moisture. The Operable Unit 5 in situ K_d values ranged from 16 to 235 L/kg which were similar to the range of Operable Unit 2 K_d values for the Solid Waste Landfill and South Field in the glacial overburden (12 to 280 L/kg) when the high K_d values are deleted from the Solid Waste Landfill (1370 L/kg) and South Field (9350 L/kg).

The Operable Unit 2 RI sampling program collected a soil (silty sand) and water sample from Inactive Flyash Pile Boring No. 11003 at 26 feet, which produced an in situ K_d value of 525 L/kg. Also, a K_d value was calculated for the South Field saturated sand and gravel layer by removing the free liquid from the sample and analyzing the free liquid and sand and gravel material. The sand and gravel were considered to be in equilibrium with the groundwater. A K_d value of 64 L/kg resulted. These

two Operable Unit 2 in situ K_d values were much higher then the Operable Unit 2 laboratory K_d values for the sand and gravel layer. The in situ K_d at Boring No. 11003 was believed to be high due to the uranium contamination not being soluble and was probably specific to that area of contamination.

ATTACHMENT D.4.I

LABORATORY PROCEDURES

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ATTACHMENT D.4.1
LABORATORY PROCEDURES

D.4.1 Procedure a (Contaminated Samples for Uranium k_d Determination)

D.4.1.1 Sample Homogenization

The sample will be thoroughly homogenized using a stainless steel mixing spoon in a stainless steel mixing bowl.

D.4.1.2 Sample Filtration

If the sample has any free liquid, it should be vacuum filtered through a .45 micron filter paper (note that it may be necessary to use several filtration steps). Any filtrate should be collected and analyzed for total uranium.

D.4.1.3 Initial Characterization of Soil Sample

Samples for the total uranium soil analysis should be split between the FEMP laboratory and the off-site laboratory if adequate sample is available. If there is inadequate sample for the off-site analysis, then samples should only be analyzed at the FEMP laboratory. Sample volumes should be collected for total uranium and placed in the containers as shown in the attached table. Additionally, a 10 gram sample should be analyzed for moisture content at the FEMP laboratory.

D.4.1.4 Sample Preparation

Place 400 grams (dry weight) of soil sample in the 4.0 liter reactor and add 3500 ml of the appropriate leachate solution to the reactor. For soil samples collected in the subunits, the leachate solution will be 3500 ml of deionized (DI) water adjusted to a pH 5.6 using a mixture of sulfuric acid and nitric acid at a 60/40 ratio. For soil samples collected from the glacial overburden below the subunits, use DI water with no pH adjustment. For soil samples from the sand and gravel zone (unsaturated or saturated) below the subunits, the leachate solution will be clean groundwater from a background well. A sample of the background groundwater must be submitted for total uranium analysis to the off-site laboratory and the FEMP laboratory according to the volumes and container requirements shown in the attached table. This analysis will serve as a background concentration for the groundwater used for the testing. (Note: background groundwater only requires one analysis to establish a baseline concentration.)

D.4.1.5 Sample Mixing

The samples should be placed in the rotating tumbler and mixed continuously until completion of the testing. The extractor must be operated at 29 +/- 2 rpm.

D.4.1.6 Sample Collection

Samples of the leachate should be collected by stopping the tumbler for a sufficient time period (minimum of 10 minutes) to allow the solids to settle. An appropriate volume of the leachate (see attached table for sample volumes required for analysis) should then be decanted from the reactor and filtered through a .45 micron filter paper or separated with a constant temperature centrifuge capable of separating > 0.1 micron particles. Any solids from the separation step should be returned to the reactor.

Intermediate samples should be collected at 72, 144, 168, 240, 288, 360, and 384 hours and analyzed at the FEMP laboratory for total uranium. The study may be stopped earlier if the data indicates that the results for uranium is in equilibrium with the soil and liquid. Equilibrium will be determined by plotting each concentration (Y-axis) vs. time (X-axis) to determine when the curve begins to flatten, which indicates that an equilibrium concentration is achieved. Prior to stopping the test earlier or collecting intermediate samples for one of the radionuclides, confirm that the contaminant is in equilibrium with the CRU2 representative.

The final sample will be collected after the results indicate that uranium is in equilibrium and will be split between the FEMP laboratory and the off-site laboratory. The final sample will be collected and analyzed for total uranium. If a sample does not reach equilibrium after 384 hours, then the CRU2 contact person (Bert Crapse at extension 6974) should be notified to determine the appropriate action to be taken. (Note: the final water samples should only be split with the FEMP and off-site laboratories if the soil samples were initially split between the two laboratories.)

At the completion of the study, the soil will be stored for possible future leaching tests to determine the extractable concentrations of the radionuclides. Prior to storing the sample, the sample will be vacuum filtered through a .45 micron filter paper to remove all free liquid. The CRU2 contact person will identify which samples will be used to determine the extractable portion.

D.4.2 Procedure A1 (Non-Contaminated Samples for Uranium k_d Determination)

D.4.2.1 Sample Homogenization

The sample will be thoroughly homogenized using a stainless steel mixing spoon in a stainless steel mixing bowl.

D.4.2.2 Sample Filtration

If the sample has any free liquid, it should be vacuum filtered through a .45 micron filter paper (note that it may be necessary to use several filtration steps).

D.4.2.3 Initial Characterization of Soil Sample

Samples for the total uranium soil analysis should be split between the FEMP laboratory and the off-site laboratory if an adequate sample is available. If there is an inadequate sample for the off-site analysis, then samples should only be analyzed at the FEMP laboratory. Sample volumes should be collected for total uranium and placed in the containers as shown in the attached table. Additionally, a 10 gram sample should be analyzed for moisture content at the FEMP laboratory.

D.4.2.4 Sample Preparation

Place 400 grams (dry weight) of soil sample in the 4.0 liter reactor and add 3500 ml of the appropriate leachate solution to the reactor. For soil samples collected in the subunits, the leachate solution will be 3500 ml of deionized (DI) water adjusted to a pH 5.6 using a mixture of sulfuric acid and nitric acid at a 60/40 ratio. For soil samples from the sand and gravel zone (unsaturated or saturated) below the subunits, the leachate solution will be clean groundwater from a background well. If baseline concentration is not established for groundwater, then a sample must be submitted for total uranium analysis to the off-site laboratory and the FEMP laboratory according to the volumes and container requirements shown in the attached table.

Once the proper leaching solution has been prepared, then the proper mass of radionuclides must be added to obtain a liquid concentration of approximately 100 times the MCL concentration. The following is the MCL (proposed) for uranium:

Radionuclide	MCL	Mass of Radionuclide to be Spiked
Uranium	20 μg/L	7.0 mg Uranium 238

Place 400 grams (dry weight) of soil/waste in the 4.0 liter reactor, and add 3500 ml of the appropriate leachate solution to the reactor.

D.4.2.5 Sample Mixing

The samples should be placed in the rotating tumbler and mixed continuously until completion of the testing. The extractor must be operated at 29 +/- 2 rpm.

D.4.2.6 Sample Collection

Samples of the leachate should be collected by stopping the tumbler for a sufficient time period (minimum of 10 minutes) to allow the solids to settle. An appropriate volume of the leachate (see attached table for sample volumes required for analysis) should then be decanted from the reactor and filtered through a .45 micron filter paper or separated with a constant temperature centrifuge capable of separating greater than 0.1 micron particles. Any solids from the separation step should be returned to the reactor.

Intermediate samples should be collected at 4, 24, 48, and 72 hours. After the 72 hour data point is obtained, verify that the uranium is at an equilibrium concentration between the soil and the leachate solution. Equilibrium will be determined by plotting each concentration (Y-axis) vs. time (X-axis) to determine when the curve begins to flatten, which indicates that an equilibrium concentration is achieved. If a sample does not reach equilibrium after 72 hours, then the CRU2 contact person (Bert Crapse at extension 6974) should be notified to determine the appropriate action to be taken.

All of the intermediate samples will be analyzed for total uranium at the FEMP laboratory. The final sample will be collected after the results indicate that uranium is in equilibrium. The final sample will be split between the FEMP laboratory and the off-site laboratory and analyzed for total uranium. (Note: the final water samples should only be split with the FEMP and off-site laboratories if the soil samples were split.)

Table D.4.I-1

SAMPLE VOLUMES/DETECTION LIMIT

Chemical	Media	Method	Volume	Sample Container	Instrument	Detection Limit
Off-Site Laboratory						
Total - Uranium	Water Soil	OR 7127 OR 7003	210 ml 135 g (dry)	250 ml glass 250 ml glass	Laser Phosphorimetry Gamma Spectrometry	1 ug/l 1 ppm
FEMP laboratory						
Total - Uranium	Water Soil	3062 3002	10 ml 5 g	-[a]	Laser Phosphorimetry Color Metric	1 ug/l 0.1 ppm

[a]To be determined by laboratory personnel.

Note: Water samples to be preserved with HNO_3.

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ATTACHMENT D.4.II

LABORATORY RESULTS FOR DESORPTION TESTS

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DESORPTION TEST FOR
SOLID WASTE LANDFILL BORING 1986
WASTE MATERIAL
SAMPLE #111455

	SAMPLING PERIOD (DAYS)									
LEACHATE ANALYTICAL PARAMETERS	Start 6/18/93	3	6	7	10	12	14	18	20	28 Final[1]
Total-U Conc. (ug/l)	N/A	1300	1685	1667	1762	1626	1619	1300	1500	1768/ 1700
Percent Concentration Change	-	-	+29.6	-1.1	+5.7	-7.7	-0.4	-19.7	+15.4	+17.9
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	8.35	-
pH	5.60	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Specific Conductivity (uMHOS)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Temp. (°C)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Initial Soil Uranium Concentration = 146 ppm (IT) & 94 ppm (FEMP)
Soil Sample Wt. = 400 g
Initial Liquid to Soil Ratio = 8.75
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not Analyzed

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DESORPTION TEST FOR
SOLID WASTE LANDFILL BORING 1985
WASTE MATERIAL
SAMPLE #111440

	SAMPLING PERIOD (DAYS)									
LEACHATE ANALYTICAL PARAMETERS	Start 7/19/93	1	3	4	7	10	11	15	17	18 Final[1]
Total-U Conc. (ug/l)	N/A	360	579	465	476	489	507	555	549	551/52.5
Percent Concentration Change	-	-	+61	-19.7	+2.4	+2.7	+3.7	+9.5	-1.1	0.4
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	8.35	-
pH	5.60	8.54	8.42	8.42	8.32	8.04	7.98	7.89	7.85	N/A
Specific Conductivity (uMHOS)	N/A	185	220	234	275	300	310	325	322	N/A
Temp. (°C)	N/A	30.1	31.2	32.0	33.0	32.1	32.0	30.5	28.8	N/A

Initial Soil Uranium Concentration = 74 ppm (IT) & 64 ppm (FEMP)
Moisture Content = 86.5% solid
Soil Wt. = 400g
Initial Liquid to Soil Ratio = 8.75
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

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DESORPTION TEST FOR
SOLID WASTE LANDFILL BORING 1986
GLACIAL OVERBURDEN LAYER
SAMPLE #111457

	SAMPLING PERIOD (DAYS)								
LEACHATE ANALYTICAL PARAMETERS	Start 7/27/93	1	3	6	8	10	13	15	16 Final[1]
Total-U Conc. (ug/l)	N/A	6.6	12.1	9.9	9.9	14.0	10.1	14.5	11.6/10.6
Percent Concentration Change	-	-	+83.3	-18.2	0.0	+41.4	-27.9	43.6	-20
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	-
pH	5.60	7.32	7.36	7.23	7.31	7.34	7.26	7.32	7.31
Specific Conductivity (uMHOS)	N/A	170	205	230	248	249	260	265	265
Temp. (°C)	N/A	32.4	30.8	29.6	31.1	28.4	29.4	29.0	28.7

Initial Soil Uranium Concentration = 18.3 ppm (IT) & 6 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 74.9% solid
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

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DESORPTION TEST FOR
SOLID WASTE LANDFILL BORING 11037
GLACIAL OVERBURDEN LAYER
SAMPLE #115370

	SAMPLING PERIOD (DAYS)								
LEACHATE ANALYTICAL PARAMETERS	Start 7/27/93	1	3	6	8	10	13	15	16 Final[1]
Total-U Conc. (ug/l)	N/A	5.4	10.0	8.6	13.6	7.5	10.8	11.5	10.1/10.0
Percent Concentration Change	-	-	+85.2	-14.0	+58.1	-44.8	+44.0	+6.5	-12.2
Ratio Change of Liquid									
pH	5.60	7.94	7.82	7.80	7.72	7.80	7.76	7.69	7.75
Specific Conductivity (uMHOS)	N/A	300	380	420	430	440	455	467	470
Temp. (°C)	N/A	32.9	31.9	31.3	30.9	28.2	29.0	29.3	28.6

Initial Soil Uranium Concentration = 2.65 ppm (IT) & 9 ppm (FEMP)
Soil sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 80.9% solid
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A = Not Analyzed

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DESORPTION TEST FOR
LIME SLUDGE PONDS SURFACE SOIL #03
LIME SLUDGE
SAMPLE #114472

	SAMPLING PERIOD (DAYS)								
Analytical Parameters	Start	1	3	6	8	10	13	15	16 Final[1]
Total-U Conc. (ug/l)	0	18.1	34.0	24.9	30.0	31.1	36.1	37.9	40.0/41.6
Percent Concentration Change	-	-	87.8	-26.8	20.5	3.7	16.1	5.0	5.5
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	-
pH	5.60	7.60	7.47	7.28	7.17	7.16	7.08	7.00	7.05
Specific Conductivity (uMHOS)	0	191	257	320	357	380	420	449	455
Temp. (°C)	N/A	33.0	31.7	30.4	31.0	28.6	29.1	29.1	28.8

Initial Soil Uranium Concentration = 18.9 ppm (IT) & 17 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 80.6% solid
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

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DESORPTION TEST FOR
INACTIVE FLYASH PILE BORING 11001
COVER MATERIAL LAYER (FLYASH)
SAMPLE #114067

	SAMPLING PERIOD (DAYS)									
LEACHATE ANALYTICAL PARAMETERS	Start 7/19/93	1	3	4	7	10	11	15	17	18 Final [1]
Total-U Conc. (ug/l)	N/A	1557	2240	2111	1634	1505	1506	1472	1470	1696/ 1810
Percent Concentration Change	-	-	+43.9	-5.8	-22.6	-7.9	+0.1	-2.3	+0.1	+15.4
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	8.35	-
pH	5.60	8.50	8.47	8.52	8.44	8.27	8.15	8.18	8.20	N/A
Specific Conductivity (uMHOS)	N/A	175	200	213	239	249	264	255	252	N/A
Temp. (°C)	N/A	30.1	31.2	32.2	33.6	31.9	32.2	30.9	28.8	N/A

Initial Soil Uranium Concentration = 147 ppm (IT) & 150 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 97.9% solid (air-dried)
[1] - Final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

DESORPTION TEST FOR
INACTIVE FLYASH PILE BORING 11003
WASTE MATERIAL (FLYASH)
SAMPLE #114068

	SAMPLING PERIOD (DAYS)					
LEACHATE ANALYTICAL PARAMETERS	Start 7/29/93	1	3	6	8	10 Final[1]
Total-U Conc. (ug/l)	N/A	<0.2	0.7	<0.2	<0.2	0.5
Percent Concentration Change	-	-	-	-	-	-
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50
pH	5.60	5.95	6.02	5.96	5.95	6.00
Specific Conductivity (uMHOS)	N/A	123	160	178	184	190
Temp. (°C)	N/A	32.5	32.1	29.9	30.9	28.7

Initial Soil Uranium Concentration = 16.9 ppm (IT) & 6 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 98.8% (air-dried)
N/A - Not Analyzed
Note: Test was stopped due to leachate being below detection limit

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DESORPTION TEST FOR
SOUTH FIELD BORING 1974
GLACIAL OVERBURDEN
SAMPLE # 114070

	SAMPLING PERIOD (DAYS)								
LEACHATE ANALYTICAL PARAMETERS	Start 7/27/93	1	3	6	8	10	13	15	16 Final[1]
Total-U Conc. (ug/l)	N/A	15.3	13.6	15.5	32.0	14.7	13.3	18.3	28.0/32.5
Percent Concentration Change	-	-	-11.1	+14.0	+106.5	-54.1	-9.5	+37.6	+53.0
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	-
pH	5.60	7.11	7.28	7.26	7.31	7.29	7.30	7.30	7.41
Specific Conductivity (uMHOS)	N/A	53	60	60	60	60	60	60	65
Temp. (°C)	N/A	33.2	31.1	30.7	30.6	28.7	29.1	28.7	28.8

Initial Soil Uranium Concentration = 308 ppm (IT) & 140 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 83.3%
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

DESORPTION TEST FOR SOUTH FIELD TRENCH #1 WASTE MATERIAL SAMPLE # 113717

	SAMPLING PERIOD (DAYS)									
LEACHATE ANALYTICAL PARAMETERS	Start 7/19/93	1	3	4	7	10	11	15	17	18 Final[1]
Total-U Conc. (ug/l)	N/A	1621	1831	1314	946	865	1168	1221	1253	1526/ 1480
Percent Concentration Change	-	-	+13.0	-28.2	28.0	-8.6	+35.0	+4.5	+2.6	+21.8
Ratio Change in Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	8.35	-
pH	5.60	8.85	8.86	8.90	8.90	8.67	8.60	8.47	8.45	N/A
Specific Conductivity (uMHOS)	N/A	170	185	183	211	239	245	260	260	N/A
Temp. (°C)	N/A	30.3	31.3	31.7	33.6	32.2	32.6	31.1	28.9	N/A

Initial Soil Uranium Concentration = 278 ppm (IT) & 96 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 88.7%
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

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DESORPTION TEST FOR
SOUTH FIELD TRENCH #4
GLACIAL OVERBURDEN LAYER
SAMPLE #113721

LEACHATE ANALYTICAL PARAMETERS	SAMPLING PERIOD (DAYS)									
	Start 7/19/93	1	3	4	7	10	11	15	17	18 Final[1]
Total-U Conc. (ug/l)	N/A	30.1	7.3	2.6	8.0	14.0	10.6	12.1	5.6	2.4/2.16
Percent Concentration Change	-	-	-75.7	-64.4	+207.7	+75.0	-24.3	14.2	-53.7	-57.1
Ratio Chnage of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	8.35	-
pH	5.60	8.44	8.42	8.63	8.60	8.29	8.15	8.10	8.09	N/A
Specific Conductivity (uMHOS)	N/A	103	120	130	143	157	159	165	163	N/A
Temp. (°C)	N/A	30.4	31.4	31.7	33.0	32.3	32.1	30.5	29.0	N/A

Initial Soil Uranium Concentration = 4.34 ppm (IT) & 15 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 79.7%
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

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DESORPTION TEST FOR
LIME SLUDGE POND SURFACE SOIL #05/06
LIME SLUDGE
SAMPLE #114494

	SAMPLING PERIOD (DAYS)										
LEACHATE ANALYTICAL PARAMETERS	Start 8/19/93	1	4	6	8	11	12	13	14	15	19 Final[1]
Total-U Conc. (ug/l)	N/A	8.2	5.4	5.7	276[A]	3934[A]	39	48	1.8	3.8	6.4
Percent Concentration Change	-	-	-34.1	+3.7	>1000	>1000	-99	+23.0	-96.3	+111	+40.6
Ratio Change of Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	8.35	8.30	-
pH	8.90	8.81	8.77	8.84	8.86	8.81	8.85	8.74	8.75	8.74	8.70
Specific Conductivity (uMHOS)	152	202	216	218	232	239	240	238	236	247	270
Temp. (°C)	23.8	25.3	24.9	23.7	25.8	25.1	25.4	24	22.6	25.1	24.6

Initial Soil Uranium Concentration = ? ppm (IT) & 15 ppm (FEMP)
Moisture Content = 56.66% solid
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
[A] - samples were contaminated
N/A - Not Analyzed

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ATTACHMENT D.4.III

LABORATORY RESULTS FOR ADSORPTION TESTS

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ADSORPTION TEST FOR
SOLID WASTE LANDFILL BORING 2953
UNSATURATED SAND AND GRAVEL LAYER
SAMPLE # 115445

LEACHATE ANALYTICAL PARAMETERS	SAMPLING PERIOD (DAYS)											
	Start 7/20/93	1/6 (4 hr)	1	2	3	6	8	9	13	15	16	17 Final[1]
Total-U Conc. (ug/l)	2000	1697	1354	1262	1492	1361	897	948	839	736	888	793/918
Percent Concentration Change	-	+15.2	+20.2	+6.8	-18.2	+8.8	+34.1	-5.7	+11.5	+12.3	-20.7	+10.7
Ratio Change of Liquid	8.75	8.7	8.65	8.6	8.55	8.50	8.45	8.40	8.35	8.30	8.25	-
pH	6.70	6.95	6.82	6.86	7.00	7.03	7.07	7.20	7.27	7.29	7.35	N/A
Specific Conductivity (uMHOS)	700	1480	1470	1470	1470	1500	1440	1420	1400	1380	1340	N/A
Temp. (°C)	N/A	28.8	30.2	30.0	31.2	33.1	31.0	32.3	30.6	30.5	28.2	N/A

Initial Soil Uranium Concentration = 1.63 ppm (IT) & 4 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 96.8% solids
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

000878

5504

ADSORPTION TEST FOR
SOLID WASTE LANDFILL BORING 2953
SATURATED SAND AND GRAVEL LAYER
SAMPLE # 115454

	SAMPLING PERIOD (DAYS)											
LEACHATE ANALYTICAL PARAMETERS	Start 7/20/93	1/6 (4 hr.)	1	2	3	6	8	9	13	15	16	17 Final[1]
Total-U Conc. (ug/l)	2000	1258	1282	1247	1240	1172	969	1035	873	851	900	752/982
Percent Concentration Change	-	+37.1	-1.9	+2.7	+0.6	+5.5	+17.3	-6.8	+15.6	+2.5	-5.8	+16.4
Ratio Change in Liquid	8.75	8.70	8.65	8.60	8.55	8.50	8.45	8.40	8.35	8.30	8.25	
pH	6.70	7.12	7.09	7.11	7.30	7.25	7.20	7.40	7.45	7.45	7.52	N/A
Specific Conductivity (uMHOS)	700	900	900	900	920	980	920	900	920	900	880	N/A
Temp. (°C)	N/A	28.6	30.2	30.3	31.5	33.1	31.1	31.1	30.6	30.5	28.1	N/A

Initial Soil Uranium Concentration = 1.17 ppm (IT) & 4 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 86.3% solid
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

000829

ADSORPTION TEST FOR
SOLID WASTE LANDFILL BORING 1986
GLACIAL OVERBURDEN LAYER
SAMPLE # 111457

LEACHATE ANALYTICAL PARAMETERS	SAMPLING PERIOD (DAYS)								
	Start 7/27/93	1/6 (4 hr)	1	2	3	7	8	10	10 Final[1]
Total-U Conc. (ug/l)	2000	506	334	367	343	295	283	288	318/357
Percent Concentration Change	-	+74.7	+34.0	-9.9	+6.5	+14.0	+4.1	-1.8	-10.4
Ratio Change in Liquid	8.75	8.70	8.65	8.6	8.55	8.5	8.45	8.4	-
pH	6.70	7.49	6.84	6.92	6.99	6.95	6.96	7.13	N/A
Specific Conductivity (uMHOS)	700	830	810	810	800	790	780	750	N/A
Temp. (°C)	N/A	32.1	32.7	31.8	32.0	30.1	30.8	28.3	N/A

Initial Soil Uranium Concentration = 18.3 ppm (IT) & 6 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 74.9% solid
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

ADSORPTION TEST FOR
ACTIVE FLYASH PILE BORING 1980
WASTE MATERIAL (FLYASH)
SAMPLE # 114069

LEACHATE ANALYTICAL PARAMETERS	SAMPLING PERIOD (DAYS)									
	Start 7/20/93	1/6 (4 hr.)	1	2	3	6	8	9	10	10 Final[1]
Total-U Conc. (ug/l)	2000	668	612	564	556	450	431	507	449	493/564
Percent Concentration Change	-	+66.6	+8.4	+7.8	+1.4	+19.1	+4.2	-17.6	+11.4	-9.8
Ratio Change in Liquid	8.75	8.7	8.65	8.6	8.55	8.50	8.45	8.4	8.35	-
pH	6.70	6.81	6.85	6.86	6.95	6.90	6.80	6.96	7.00	N/A
Specific Conductivity (uMHOS)	700	1380	1400	1400	1400	1450	1400	1400	1280	N/A
Temp. (°C)	N/A	28.4	28.9	30.3	30.9	32.5	31.4	30.6	27.9	N/A

Initial Soil Uranium Concentration = 12.2 ppm(IT) & 6 ppm (FEMP)
Moisture Content = 99.3% solid (air-dried)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

ADSORPTION TEST FOR
SOUTH FIELD TRENCH #4
GLACIAL OVERBURDEN LAYER
SAMPLE #113721

	SAMPLING PERIOD (DAYS)											
LEACHATE ANALYTICAL PARAMETERS	Start 7/20/93	1/6 (4 hrs.)	1	2	3	6	8	9	13	15	16	17 Final[1]
Total-U Conc. (ug/l)	2000	1072	1282	1122	1015	878	748	854	718	714	785	724/876
Percent Concentration Change	-	+46.4	-19.6	+12.5	+9.5	+13.5	+14.8	-14.2	+15.9	+0.6	-9.9	+7.7
Ratio Change in Liquid	8.75	8.7	8.65	8.6	8.55	8.5	8.45	8.4	8.35	8.3	8.25	-
pH	6.70	7.10	7.14	7.20	7.30	7.21	7.00	7.25	7.26	7.22	7.34	N/A
Specific Conductivity (uMHOS)	700	810	810	820	830	800	780	790	800	780	720	N/A
Temp. (°C)	N/A	28.7	29.1	30.3	31.0	32.4	31.6	30.6	30.4	30.7	27.8	N/A

Initial Soil Uranium Concentration = 1.63 ppm (IT) & 15 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 79.7%
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

000882

ADSORPTION TEST FOR SOUTH FIELD BORING 2944 UNSATURATED SAND AND GRAVEL LAYER SAMPLE #113755

	SAMPLING PERIOD (DAYS)									
LEACHATE ANALYTICAL PARAMETERS	Start 7/20/93	1/6 (4 hrs.)	1	2	3	6	8	9	10	10 Final[1]
Total-U Conc. (ug/l)	2000	1564	1080	1285	1209	898	791	777	609	651/826
Percent Concentration Change	-	+21.8	+30.9	-19.0	+5.9	+25.7	+11.9	+17.7	+21.6	-6.9
Ratio Change in Liquid	8.75	8.7	8.65	8.6	8.55	8.5	8.45	8.4	8.35	-
pH	6.70	7.03	7.14	7.20	7.35	7.37	7.22	7.46	7.50	N/A
Specific Conductivity (uMHOS)	700	850	880	880	890	900	880	850	800	N/A
Temp. (°C)	N/A	28.6	29.7	30.0	31.0	33.0	31.0	32.0	29.8	N/A

Initial Soil Uranium Concentration = 1.43 ppm (IT) & 2 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 93.1% solid
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

000883

ADSORPTION TEST #1 FOR
SOUTH FIELD BORING 2944
SATURATED SAND AND GRAVEL
SAMPLE #113770

	SAMPLING PERIOD (DAYS)									
LEACHATE ANALYTICAL PARAMETERS	Start 7/20/93	1/6 (4 hours)	1	2	3	6	8	9	10	10 Final[1]
Total-U Conc. (ug/l)	2000	1593	1598	1423	1417	1310	1290	1326	1219	958/1190
Percent Concentration Change	-	+20.4	-0.3	+11.0	+0.4	+7.6	+1.5	-2.8	+8.1	+21.4
Ratio Change in Liquid	8.75	8.7	8.65	8.6	8.55	8.5	8.45	8.4	8.35	-
pH	6.70	7.09	7.21	7.26	7.40	7.36	7.17	7.49	7.50	N/A
Specific Conductivity (uMHOS)	700	850	900	900	900	900	890	840	800	N/A
Temp. (°C)	N/A	28.6	30.0	30.4	30.8	32.5	31.4	31.1	28.4	N/A

Initial Soil Uranium Concentration = 2.86 ppm (IT) & 6 ppm (FEMP)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
Moisture Content = 98.8% solid (air-dried)
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

0008884

5504

ADSORPTION TEST FOR
INACTIVE FLYASH PILE BORING 11003
WASTE MATERIAL (FLYASH)
SAMPLE #114068

LEACHATE ANALYTICAL PARAMETERS	SAMPLING PERIOD (DAYS)						
	Start 8/11/93	1/6 (4 hours)	1	2	5	6	7 Final[1]
Total-U Conc. (ug/l)	2000	3.2	4.0	1.2	4.0	2.6	3.1/ <1.0
Percent Concentration Change	-	+99.8	-25.0	+70.0	-233.3	+35.0	-19.2
Ratio Change to LIquid	8.75	8.70	8.65	8.60	8.55	8.50	-
pH	N/A	5.71	5.76	5.79	5.81	5.83	5.79
Specific Conductivity (uMHOS)	N/A	287	286	255	260	268	269
Temp. (°C)	N/A	29.9	29.5	23.3	24.3	25.0	25.1

Initial Soil Uranium Concentration = 16.9 ppm (IT) & 6 ppm (FEMP)
Moisture Content = 98.8% solid (air-dried)
Soil Sample Wt. = 400g
Liquid to Soil Ratio = 8.75
[1] - final sample split and analyzed for total-U by FEMP/IT Oak Ridge
N/A - Not analyzed

CC0885

A062

ATTACHMENT D.4.IV

K_d CALCULATIONS FOR DESORPTION TESTS

Desorption Test Calculations

10/15/93
B. Crapse

FEMP-OU02-4 DRAFT
April 29, 1994

Symbols and Units

$$K_d = \frac{C_s'}{C_L}$$

V = volume of liquid used during equilibrium tests always ≈ 3.5 liters

M = mass of soil or test media; ≈ 400 grams

C_o = initial concentration of uranium in soil or test media (μg/g)

C_s = concentration of uranium in soil or test media at equilibrium (μg/g)

C_b = background concentration of uranium in soil ; calculated ≈ 3.7 μg/g

C_L = concentration of uranium in liquid at equilibrium (μg/ℓ)

C_s' = final concentration of uranium in soil or test media above background (μg/g)

m_L = mass of uranium leached from soil (μg)

m_s = mass of uranium in soil at equilibrium (μg)

---

① Sample # 111457 (Glacial Overburden)

C_o = 18.3 μg/g

C_L = 10.6 μg/ℓ

uranium mass leached from soil

$$m_\ell = C_L V = (10.6\ \mu g/\ell)(3.5\ \ell) = 37.1\ \mu g$$

uranium mass remaining in soil

$$m_s = C_o M - 37.1\ \mu g = (18.3\ \mu g/g)(400\ g) - 37.1\ \mu g$$

$$= 7282.9\ \mu g$$

000887

$$C_s = \frac{m_s}{M} = \frac{7282.9\ \mu g}{400\ g} = 18.2\ \mu g$$

10/15/93

subtract background concentration from sample

$$C_s' = C_s - C_b = 18.2\ \mu g/g - 3.7\ \mu g/g$$
$$= 14.5\ \mu g/g$$

so, $$K_d = \frac{C_s'}{C_L} = \frac{14.5\ \mu g/g}{10.6\ \mu g/\ell} = 1.37\ \ell/g = 1370\ \ell/kg$$

---

(2) Sample # 111440 (Waste Material)

$C_o = 74.0\ \mu g/g$

$C_L = 726.0\ \mu g/\ell$

uranium mass leached from soil

$$m_\ell = C_L V = (726.0\ \mu g/\ell)(3.5\ \ell)$$
$$= 2541.0\ \mu g$$

uranium mass remaining in soil

$$m_s = C_o M - 2541.0\ \mu g = (74.0\ \mu g/g)(400\ g) - 2541.0\ \mu g$$
$$= 27{,}059\ \mu g$$

$$C_s = \frac{m_s}{M} = \frac{27{,}059\ \mu g}{400\ g} = 67.6\ \mu g/g$$

subtract background concentration from sample

$$C_s' = C_s - C_b = 67.6\ \mu g/g - 3.7\ \mu g/g$$
$$= 63.9\ \mu g/g$$

so, $$K_d = \frac{C_s'}{C_L} = \frac{63.9\ \mu g/g}{726.0\ \mu g/\ell} = 0.088\ \ell/g = 88\ \ell/kg$$

000888

10/15/93
Checked by: [illegible]

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

10/15/93 5504
B. Crapse

FEMP-OU02-4 DRAFT
April 29, 1994

③ Sample # 111455 (waste material)

$C_o = 146.0\ \mu g/g$

$C_L = 1700\ \mu g/\ell$

$$C_s = \frac{(C_o \times M) - (C_L \times V)}{M} = \frac{[(146.0\ \mu g/g)(400g) - (1700\ \mu g/\ell)(3.3$$

$$= 131.1\ \mu g/g$$

$$C_s' = 131.1\ \mu g/g - 3.7\ \mu g/g = 127.4\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{127.4\ \mu g/g}{1700} = 0.075\ \ell/g = 75\ \ell/kg$$

---

④ Sample # 115370 (Glacial Overburden)

$$C_o = \frac{9.0\ \mu g/g + 2.65\ \mu g/g}{2} = 5.83\ \mu g/g$$ {average of both IT + FEMP analysis}

$C_L = 10.0\ \mu g/\ell$

$$C_s = \frac{(C_o \times M) - (C_L \times V)}{M} = \frac{[(5.83\ \mu g/g)(400g) - (10.0\ \mu g/\ell)(3.5\ \ell)]}{400g}$$

$$= 5.7\ \mu g/g$$

$$C_s' = C_s - C_b = 5.7\ \mu g/g - 3.7\ \mu g/g = 2.0\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{2.0\ \mu g/g}{10.0\ \mu g/\ell} = 0.2\ \ell/g = 200\ \ell/kg$$

10/15/93
Checked by: ACL

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

10/11/93
B. Crapse

FEMP-OU02-4 DRAFT
April 29, 1994

(5) Sample # 114472 (Waste Material)

$C_o = 18.9\ \mu g/g$
$C_L = 41.6\ \mu g/\ell$

$$C_s = \frac{(C_o \times M) - (C_L \times V)}{M} = \frac{[(18.9\ \mu g/g)(400g) - (41.6\ \mu g/\ell)(3.5\ell)]}{400g}$$

$$= 18.5\ \mu g/g$$

$$C_s' = 18.5\ \mu g/g - 3.7\ \mu g/g = 14.8\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{14.8\ \mu g/g}{41.6\ \mu g/\ell} = 0.36\ \ell/g = 360\ \ell/kg$$

---

(6) Sample # 114067 (Cover Material)

$C_o = 147.0\ \mu g/g$
$C_L = 1810.0\ \mu g/\ell$

$$C_s = \frac{(147.0\ \mu g/g)(400g) - (1810.0\ \mu g/\ell)(3.5\ell)}{400g} = 131.2\ \mu g/g$$

$$C_s' = 131.2\ \mu g/g - 3.7\ \mu g/g = 127.5\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{127.5\ \mu g/g}{1810\ \mu g/\ell} = 0.07\ \ell/g = 70\ \ell/kg$$

000830

Checked by: ACS 10/15/93

10/15/93 5504

B. Crapse

FEMP-OU02-4 DRAFT
April 29, 1994

(7) Sample # 114070 (Glacial overburden)

$C_o = 308\ \mu g/g$

$C_L = 32.5\ \mu g/l$

$$C_s = \frac{(308.0\ \mu g/g)(400\ g) - (32.5\ \mu g/l)(7.5\ l)}{400\ g} = 307.7\ \mu g/g$$

$$C_s' = C_s - C_b = 307.7\ \mu g/g - 3.7\ \mu g/g$$

$$= 304\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{304\ \mu g/g}{32.5\ \mu g/l} = 9.35\ l/g = 9350\ l/kg$$

(8) Sample # 113717 (Waste Material)

$C_o = 278.0\ \mu g/g$

$C_L = 1480.0\ \mu g/l$

$$C_s = \frac{(278.0\ \mu g/g)(400\ g) - (1480\ \mu g/l)(3.5\ l)}{400\ g} = 265.1\ \mu g/g$$

$$C_s' = 265.1\ \mu g/g - 3.7\ \mu g/g = 261.4\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{261.4\ \mu g/g}{1480\ \mu g/l} = .18\ l/g = 180\ l/kg$$

10/15/93

checked by: ACS

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

10-15-93
B. Crapse

FEMP-OU02-4 DRAFT
April 29, 1994

(9) Sample # 113721 (Glacial Overburden)

$C_o = 4.34\ \mu g/g$

$C_L = 2.16\ \mu g/\ell$

$$C_s = \frac{(4.34\ \mu g/g)(400g) - (2.16\ \mu g/\ell)(3.5\ell)}{400g} = 4.3\ \mu g/g$$

$$C_s' = 4.3\ \mu g/g - 3.7\ \mu g/g = 0.6\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{0.6\ \mu g/g}{2.16\ \mu g/\ell} = .28\ \ell/g = 280\ \ell/kg$$

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(10) Sample # 114494 (Lime Sludge)

$C_o = 14.3\ \mu g/g$

$C_L = 4.0\ \mu g/\ell$

$$C_s = \frac{(14.3\ \mu g/g)(400g) - (4.0\ \mu g/\ell)(3.5\ell)}{400g} = 14.3\ \mu g/g$$

$$C_s' = 14.3\ \mu g/g - 3.7\ \mu g/g = 10.6\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{10.6\ \mu g/g}{4.0\ \mu g/\ell} = 2.65\ \ell/g$$

$$= 2650\ \ell/kg$$

000892

10/15/93
Checked by: ACS

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

ATTACHMENT D.4.V

K_d CALCULATIONS FOR ADSORPTION TESTS

10-15-93
B. Crapse
FEMP-OU02-4 DRAFT
April 29, 1994

Symbols and units

V = volume of liquid used during equilibrium testing always [redacted] ≈ 3.5 liters

M = mass of soil or test media; [redacted] approximately 400 grams

S = initial concentration of uranium in spiked solution ≈ 2000 μg/l

C_o = initial concentration of uranium in soil or test media (μg/g)

C_s = concentration of uranium in soil or test media at equilibrium (μg/g)

C_b = background concentration of uranium in soil; calculated ≈ 3.7 μg/g

C_L = concentration of uranium in liquid at equilibrium (μg/l)

C_s' = final concentration of uranium in soil or test media above background μg/g

C_a = concentration of uranium absorbed in soil or test media above background (μg/g)

m_a = mass of uranium adsorbed in soil or test media [redacted] (μg)

$$K_d = \text{adsorption coefficient} \left(\frac{l}{kg}\right) = \frac{C_s'}{C_L}$$

Assumption: The mass of soil prior to the leachate testing is approximately equal to the mass of soil after the leachate testing.

10/18
Checked by: [illegible]

10-15-93 B. Crapse

(1) Sample # 115445 (Unsaturated sand + gravel)

FEMP-OU02-4 DRAFT
April 29, 1994

$C_o = 1.63\ \mu g/g$

$C_L = 918.0\ \mu g/\ell$

mass of uranium adsorbed

$$m_a = SV - C_L V = (2000\ \mu g/\ell)(3.5\ \ell) - (918.0\ \mu g/\ell)(3.5\ \ell)$$

$$= 3787.0\ \mu g$$

Concentration of uranium adsorbed

$$C_a = \frac{m_a}{M} = \frac{3787.0\ \mu g}{400\ g} = 9.5\ \mu g/g$$

Concentration of uranium in soil at equilibrium

$$C_s = C_o + C_a = 1.63\ \mu g/g + 9.5\ \mu g/g = 11.1\ \mu g/g$$

$$C_s' = C_s$$ [background concentration not subtracted]

Note: The background concentration was not subtracted because site groundwater was used for the water solutions. When groundwater is used, the background concentration in the soil is assumed to be in equilibrium with groundwater background concentration.

$$K_d = \frac{C_s'}{C_L} = \frac{11.1\ \mu g/g}{918.0\ \mu g/\ell} = 0.012\ \ell/g$$

$$= 12.0\ \ell/kg$$

checked by: AC 10/18

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

10-15-93
B. Crapse

FEMP-OU02-4 DRAFT
April 29, 1994

(2) Sample # 115454 (Saturated sand + gravel)

$C_o = 1.17\ \mu g/g$

$C_L = 982.0\ \mu g/l$

mass of uranium adsorbed

$m_a = SV - C_L V = (2000\ \mu g/l)(3.5\ l) - (982.0\ \mu g/l)(3.5\ l)$

$= 3563.0\ \mu g$

Concentration of uranium adsorbed

$C_a = \frac{m_a}{M} = \frac{3563.0\ \mu g}{400\ g} = 8.9\ \mu g/g$

Concentration of uranium in soil at equilibrium

$C_s = C_o + C_a = 1.17\ \mu g/g + 8.9\ \mu g/g = 10.1\ \mu g/g$

$C_s' = C_s$

$K_d = \frac{C_s'}{C_L} = \frac{10.1\ \mu g/g}{982\ \mu g/l} = 0.010\ l/g$

$= 10\ l/kg$

(3) Sample # 111457 (Glacial Overburden)

$C_o = 18.3\ \mu g/g$

$C_L = 357.0\ \mu g/l$

amount of uranium adsorbed

$m_a = SV - C_L V = (2000\ \mu g/l)(3.5\ l) - (357.0\ \mu g/l)(3.5\ l)$

$= 5750.5\ \mu g$

Concentration adsorbed

$C_a = \frac{m_a}{M} = \frac{5750.5\ \mu g}{400\ g} = 14.4\ \mu g/g$

000896

Checked by: AC 10/18

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD

10-15-93
B. Capse

FEMP-OU02-4 DRAFT
April 29, 1994

concentration in soil at equilibrium

$C_s = 14.4\ \mu g/g + 18.3\ \mu g/g$

$C_s = 32.7\ \mu g/g$

subtract background concentration for soil

$C_s' = C_s - C_b = 32.7\ \mu g/g - 3.7\ \mu g/g$

$= 29.0\ \mu g/g$

$K_d = \frac{C_s'}{C_L} = \frac{29.0\ \mu g/g}{357.0\ \mu g/l} = 0.081\ l/g$

$K_d = 81\ l/kg$

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(7) Sample # 113721 (Glacial Overburden)

$C_o = 4.34\ \mu g/g$

$C_L = 876.0\ \mu g/l$

Concentration adsorbed

$C_a = \frac{(2000\ \mu g/l)(3.5\ l) - (876.0\ \mu g/l)(3.5\ l)}{400\ g}$

$= 9.84\ \mu g/g$

concentration at equilibrium

$C_s = 9.84\ \mu g/g + 4.34\ \mu g/g = 14.2\ \mu g/g$

$C_s' = 14.2\ \mu g/g - 3.7\ \mu g/g = 10.4\ \mu g/g$

$K_d = \frac{10.4\ \mu g/g}{876.0\ \mu g/l} = 0.012\ l/g = 12\ l/kg$

000897

10/18/
Checked by: [illegible]

10-15-93
B. Crouse

FEMP-OU02-4 DRAFT
April 29, 1994

(5) Sample # 113755 (Unsaturated sand and gravel)

$C_o = 1.43\ \mu g/g$

$C_L = 826.0\ \mu g/\ell$

concentration adsorbed

$$C_a = \frac{(2000\ \mu g/\ell)(3.5\ \ell) - (826\ \mu g/\ell)(3.5\ \ell)}{400\ g}$$

$$= 10.3\ \mu g/g$$

Concentration at equilibrium

$$C_s = 10.3\ \mu g/g + 1.43\ \mu g/g = 11.7\ \mu g/g$$

$$C_s' = C_s$$

$$K_d = \frac{C_s'}{C_L} = \frac{11.7\ \mu g/g}{826.0\ \mu g/\ell} = 0.014\ \ell/g$$

$$= 14\ \ell/kg$$

---

(6) Sample # 113770 (Saturated sand + gravel)

$C_o = 2.86\ \mu g/g$

$C_L = 1190\ \mu g/\ell$

$$C_a = \frac{(2000\ \mu g/\ell)(3.5\ \ell) - (1190\ \mu g/\ell)(3.5\ \ell)}{400\ g} = 7.088\ \mu g/g$$

$$C_s = 7.09\ \mu g/g + 2.86\ \mu g/g = 9.95\ \mu g/g$$

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$$C_s' = C_s$$

$$K_d = \frac{9.95\ \mu g/g}{1190\ \mu g/\ell} = 0.0084\ \ell/g$$

$$k_d = \text{[redacted]} = 8.4\ \ell/kg$$

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April 29, 1994

(7) Sample # 114068 (Flyash)

$C_o = 16.9\ \mu g/g$

$C_L = 3.0\ \mu g/l$

$$C_a = \frac{(2000\ \mu g/l)(3.5\ l) - (3.0\ \mu g/l)(3.5\ l)}{400\ g} = 17.5\ \mu g/g$$

$$C_s = 17.5\ \mu g/g + 16.9\ \mu g/g = 34.4\ \mu g/g$$

$$C_s' = 34.7\ \mu g/g - 3.7\ \mu g/g = 30.7\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{30.7\ \mu g/g}{3.0\ \mu g/l} = 10.23\ l/g$$

$$K_d = 10{,}230\ l/kg$$

---

(8) Sample # 114069 (Flyash Material)

$C_o = 12.2\ \mu g/g$

$C_L = 564.0\ \mu g/l$

$$C_a = \frac{(2000\ \mu g/l)(3.5\ l) - (564.0\ \mu g/l)(3.5\ l)}{400\ g} = 12.6\ \mu g/g$$

$$C_s = 12.6\ \mu g/g + 12.2\ \mu g/g = 24.8\ \mu g/g$$

$$C_s' = 24.8\ \mu g/g - 3.7\ \mu g/g = 21.1\ \mu g/g$$

$$K_d = \frac{C_s'}{C_L} = \frac{21.1\ \mu g/g}{564.0\ \mu g/l} = 0.037\ l/g$$

$$= 37\ l/kg$$

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22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
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APPENDIX D.5

AIR TRANSPORT MODELING FOR LONG-TERM RESIDUAL RISK

D.5.0 AIR TRANSPORT MODELING FOR LONG-TERM RESIDUAL RISK

D.5.1 LONG-TERM AIR TRANSPORT MODELING

This section presents the approach, methodology, and results of the long-term air transport analysis of the Operable Unit 2 remedial alternatives. The objective of this analysis was to determine the maximum on-subunit, on-property, and off-property annual average air contaminant concentrations and deposition rates from the remediated Operable Unit 2 subunits. These concentrations were used for the residual risk assessment described in this FS.

The analysis was conducted in accordance with EPA guidance (EPA 1989a). Two emission models and an air dispersion model were used to estimate air emissions from each source and to calculate annual average concentrations and deposition rates at various receptor locations. One emission model predicted the quantity of exposed soil that would be resuspended by the wind, and the other emission model estimated the flux of radon-222 gas from soil containing radium-226. Particulate-phase contaminants examined include radionuclides, inorganic compounds, and nonvolatile organic compounds. The only gas-phase contaminant evaluated in this analysis was radon-222. VOCs were not analyzed as they would be lost to the atmosphere prior to the start of the postremediation periods analyzed in the FS. The air dispersion model accounted for dispersion and dilution of the contaminants under defined meteorological conditions, such as wind speed and direction, atmospheric stability, and mixing height. The meteorological parameters used were collected from an on-property meteorological station, as well as from the National Weather Service (NWS) in Dayton, Ohio.

Four major steps were required to achieve the objective of this analysis:

1. Scenarios for the air transport analysis were defined.
2. Sources of air emissions and contaminants released were identified based on site-specific information.
3. The appropriate EPA regulatory air dispersion model was selected which best represented the site characteristics and the objective of the analysis.
4. Particulate or gaseous air emissions were estimated from site-specific soil contaminant concentrations, and additional inputs to the model such as meteorological data and receptor locations were determined.

Figure D.5.1-1 presents the sequential block diagram of these steps and indicates the sections below that describe them.

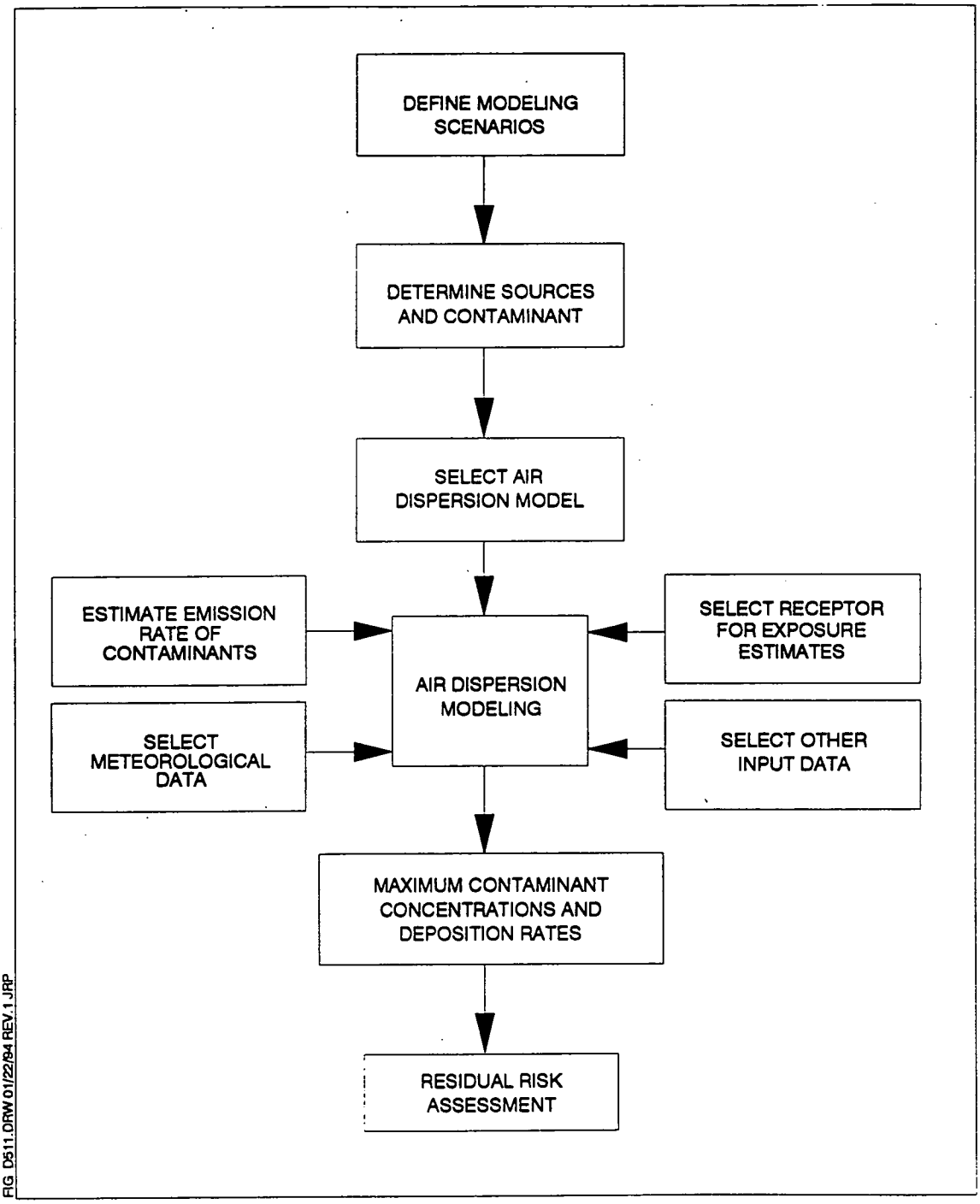

FIGURE D.5.1-1. SEQUENTIAL BLOCK DIAGRAM OF AIR TRANSPORT ANALYSIS

Throughout the analysis, site-specific data were used where available. When such data were not available, conservative assumptions were made. Regulatory default options and values were used where applicable in the air emission and dispersion models. The intent of the assumptions was to make the results relevant to the site so that the risk associated with the air exposure pathway was realistic.

D.5.1.1 Source Term Assumptions for Air Transport Analysis

The residual risks from remediated Operable Unit 2 subunits were evaluated for a number of exposure scenarios under three land use assumptions: Current, Future With Federal Ownership, and Future Without Federal Ownership. The air emissions for these land use assumptions are identical, except for the on-property resident farmer exposure scenario under the Future Land Use Without Federal Ownership. In all other scenarios, the on-property soil is assumed to relatively undisturbed and mostly covered (85 percent) with grass or other vegetation throughout the year. For the on-property farmer scenario, the farmed land will be periodically plowed and planted, harvested, plowed, and left fallow. Under this scenario, the topsoil is assumed to be covered with vegetation for only 50 percent of the year. The South Field was the only subunit that was considered large enough to support a farm and would result in direct exposure to residual contamination in the exposed top soil. Therefore, the South Field was the only subunit analyzed for direct air pathway impacts to the on-property resident farmer.

A total of 29 remedial alternatives were analyzed in the main body of this FS report. Air impacts associated with the five No Action alternatives (one for each subunit) are presented in the Operable Unit 2 RI Report Baseline Risk Assessment (BLRA) (DOE 1994). Potential air impacts associated with the remaining 24 alternatives are summarized below.

Solid Waste Landfill

The Offsite Disposal alternative was assumed to have negligible air impacts. The soil and material with contaminant concentrations greater than the on-property farmer PRLs will be removed from the site and the excavated area will be backfilled with clean soil and vegetated. No contaminated particulate matter or radon gas were assumed to be emitted from the landfill.

The On-Property Disposal alternative was assumed to have minimal air impacts. The soil and material with contaminant concentrations greater than the expanded trespasser PRLs will be placed in the on-property disposal cell and the excavated area will be backfilled covered with an engineered cap. No contaminated particulate matter was assumed to be emitted from the landfill or disposal cell. However, gaseous radon-222 emissions through the landfill cap and disposal cell cover were estimated and included in the air dispersion model.

The Consolidation/Containment alternative was assumed to have minimal air impacts. The landfill will be covered with an engineered cap and no contaminated particulate matter was assumed to be emitted. Gaseous radon-222 emissions through the cap were estimated and included in the dispersion model.

Lime Sludge Ponds

The Offsite Disposal alternative was assumed to have negligible air impacts. The soil with contaminant concentrations greater than the on-property farmer PRLs and sludge will be removed from the site and the excavated area will be backfilled and clean closed. No contaminated particulate matter or radon gas were assumed to be emitted from the lime sludge ponds.

The On-Property Disposal alternatives (with or without lime sludge stabilization) were assumed to have minimal air impacts. The lime sludge and soil with contaminant concentrations greater than the expanded trespasser PRLs will be placed in the on-property disposal cell and the excavated area will be backfilled and clean closed. No contaminated particulate matter was assumed to be emitted from the sludge ponds or disposal cell. However, gaseous radon-222 emissions through the disposal cell cover were estimated and included in the air dispersion model.

The In-Situ Containment alternative was assumed to have minimal air impacts. The ponds will be covered with an engineered cap and no contaminated particulate matter was assumed to be emitted. Gaseous radon-222 emissions through the cap were estimated and included in the dispersion model.

Inactive Flyash Pile

The Offsite Disposal alternative was assumed to have residual air impacts. Soil and material with contaminant concentrations greater than the on-property resident farmer PRLs will be excavated and removed from the site. These PRL values are essentially the contaminant background concentrations. Since the risks associated with background levels were addressed in the BLRA, no additional modeling was conducted for this alternative.

The On-Property Disposal Cell alternatives (five total) were assumed to have residual air impacts. Soil and material with contaminant concentrations greater than the expanded trespasser PRLs will be excavated and placed in the on-property disposal cell. Particulate matter emissions (with contaminant concentrations less than or equal to the expanded trespasser PRLs) were estimated for the Inactive Flyash Pile. Gaseous radon-222 emissions from the exposed soil as well as through the disposal cell cover were estimated and included in the model. For this remedial alternative, the Inactive Flyash Pile will consist of two distinctive areas after remediation. The portion that lies directly on the upper Great Miami Aquifer (GMA) will be will be excavated down to the GMA layer. The portion that contains an intervening till layer between the source material and the GMA will be excavated down to the unimpacted (lower) till layer.

The Consolidation/Containment alternative was assumed to have residual air impacts. These impacts will be virtually identical to the impacts associated with the On-Property Disposal Cell alternatives since soil and material with contaminant concentrations exceeding the expanded trespasser PRLs will be excavated, placed in the consolidation area and covered with an engineered cap. The location of maximum radon-222 impacts could potentially change since the consolidation area is closer to the Inactive Flyash Pile than the disposal cell.

Active Flyash Pile

The Offsite Disposal alternative was assumed to have residual air impacts. Soil and material with contaminant concentrations greater than the on-property resident farmer PRLs will be excavated and removed from the site. These PRL values are essentially the contaminant background concentrations. Since the risks associated with background levels were addressed in the BLRA, no additional modeling was conducted for this alternative.

The On-Property Disposal Cell alternatives (with and without flyash stabilization) were assumed to have residual air impacts. Soil and material with contaminant concentrations greater than the expanded trespasser PRLs will be excavated and placed in the on-property disposal cell. Particulate matter emissions (with contaminant concentrations less than or equal to the expanded trespasser PRLs) were estimated for the Active Flyash Pile. Gaseous radon-222 emissions from the exposed soil as well as through the disposal cell cover were estimated and included in the model. For this remedial alternative, the Active Flyash Pile will consist of two distinctive areas after remediation. The portion that lies directly on the upper Great Miami Aquifer (GMA) will be will be excavated down to the GMA layer. The portion that contains an intervening till layer between the source material and the GMA will be excavated down to the unimpacted (lower) till layer.

The Consolidation/Containment alternative was assumed to have residual air impacts. These impacts will be similar to the impacts associated with the On-Property Disposal Cell alternatives since soil and material with contaminant concentrations exceeding the expanded trespasser PRLs will be excavated, placed in the consolidation area and covered with an engineered cap. The consolidation area partly covers the Active Flyash Pile location, slightly reducing the total area available for particulate matter and uncovered radon emissions. Therefore, the total air impacts associated with this alternative will be less than the impacts associated with the On-Property Disposal Cell alternatives.

South Field

The Offsite Disposal alternative was assumed to have residual air impacts. Soil and material with contaminant concentrations greater than the on-property resident farmer PRLs will be excavated and removed from the site. These PRL values are essentially the contaminant background concentrations. Since the risks associated with background levels were addressed in the BLRA, no additional modeling was conducted for this alternative.

The On-Property Disposal Cell alternatives (four total) were assumed to have residual air impacts. Soil and material with contaminant concentrations greater than the expanded trespasser PRLs will be excavated and placed in the on-property disposal cell. Particulate matter emissions (with contaminant concentrations less than or equal to the expanded

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trespasser PRLs) were estimated for the South Field. Gaseous radon-222 emissions from the exposed soil as well as through the disposal cell cover were estimated and included in the model. For this remedial alternative, the South Field will consist of three distinctive areas after remediation. The portion that lies directly on the upper Great Miami Aquifer (GMA) will be will be excavated down to the GMA layer. The portion that contains less than 16 ft of an intervening till layer between the source material and the GMA will be excavated down to the unimpacted (lower) till layer. The portion that contains more than 16 ft of an intervening till layer between the source material and the GMA does not require extensive excavation.

The Consolidation/Containment alternative was assumed to have residual air impacts. These impacts will be similar to the impacts associated with the On-Property Disposal Cell alternatives since soil and material with contaminant concentrations exceeding the expanded trespasser PRLs will be excavated, placed in the consolidation area and covered with an engineered cap. The consolidation area partly covers the South Field location, reducing the total area available for particulate matter and uncovered radon emissions. Therefore, the total air impacts associated with this alternative will be less than the impacts associated with the On-Property Disposal Cell alternatives.

To analyze the Operable Unit 2 subunits, a total of 373 area sources were used. These sources were combined into 13 source groups where each source group contained sources with identical emission rates. The eight major source groups in the South Field Area are presented on Figure D.5.1-2. These source groups were assumed to emit both contaminated particulates and radon gas. The remaining source groups were assumed to emit only radon gas and included the Solid Waste Landfill, Lime Sludge Ponds, On-Property Disposal Cell, and the Consolidation Area (north end and south end).

D.5.1.2 Air Transport Models

The annual average contaminant concentrations and deposition rates were determined using ISCLT2. This model is recommended by EPA for air pathway analysis of Superfund sites (EPA 1989a).

The ISCLT2 model (EPA 1992 and 1992a) was designed by the EPA to assess the air quality impact of emissions from a wide variety of sources. It incorporates a steady-state gaussian plume equation that is applicable in flat or gently rolling terrain, for multiple point, area, and volume sources. The ISCLT2 model calculates the annual average concentration due to airborne emissions at user-selected receptors, based on sector-averaged statistical wind summaries. Data required for input to the model include source emission rates, the locations and configurations of sources, statistical summaries of wind speed, wind direction, and atmospheric stability, and the locations of the selected receptors.

D.5.1.3 Particulate Contaminant Emission Rates

Radionuclide, inorganic, and nonvolatile organic contaminants were assumed to be present in the suspended particulate matter emitted from the site. The emission rate for each contaminant in this particulate matter was calculated from the concentration of the contaminant in the exposed soil and from the estimated site-wide average particulate matter emission rate. For concentration calculations, the emission rate of particulate matter less than 10 micrometers in diameter (PM_{10}) was used. For deposition rate calculations, the emission rate of total suspended particulates (TSP) was used. The TSP emission rate was determined by assuming that PM_{10} represented 50 percent of the TSP value (EPA 1993).

D.5.1.3.1 Contaminated Soil Concentrations

The radionuclide contaminant concentrations in soil used for development of emission source terms are presented in Table D.5.1-1. The chemical contaminant concentrations in soil used are presented in Tables D.5.1-2. Contaminant soil concentrations were selected from data in the RI/FS database developed for this FS.

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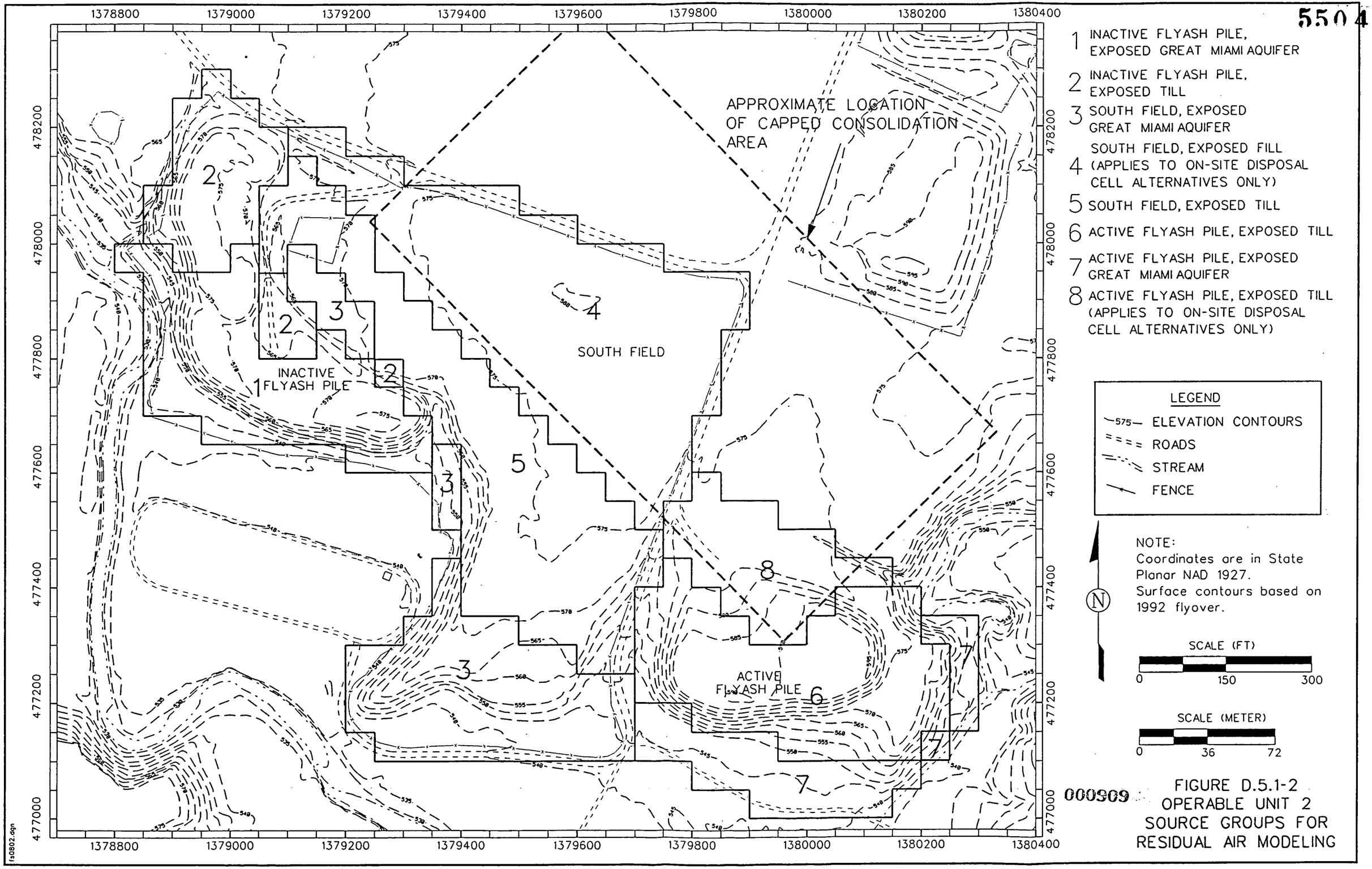

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FIGURE D.5.1-2
OPERABLE UNIT 2
SOURCE GROUPS FOR
RESIDUAL AIR MODELING

TABLE D.5.1-1

ESTIMATED RESIDUAL RADIONUCLIDE CONCENTRATIONS IN EXPOSED SOIL

Radionuclide (pCi/g)	Active Flyash Pile		
	Exposed GMA	Exposed Till	Add'l Exposed Till (On-Property Disposal)
Cs-137	NC	NC	NC
Np-237	5.00×10^{0} [b]	1.90×10^{-1} [a]	1.90×10^{-1} [a]
Ra-226	5.94×10^{-1} [a]	1.14×10^{0} [a]	1.14×10^{0} [a]
Ra-228	5.37×10^{-1} [a]	9.00×10^{-1} [a]	9.00×10^{-1} [a]
Tc-99	0 [c]	0 [c]	0 [c]
Th-228	1.19×10^{0} [a]	1.74×10^{0} [b]	1.74×10^{0} [b]
Th-230	1.42×10^{0} [a]	2.67×10^{0} [a]	2.67×10^{0} [a]
Th-232	9.65×10^{-1} [a]	1.20×10^{0} [a]	1.20×10^{0} [a]
U-234	9.21×10^{-1} [a]	1.00×10^{0} [a]	1.00×10^{0} [a]
U-235	0 [c]	3.40×10^{-2} [a]	3.40×10^{-2} [a]
U-236	0 [c]	3.40×10^{-2} [a]	3.40×10^{-2} [a]
U-238	7.54×10^{-1} [a]	1.05×10^{0} [a]	1.05×10^{0} [a]

See footnotes at end of table.

TABLE D.5.1-1 (Continued)

Radionuclide (pCi/g)	Inactive Flyash Pile	
	Exposed GMA	Exposed Till
Cs-137	0 [c]	0 [c]
Np-237	1.80×10^{-1} [a]	1.60×10^{-1} [a]
Ra-226	8.70×10^{-1} [a]	1.01×10^{0} [a]
Ra-228	5.30×10^{-1} [a]	7.30×10^{-1} [a]
Tc-99	0 [c]	NC
Th-228	4.10×10^{-1} [a]	8.33×10^{-1} [a]
Th-230	2.03×10^{0} [a]	1.62×10^{0} [a]
Th-232	3.60×10^{-1} [a]	7.32×10^{-1} [a]
U-234	1.09×10^{0} [b]	7.70×10^{0} [a]
U-235	8.00×10^{-2} [a]	5.20×10^{-2} [a]
U-236	8.00×10^{-2} [a]	5.20×10^{-2} [a]
U-238	1.44×10^{0} [a]	8.50×10^{-1} [a]

See footnotes at end of table.

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TABLE D.5.1-1 (Continued)

Radionuclide (pCi/g)	South Field		
	Exposed GMA	Exposed Till	Exposed Fill (On-Property Disposal)
Cs-137	0 [c]	0 [c]	6.92×10^{-1} [a]
Np-237	0 [c]	5.00×10^{0} [b]	3.69×10^{-1} [a]
Ra-226	6.76×10^{-1} [a]	1.06×10^{0} [a]	9.21×10^{0} [a]
Ra-228	4.61×10^{-1} [a]	1.02×10^{0} [a]	1.94×10^{0} [b]
Tc-99	0 [c]	0 [c]	9.00×10^{-1} [a]
Th-228	3.30×10^{-1} [a]	8.75×10^{-1} [a]	1.70×10^{0} [b]
Th-230	1.37×10^{0} [a]	1.09×10^{0} [a]	1.38×10^{1} [a]
Th-232	3.30×10^{-1} [a]	7.92×10^{-1} [a]	1.29×10^{1} [a]
U-234	5.85×10^{-1} [a]	3.51×10^{0} [a]	7.83×10^{1} [a]
U-235	2.00×10^{-2} [a]	2.19×10^{-1} [a]	4.05×10^{0} [a]
U-236	2.00×10^{-2} [a]	2.19×10^{-1} [a]	4.05×10^{0} [a]
U-238	6.60×10^{-1} [a]	4.55×10^{0} [a]	5.70×10^{1} [a]

NC = Not characterized.
[a]From given layer source term concentrations, April 1994.
[b]From OU2 subunit expanded trespasser PRLs.
[c]Not detected.

TABLE D.5.1-2

ESTIMATED CHEMICAL CONCENTRATIONS IN EXPOSED SOIL

	Active Flyash Pile		
Chemical (mg/kg)	Exposed GMA	Exposed Till	Add'l Exposed Till (On-Property Disposal)
Aroclor-1254	NC	NC	NC
Aroclor-1260	NC	NC	NC
Arsenic	2.92×10^{1} [b]	1.40×10^{1} [a]	1.40×10^{1} [a]
Benzo(a)anthracene	NC	NC	NC
Benzo(a)pyrene	NC	NC	NC
Benzo(b)fluoranthene	NC	NC	NC
Benzo(k)fluoranthene	NC	NC	NC
Beryllium	5.44×10^{0} [b]	1.10×10^{0} [a]	1.10×10^{0} [a]
Chromium	NC	NC	NC
Chrysene	NC	NC	NC
Dibenzo(a,h)anthracene	NC	NC	NC
Dieldrin	NC	NC	NC
Indeno(1,2,3-cd)pyrene	NC	NC	NC
Uranium (Total)	8.42×10^{0} [a]	4.27×10^{0} [a]	4.27×10^{0} [a]

See footnotes at end of table.

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TABLE D.5.1-2 (Continued)

	Inactive Flyash Pile	
Chemical (mg/kg)	Exposed GMA	Exposed Till
Aroclor-1254	NC	NC
Aroclor-1260	NC	NC
Arsenic	5.10×10^{1} [a]	6.90×10^{0} [a]
Benzo(a)anthracene	NC	NC
Benzo(a)pyrene	NC	NC
Benzo(b)fluoranthene	NC	NC
Benzo(k)fluoranthene	NC	NC
Beryllium	9.30×10^{-1} [a]	1.40×10^{0} [a]
Chromium	NC	NC
Chrysene	NC	NC
Dibenzo(a,h)anthracene	NC	NC
Dieldrin	NC	NC
Indeno(1,2,3-cd)pyrene	NC	NC
Uranium (Total)	5.86×10^{0} [a]	4.39×10^{0} [a]

See footnotes at end of table.

TABLE D.5.1-2 (Continued)

Chemical (mg/kg)	South Field		
	Exposed GMA	Exposed Till	Exposed Fill (On-Property Disposal)
Aroclor-1254	0 [c]	0 [c]	3.50×10^{-2} [a]
Aroclor-1260	0 [c]	0 [c]	3.50×10^{-2} [a]
Arsenic	6.20×10^{0} [a]	7.64×10^{0} [a]	6.98×10^{0} [a]
Benzo(a)anthracene	0 [c]	0 [c]	1.10×10^{0} [a]
Benzo(a)pyrene	0 [c]	0 [c]	1.80×10^{0} [a]
Benzo(b)fluoranthene	0 [c]	0 [c]	1.60×10^{0} [a]
Benzo(k)fluoranthene	0 [c]	0 [c]	1.60×10^{0} [a]
Beryllium	0 [c]	7.79×10^{-1} [a]	8.80×10^{-1} [a]
Chromium	5.00×10^{0} [a]	1.99×10^{1} [a]	1.80×10^{1} [a]
Chrysene	0 [c]	0 [c]	1.40×10^{0} [a]
Dibenzo(a,h)anthracene	0 [c]	0 [c]	4.40×10^{-1} [a]
Dieldrin	0 [c]	0 [c]	9.70×10^{-3} [a]
Indeno(1,2,3-cd)pyrene	0 [c]	0 [c]	6.20×10^{-1} [a]
Uranium (Total)	1.03×10^{1} [a]	1.67×10^{1} [a]	2.97×10^{2} [a]

NC = Not characterized.
[a]From given layer source term concentrations, April 1994.
[b]From OU2 subunit expanded trespasser PRLs.
[c]Not detected.

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Because this analysis assumed that the site has been remediated, any soil concentrations exceeding the extended tresspasser PRLs identified in this FS were reset to the PRL value. For COCs which did not exceed the PRL value, the exposed soil concentration terms were used. These layers included the upper GMA and lower till in the Flyash Piles and South Field, and the fill in the South Field (for On-Property Disposal Cell alternatives). This approach assumed that the residual contamination after remediation will not be worse than currently measured levels.

D.5.1.3.2 Suspended Particulate Emission Estimate

The method used to estimate PM_{10} emission rates for the FEMP is based on EPA guidance for estimating wind erosion rates from flat soil surfaces at hazardous waste sites (EPA 1985a). The EPA methodology assumes that a minimum wind speed is required for the suspension of respirable dust, and the emission rate is a nonlinear function of the "Threshold Friction Velocity" (TFV) and the erosion potential of the site, which depends on the particle size distribution of the soil. Very fine soils (those with small modal diameters) have low TFVs and high potential for erosion by wind.

In addition to modal diameter, other factors such as the amount of nonerodible elements (gravel and pebbles with diameters greater than approximately 1 cm), crustiness of the surface soil, and the amount of vegetative cover effect the quantity of soil that can be resuspended by the wind.

The on-property resident farmer receptor would be continuously breaking up the soil crust in the farmed area. Therefore, crustiness was not applied as a factor in determining the particulate emissions for this receptor. To conservatively estimate the emissions from an on-property farm, only the modal diameter was used to calculate the flux of particulate matter for determining risk under this scenario. For all other receptors/scenarios, the ability of the soil to form a crust as well as moisture content and presence of nonerodible elements was taken into account.

On-Property Resident Farmer Particulate Emission Rates

The modal diameter of Operable Unit 2 exposed soil was estimated from particle size distributions presented in the Operable Unit 2 Remedial Investigation Report. From the data in these reports, the modal diameter occurs in the silt fraction, which is between (0.002 and 0.075 mm or 0.000001 and 0.00003 in.). The modal diameter selected was approximately 0.021 mm, which is in agreement with the typical 50 percent particle size diameter for the FEMP (Mulder, 1993).

Using an exposed soil modal diameter of 0.021 mm, the TFV can be determined from the EPA guidance document (EPA 1985a, Figure 3-4). The relationship between the modal diameter and the TFV can be represented by the equation:

$$\log(TFV) = 1.812 + 0.4161 \log(d_p) \qquad (1)$$

where

TFV	=	threshold friction velocity (cm/s) near the soil surface, and
d_p	=	modal diameter of soil sample (mm).

The calculated TFV is approximately 13.0 cm/s (5 in./s) based on a modal diameter of 0.021 mm (0.00001 in.). The calculated TFV should be corrected based on the surface roughness, crustiness, and quantity of nonerodible elements. The ratio of the corrected TFV to the uncorrected TFV is a nonlinear function of the ratio of the silhouette area of the roughness elements to the total area of bare loose soil (EPA 1985a). For this FS, no correction was applied to the calculated TFV based on the assumption that the exposed surface would behave like dry, loose silt. This assumption is obviously conservative since the site has enough clay in the soil to form a nonerodible crust, the surface contains nonerodible elements, and the vegetation present will significantly increase the TFV necessary to resuspend surface soil.

The calculated TFV is less than the 75 cm/s (30 in./s); therefore, the FEMP surface soil was considered to have an "unlimited" erosion potential (EPA 1985a). The equation for respirable particulate emissions of soils with unlimited erosion potential takes the following form:

$$E_{10} = 0.036 \times (1-V) \times [(u/u_t)^3] \times F(y) \qquad (2)$$

where

E_{10}	=	annual average PM_{10} emission rate per unit area of contaminated surface ($g/hr/m^2$),
PM_{10}	=	particulate matter with a diameter $\leq$ 10 meters,
V	=	fraction of soil covered by vegetation,
u	=	mean annual wind speed (m/s),
u_t	=	TFV at the height of "u" (m/s),
y	=	$0.886 \times u_t / u$,
F(y)	=	1.91 for $y < 0.5$,
F(y)	=	$0.18 \times (y^3 + 12y) \times EXP(-y^2)$ for $y > 2$, and
F(y)	=	See Figure 4-3, EPA 1985a, for $0.5 < y < 2$.

For the on-property farmer scenario, the farmed land will be periodically plowed and planted, harvested, plowed, and left fallow. Under this scenario, the topsoil is assumed to be covered with vegetation for only 50 percent of the year.

The TFV must be corrected to the anemometer height (10 meters) used to collect site wind speed data. The corrected TFV is calculated from the following equation (EPA 1985a):

$$U_t/TFV = (1/0.4) \ln (Z/Z_o) \quad (3)$$

where

Z = anemometer height (m), and
Z_o = surface roughness height (m).

The surface at the FEMP will be covered with grass and other vegetation after completion of remedial actions. Using an approximated value of 0.03 meters (0.1 feet) for grassland (EPA 1985a) as Z_o, the value of U_t was calculated to be 1.89 m/s (6 ft/s).

The methodology used to calculate the emissions for soil with unlimited erosion potential is based on multiplying the emission rate for a single mean annual wind speed value by an estimated annual wind speed probability distribution. This method allows for rapid calculation of annual PM_{10} emissions knowing only the mean annual wind speed. The highest annual average wind speed from the on-site meteorological data set was 2.28 m/s (DOE, 1993c). Using this wind speed value in Equation (1) provides an estimated PM_{10} emission flux of 1.59×10^{-5} g/sec/m^2.

The annual average radionuclide emissions from the South Field under the on-property resident farmer scenario are presented in Table D.5.1-3. The chemical emissions from the South Field are presented in Table D.5.1-4.

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TABLE D.5.1-3

RADIONUCLIDE EMISSION FLUXES FROM EXPOSED SOIL UNLIMITED EROSION WITH 50% VEGETATIVE COVER[a]

Radionuclide ($pCi/s/m^2$)	South Field					
	Exposed GMA		Exposed Till		Exposed Fill (On-Property Disposal)	
	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}
Cs-137	0	0	0	0	2.20×10^{-5}	1.10×10^{-5}
Np-237	0	0	1.59×10^{-4}	7.95×10^{-5}	1.17×10^{-5}	5.87×10^{-6}
Ra-226	2.15×10^{-5}	1.07×10^{-5}	3.36×10^{-5}	1.68×10^{-5}	2.93×10^{-4}	1.46×10^{-4}
Ra-228	1.47×10^{-5}	7.33×10^{-6}	3.25×10^{-5}	1.62×10^{-5}	6.17×10^{-5}	3.08×10^{-5}
Tc-99	0	0	0	0	2.86×10^{-5}	1.43×10^{-5}
Th-228	1.05×10^{-5}	5.25×10^{-6}	2.78×10^{-5}	1.39×10^{-5}	5.41×10^{-5}	2.70×10^{-5}
Th-230	4.36×10^{-5}	2.18×10^{-5}	3.58×10^{-5}	1.74×10^{-5}	4.39×10^{-4}	2.19×10^{-4}
Th-232	1.05×10^{-5}	5.25×10^{-6}	2.52×10^{-5}	1.26×10^{-5}	4.10×10^{-4}	2.05×10^{-4}
U-234	1.86×10^{-5}	9.30×10^{-6}	1.12×10^{-4}	5.58×10^{-5}	2.49×10^{-3}	1.24×10^{-3}
U-235/236	6.36×10^{-7}	3.18×10^{-7}	6.96×10^{-6}	3.48×10^{-6}	1.29×10^{-4}	6.44×10^{-5}
U-238	2.10×10^{-5}	1.05×10^{-5}	1.45×10^{-4}	7.23×10^{-5}	1.81×10^{-3}	9.06×10^{-4}

NC = Not calculated.
[a]Based on an annual average PM_{10} Emission Flux of 1.59×10^{-5} $g/s/m^2$, TSP Emission Flux of 3.18×10^{-5} $g/s/m^2$, and the COC concentration in exposed soil.

TABLE D.5.1-4

CHEMICAL EMISSION FLUXES FROM EXPOSED SOIL UNLIMITED EROSION WITH 50% VEGETATIVE COVER[a]

South Field						
Chemical ($\mu g/s/m^2$)	Exposed GMA		Exposed Till		Exposed Fill (On-Property Disposal)	
	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}
Aroclor-1254	0	0	0	0	1.11×10^{-6}	5.57×10^{-7}
Aroclor-1260	0	0	0	0	1.11×10^{-6}	5.57×10^{-7}
Arsenic	1.97×10^{-4}	9.86×10^{-5}	2.43×10^{-4}	1.21×10^{-4}	2.22×10^{-4}	1.11×10^{-4}
Benzo(a)anthracene	0	0	0	0	3.50×10^{-5}	1.75×10^{-5}
Benzo(a)pyrene	0	0	0	0	5.72×10^{-5}	2.86×10^{-5}
Benzo(b)fluoranthene	0	0	0	0	5.09×10^{-5}	2.54×10^{-5}
Benzo(k)fluoranthene	0	0	0	0	5.09×10^{-5}	2.54×10^{-5}
Beryllium	0	0	2.48×10^{-5}	1.24×10^{-5}	2.80×10^{-5}	1.40×10^{-5}
Chromium	1.59×10^{-4}	7.95×10^{-5}	6.33×10^{-4}	3.16×10^{-4}	5.73×10^{-4}	2.86×10^{-4}
Chrysene	0	0	0	0	4.45×10^{-5}	2.23×10^{-5}
Dibenzo(a,h)anthracene	0	0	0	0	1.40×10^{-5}	7.00×10^{-6}
Dieldrin	0	0	0	0	3.18×10^{-7}	1.59×10^{-7}
Indeno(1,2,3-cd)pyrene	0	0	0	0	1.97×10^{-5}	9.86×10^{-6}
Uranium (Total)	3.28×10^{-4}	1.64×10^{-4}	5.34×10^{-4}	2.67×10^{-4}	9.44×10^{-3}	4.72×10^{-3}

NC = Not Calculated.
[a]Based on an annual average PM10 Emission Flux of 1.59×10^{-5} g/s/m^2, TSP Emission Flux of 3.18×10^{-5} g/s/m^2, and the COC concentration in exposed soil.

All Other Receptor/Exposure Scenarios

Observations of the surface soil at the FEMP indicate that the surface may have a limited erosion potential, based on comparison of the FEMP surface to photographs of limited erosion potential surfaces presented in the reference document (EPA 1985a). Therefore, the limited erosion potential equation, presented below, is used to estimate particulate emissions for all other receptor/exposure scenarios:

$$E_{10} = 0.83 \times f \times P(u^+) \times (1 - V) / (PE/50)^2 \quad (4)$$

where

E_{10}	=	annual average PM_{10} emission rate per unit area of contaminated surface ($g/hr/m^2$),
f	=	frequency of disturbance per month,
$P(u^+)$	=	erosion potential, the quantity of erodible particles present on the surface prior to the onset of wind erosion (g/m^2),
u^+	=	observed (or probable) fastest mile of wind for the period between disturbances (m/s),
V	=	fraction of soil covered by vegetation, and
PE	=	Thornwaite's Precipitation Index (a measure of average soil moisture content).

The erosion potential in Equation 4 depends on the fastest mile as follows (EPA 1985a):

$$P(u^+) = 6.7 \times (u^+ - u_t), \text{ for } u^+ \geq u_t, \quad (5)$$
$$= 0, \text{ for } u^+ < u_t.$$

A typical fastest mile for the region is 24 m/s (EPA 1985a) at 7 meters above ground. Correcting the threshold friction velocity previously determined for the unlimited erosion potential to 7 meters above the ground (using Equation 3) results in a value of 1.77 m/s for u_t. The calculated value for $P(u^+)$ is 148.93 g/m^2.

Since the remediated site under scenarios other than the on-property farmer will be infrequently disturbed, the value of **f** was assumed to be 1. Thornwaite's Precipitation Index (PE) for the southwest corner of Ohio is 103 (EPA 1985a).

Currently, the FEMP is 80 to 85 percent covered with vegetation. After remediation, the South Field Area will be planted with appropriate vegetation for erosion control and aesthetics. The region easily supports plant life, and a 100 percent vegetative cover is expected over the postremediated site, with or without continued maintenance. For this air transport analysis, the site was conservatively assumed to be 85 percent covered with vegetation. The 85 percent value is in line with EPA estimates of control efficiencies for vegetative covers (EPA 1987).

The limited erosion potential of PM_{10} for the FEMP is then calculated to be 1.21 x 10^{-6} g/s/m^2.

Note that the ISCLT2 model calculates dispersion for six wind speed categories (EPA 1992). The use of a single emission rate for dispersion under all six wind speed categories will overestimate the concentrations for low wind speeds and underestimate concentrations at high wind speeds. The frequency of wind speeds in the lower wind speed categories is much greater than the frequency of wind speeds in the upper wind speed categories. Therefore, using a single emission rate for all wind speed categories in ISCLT2 will tend to overestimate the ground level PM_{10} concentrations. Evidence indicates (EPA 1985b) that no substantial fugitive particulate emissions occur for wind speeds less than 5 m/s (16.4 ft/s or 12 mph). These wind speeds include the lower three wind speed categories analyzed by ISCLT2.

Tables D.5.1-5 and D.5.1-6 present particulate-phase radionuclide and chemical emissions, respectively, for each source group and all receptor scenarios, except the on-property farmer.

D.5.1.4 Gaseous Contaminant Emission Rates

Emissions of radon-222 were estimated for exposed soil in the South Field Area as well as from capped or covered areas (Solid Waste Landfill, Lime Sludge Ponds, On-Property Disposal Cell, and Consolidation Area). No other gaseous emissions were estimated. Volatile and semivolatile organics were assumed to have decayed to negligible levels prior to the time period studied by this analysis. Radionuclides, nonvolatile organics, and inorganics were assumed to be transported with the particulates emitted from the site.

Radon-222 emissions of were determined from the radium-226 concentrations in the contaminated soil using the RAECOM model algorithms developed for the NRC (NRC 1984). The model accounts for the half-lives of radon and radium as well as the density, porosity, moisture content, and depth of contaminated layers and cover layers in estimating radon-222 emission rates. The model converts radium-226 soil concentrations (in pCi/g) to radon-222 fluxes (in pCi/s/m^2). The basic equations are presented in the Risk Assessment Work Plan Addendum (DOE 1992). The radium-226 concentrations and the radon-222 fluxes from each emission source are presented in Table D.5.1-7. The RAECOM model output is presented in Attachment D.5.1-I.

TABLE D.5.1-5

RADIONUCLIDE EMISSION FLUXES FROM EXPOSED SOIL LIMITED EROSION WITH 85% VEGETATIVE COVER[a]

Active Flyash Pile

Radionuclide ($pCi/s/m^2$)	Exposed GMA		Exposed Till		Exposed Till (On-Property Disposal)	
	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}
Cs-137	NC	NC	NC	NC	NC	NC
Np-237	1.21×10^{-5}	6.50×10^{-6}	4.60×10^{-7}	2.30×10^{-7}	4.60×10^{-7}	2.30×10^{-7}
Ra-226	1.44×10^{-6}	7.19×10^{-7}	2.76×10^{-6}	1.38×10^{-6}	2.76×10^{-6}	1.38×10^{-6}
Ra-228	1.30×10^{-6}	6.50×10^{-7}	2.18×10^{-6}	1.09×10^{-6}	2.18×10^{-6}	1.09×10^{-6}
Tc-99	0	0	0	0	0	0
Th-228	2.88×10^{-6}	1.44×10^{-6}	4.21×10^{-6}	2.10×10^{-6}	4.21×10^{-6}	2.10×10^{-6}
Th-230	3.44×10^{-6}	1.72×10^{-6}	6.46×10^{-6}	3.23×10^{-6}	6.46×10^{-6}	3.23×10^{-6}
Th-232	2.34×10^{-6}	1.17×10^{-6}	2.90×10^{-6}	1.45×10^{-6}	2.90×10^{-6}	1.45×10^{-6}
U-234	2.23×10^{-6}	1.11×10^{-6}	2.42×10^{-6}	1.21×10^{-6}	2.42×10^{-6}	1.21×10^{-6}
U-235/236	0	0	8.23×10^{-8}	4.11×10^{-8}	8.23×10^{-8}	4.11×10^{-8}
U-238	1.82×10^{-6}	9.12×10^{-7}	2.54×10^{-6}	1.27×10^{-6}	2.54×10^{-6}	1.27×10^{-6}

See footnotes at end of table.

TABLE D.5.1-5 (Continued)

Inactive Flyash Pile				
Radionuclide ($pCi/s/m^2$)	Exposed GMA		Exposed Till	
	TSP	PM_{10}	TSP	PM_{10}
Cs-137	0	0	0	0
Np-237	4.36×10^{-7}	2.18×10^{-7}	3.87×10^{-7}	1.94×10^{-7}
Ra-226	2.11×10^{-6}	1.05×10^{-6}	2.44×10^{-6}	1.22×10^{-6}
Ra-228	1.28×10^{-6}	6.41×10^{-7}	1.77×10^{-6}	8.83×10^{-7}
Tc-99	0	0	NC	NC
Th-228	9.92×10^{-7}	4.96×10^{-7}	2.02×10^{-6}	1.01×10^{-6}
Th-230	4.91×10^{-6}	2.46×10^{-6}	3.92×10^{-6}	1.96×10^{-6}
Th-232	8.71×10^{-7}	4.36×10^{-6}	1.77×10^{-6}	8.86×10^{-7}
U-234	2.63×10^{-6}	1.31×10^{-6}	1.86×10^{-6}	9.32×10^{-7}
U-235/236	1.94×10^{-7}	9.68×10^{-8}	1.26×10^{-7}	6.29×10^{-8}
U-238	3.48×10^{-6}	1.74×10^{-6}	2.06×10^{-6}	1.03×10^{-6}

See footnotes at end of table.

TABLE D.5.1-5 (Continued)

Radionuclide ($pCi/s/m^2$)	South Field					
	Exposed GMA		Exposed Till		Exposed Fill (On-Property Disposal)	
	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}
Cs-137	0	0	0	0	1.67×10^{-6}	8.37×10^{-7}
Np-237	0	0	1.21×10^{-5}	6.05×10^{-6}	8.93×10^{-7}	4.46×10^{-7}
Ra-226	1.64×10^{-6}	8.18×10^{-7}	2.56×10^{-6}	1.28×10^{-6}	2.23×10^{-5}	1.11×10^{-5}
Ra-228	1.12×10^{-6}	5.58×10^{-7}	2.47×10^{-6}	1.24×10^{-6}	4.69×10^{-6}	2.35×10^{-6}
Tc-99	0	0	0	0	2.18×10^{-6}	1.09×10^{-6}
Th-228	7.99×10^{-7}	3.99×10^{-7}	2.12×10^{-6}	1.06×10^{-6}	4.11×10^{-6}	2.06×10^{-6}
Th-230	3.32×10^{-6}	1.66×10^{-6}	2.65×10^{-6}	1.32×10^{-6}	3.34×10^{-5}	1.67×10^{-5}
Th-232	7.99×10^{-7}	3.99×10^{-7}	1.92×10^{-6}	9.58×10^{-7}	3.12×10^{-5}	1.56×10^{-5}
U-234	1.42×10^{-6}	7.08×10^{-7}	8.49×10^{-6}	4.25×10^{-6}	1.89×10^{-4}	9.47×10^{-5}
U-235/236	4.84×10^{-8}	2.42×10^{-8}	5.30×10^{-7}	2.65×10^{-7}	9.80×10^{-6}	4.90×10^{-6}
U-238	1.60×10^{-6}	7.99×10^{-7}	1.10×10^{-5}	5.51×10^{-6}	1.38×10^{-4}	6.90×10^{-5}

NC = Not calculated.
[a]Based on an annual average PM_{10} Emission Flux of 1.21×10^{-6} $g/s/m^2$, TSP Emission Flux of 2.42×10^{-6} $g/s/m^2$, and the COC concentration in exposed soil.

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TABLE D.5.1-6

CHEMICAL EMISSION FLUXES FROM EXPOSED SOIL LIMITED EROSION WITH 85% VEGETATIVE COVER[a]

Active Flyash Pile

Chemical ($\mu g/s/m^2$)	Exposed GMA		Exposed Till		Exposed Till (On-Property Disposal)	
	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}
Aroclor-1254	NC	NC	NC	NC	NC	NC
Aroclor-1260	NC	NC	NC	NC	NC	NC
Arsenic	7.07×10^{-5}	3.53×10^{-5}	3.39×10^{-5}	1.69×10^{-5}	3.39×10^{-5}	1.69×10^{-5}
Benzo(a)anthracene	NC	NC	NC	NC	NC	NC
Benzo(a)pyrene	NC	NC	NC	NC	NC	NC
Benzo(b)fluoranthene	NC	NC	NC	NC	NC	NC
Benzo(k)fluoranthene	NC	NC	NC	NC	NC	NC
Beryllium	1.32×10^{-5}	6.58×10^{-6}	2.66×10^{-6}	1.33×10^{-6}	2.66×10^{-6}	1.33×10^{-6}
Chromium	NC	NC	NC	NC	NC	NC
Chrysene	NC	NC	NC	NC	NC	NC
Dibenzo(a,h)anthracene	NC	NC	NC	NC	NC	NC
Dieldrin	NC	NC	NC	NC	NC	NC
Indeno(1,2,3-cd)pyrene	NC	NC	NC	NC	NC	NC
Uranium (Total)	2.04×10^{-5}	1.02×10^{-5}	1.03×10^{-5}	5.17×10^{-6}	1.03×10^{-5}	5.17×10^{-6}

See footnotes at end of table.

TABLE D.5.1-6 (Continued)

Inactive Flyash Pile

Chemical ($\mu g/s/m^2$)	Exposed GMA		Exposed Till	
	TSP	PM_{10}	TSP	PM_{10}
Aroclor-1254	NC	NC	NC	NC
Aroclor-1260	NC	NC	NC	NC
Arsenic	1.23×10^{-5}	6.17×10^{-6}	1.67×10^{-5}	8.35×10^{-6}
Benzo(a)anthracene	NC	NC	NC	NC
Benzo(a)pyrene	NC	NC	NC	NC
Benzo(b)fluoranthene	NC	NC	NC	NC
Benzo(k)fluoranthene	NC	NC	NC	NC
Beryllium	2.25×10^{-6}	1.13×10^{-6}	3.38×10^{-6}	1.69×10^{-6}
Chromium	NC	NC	NC	NC
Chrysene	NC	NC	NC	NC
Dibenzo(a,h)anthracene	0	0	0	0
Dieldrin	NC	NC	NC	NC
Indeno(1,2,3-cd)pyrene	NC	NC	NC	NC
Uranium (Total)	1.42×10^{-5}	7.09×10^{-6}	1.06×10^{-5}	5.31×10^{-6}

See footnotes at end of table.

TABLE D.5.1-6 (Continued)

South Field						
Chemical ($\mu g/s/m^2$)	**Exposed GMA**		**Exposed Till**		**Exposed Fill (On-Property Disposal)**	
	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}
Aroclor-1254	0	0	0	0	8.47×10^{-8}	4.24×10^{-8}
Aroclor-1260	0	0	0	0	8.47×10^{-8}	4.24×10^{-8}
Arsenic	1.50×10^{-5}	7.50×10^{-6}	1.85×10^{-5}	9.24×10^{-6}	1.69×10^{-5}	8.44×10^{-6}
Benzo(a)anthracene	0	0	0	0	2.66×10^{-6}	1.33×10^{-6}
Benzo(a)pyrene	0	0	0	0	4.36×10^{-6}	2.18×10^{-6}
Benzo(b)fluoranthene	0	0	0	0	3.87×10^{-6}	1.94×10^{-6}
Benzo(k)fluoranthene	0	0	0	0	3.87×10^{-6}	1.94×10^{-6}
Beryllium	0	0	1.89×10^{-6}	9.43×10^{-7}	2.13×10^{-6}	1.06×10^{-6}
Chromium	1.21×10^{-5}	6.05×10^{-6}	4.82×10^{-5}	2.41×10^{-5}	4.36×10^{-5}	2.18×10^{-5}
Chrysene	0	0	0	0	3.39×10^{-6}	1.69×10^{-6}
Dibenzo(a,h)anthracene	0	0	0	0	1.06×10^{-6}	5.32×10^{-7}
Dieldrin	0	0	0	0	2.42×10^{-8}	1.21×10^{-8}
Indeno(1,2,3-cd)pyrene	0	0	0	0	1.50×10^{-6}	7.50×10^{-7}
Uranium (Total)	2.49×10^{-5}	1.25×10^{-5}	4.06×10^{-5}	2.03×10^{-5}	7.19×10^{-4}	3.59×10^{-4}

NC = Not Calculated.
[a]Based on an annual average PM10 Emission Flux of 1.21×10^{-6} g/s/m^2, TSP Emission Flux of 2.42×10^{-6} g/s/m^2, and the COC concentration in exposed soil.

TABLE D.5.1-7

Rn-222 FLUXES FROM RAECOM MODEL

Emission Source	Ra-226 Concentration (pCi/g)	Rn-222 Flux ($pCi/s/m^2$)
OU2 Active Flyash Pile - Exposed GMA	0.59	2.62×10^{-1}
OU2 Active Flyash Pile - Exposed Till	1.14	4.98×10^{-1}
OU2 Inactive Flyash Pile - Exposed GMA	0.87	5.05×10^{-1}
OU2 Inactive Flyash Pile - Exposed Till	1.01	4.34×10^{-1}
OU2 South Field - Exposed GMA	0.68	1.03×10^{-1}
OU2 South Field - Exposed Till	1.06	4.27×10^{-2}
OU2 South Field - Exposed Fill (On-Property Disposal alternatives)	9.21	1.86×10^{0}
OU2 Consolidation Area - IFP & SF End	14.06	7.72×10^{-1}
OU2 Consolidation Area - AFP End	4.61	2.51×10^{-1}
OU2 Solid Waste Landfill	2.26	5.75×10^{-3}
OU2 Lime Sludge Ponds	3.15	1.77×10^{-2}
OU2 On-Property Disposal Cell	14.06	7.72×10^{-1}

D.5.1.5 Meteorological Data

Meteorological data characterizing the transport and dispersion conditions of an area are needed as input to the ISCLT2 model. These data include wind speed, wind direction, atmospheric stability, ambient air temperature, and mixing height. Measurements for all of these meteorological parameters, except mixing height, have been recorded at the FEMP site as part of a comprehensive environmental monitoring program since August 1986.

Direct measurements of wind speed, wind direction, and ambient air temperature were taken at a height of 10 meters (30 feet) above the ground. Atmospheric stability was derived from direct measurements of the standard deviation of the horizontal wind direction (σ_θ) during the day and the low-level temperature difference (ΔT) at night. Measurements of σ_θ were taken at a height of 60 meters (180 feet) above the ground. The temperature difference was calculated from air temperature measurements taken at 60 and 10 meters (180 and 30 feet) above the ground. Site-specific hourly measurements were obtained for 1987 through 1992, excluding 1990 due to poor data recovery. A five-year composite joint frequency distribution of wind speed, wind direction, and atmospheric stability is presented in Attachment D.5.1-II. The composite distribution was used in the ISCLT2 dispersion model.

Mixing heights were determined from twice daily atmospheric soundings made by the National Weather Service (NWS). The nearest NWS station is in Dayton, Ohio.

D.5.1.6 Receptor Locations

As previously stated, the objective of the air transport analysis was to determine the maximum on-and off-property contaminant concentrations for risk assessment calculations. Two rectangular receptor grid systems were used to determine the maximum on-property concentrations and approximate locations. The first grid consisted of 676 receptor points in a 121.9 x 121.9 meter (400 x 400 foot) pattern which extended over the entire FEMP property. The 1927 State Planar coordinate system was used for origin and location. The second grid consisted of 360 receptor points also in a 121.9 x 121.9 meter (400 x 400 foot) pattern located over the center of the FEMP. The second grid was offset 200 feet North and 200 feet East of the first grid, resulting in an effective 86.2 x 86.2 meter (283 x 283 foot) pattern over the center of the FEMP.

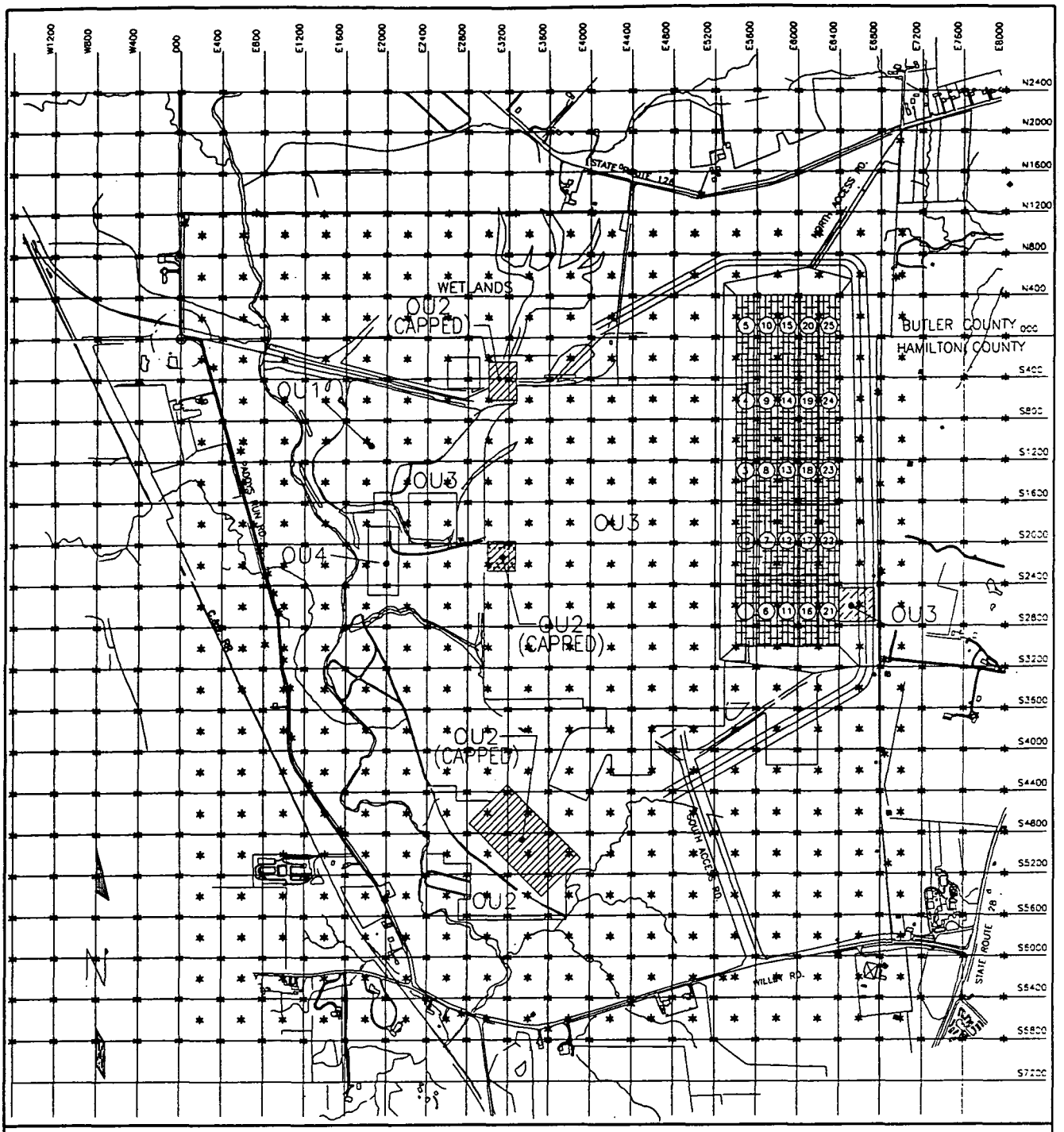
Thirty-six fenceline receptor points located around the FEMP were included in the air transport analysis to identify the maximum off-property receptor. These fenceline receptor locations were determined from the intersection of the FEMP fenceline and imaginary lines extending in 36 directions at 10-degree intervals from a point located at 1,381,000 ft East and 480,000 ft North (1927 State Planar coordinates). The analysis results for the fenceline receptor with the highest air quality impacts are reported as the maximum off-property concentrations in Section D.5.1.9.

Figure D.5.1-3 shows the layout of the receptor grid considered in the air dispersion modeling. Because the concentrations were used primarily to estimate inhalation pathway risk for outdoor activities, the receptors were assumed to be 1.5 meters (5 feet) above the ground to simulate a typical person's breathing height for outdoor activities (EPA 1989b). The variation of ground level concentration within 0 to 1.5 meters is negligible.

D.5.1.7 Dispersion Coefficients

The selection of rural or urban dispersion coefficients for use in the ISCLT2 model was based on a land-use typing procedure to determine whether the characteristics of the area around the FEMP are primarily rural or urban. The procedure involved classifying the land use within an area circumscribed by a 3 kilometer (1.9 mile) radius about the site. Urban dispersion coefficients were recommended for use if land-use types of heavy industrial, light-to-moderate industrial, commercial, single-compact residential, and multi-compact residential account for 50 percent or more of the area. Otherwise, rural dispersion coefficients were recommended.

A review of U.S. Geological Survey (USGS) maps and a site survey of the area indicated that industrial, commercial, and compact residential land use comprise no more than 10 percent of the area within a 3 kilometer (1.9 mile) radius of the site. Therefore, the area was classified as rural for the purpose of air dispersion modeling, indicating the use of rural dispersion coefficients would be appropriate.



400 0 400 800
SCALE IN FEET

* = RECEPTOR GRID POINT

FILE: FSI13

FIGURE D.5.1-3
RECEPTOR GRIDS FOR AIR DESPERSION MODELING

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D.5.1.8 Model Output Processing

The air dispersion modeling analysis was simplified by running the ISCLT2 model with an assumed emission rate of 1.0 g/s/m^2 or 1.0 pCi/s/m^2 for each area source. The source group and plot file options of the ISCLT2 program were used to group sources and write the grouped results to a plot file. The ISCLT2 source group results were multiplied by the contaminant emission rates listed in Tables D.5.1-3 through D.5.1-7 to determine the contaminant-specific annual concentrations presented in Section D.5.1.10. Spreadsheets were used to calculate the contaminant-specific concentrations from the ISCLT2 model output and emissions data in Tables D.5.1-3 through D.5.1-7. The 373 area sources were combined into 13 source groups:

1. Active Flyash Pile - Exposed GMA (26 sources)
2. Active Flyash Pile - Exposed Till, Consolidation/Containment alternatives (36 sources)
3. Active Flyash Pile - Exposed Till, Additional sources for On-Property Disposal Cell alternatives (21 sources)
4. Inactive Flyash Pile - Exposed GMA (32 sources)
5. Inactive Flyash Pile - Exposed Till (22 sources)
6. South Field - Exposed GMA (40 sources)
7. South Field - Exposed Till (43 sources)
8. South Field - Exposed Fill, On-Property Disposal Cell alternatives (58 sources)
9. Consolidation Area - IFP & SF End (49 sources for radon-222 emissions only)
10. Consolidation Area - AFP End (22 sources for radon-222 emissions only)
11. Solid Waste Landfill (4 sources for radon-222 emissions only)
12. Lime Sludge Ponds (4 sources for radon-222 emissions only)
13. On-Property Disposal Cell (16 sources for radon-222 emissions only)

D.5.1.9 Results of Air Dispersion Modeling

This section presents the modeled air concentration for each contaminant. The values presented are the maximum on-subunit, maximum on-property, and maximum off-property (fenceline) concentration or deposition rate for each contaminant.

D.5.1.9.1 Consolidation/Containment Alternatives

The modeled maximum annual average radionuclide concentrations for all exposure scenarios, except for the on-property resident farmer, under the Consolidation/Containment alternatives are presented in Tables D.5.1-8 through D.5.1-10, and radionuclide deposition rates are presented in Tables D.5.1-11 through D.5.1-13. The maximum annual average chemical concentrations for all exposure scenarios, except the on-property farmer, are presented in Tables D.5.1-14 through D.5.1-16, and chemical deposition rates are presented in Tables D.5.1-17 through D.5.1-19.

The maximum annual average radionuclide and chemical concentrations for the on-property resident farmer scenario are presented in Tables D.5.1-20 and D.5.1-21, respectively. The maximum radionuclide and chemical deposition rates for the on-property farmer scenario are presented in Tables D.5.1-22 and D.5.1-23, respectively.

Gaseous radon-222 emissions resulted in the highest activity concentrations of any radionuclide analyzed by at least three orders of magnitude. The maximum on-subunit and off-property (fenceline) concentrations of radon-222 were modeled at 3.76 and 0.173 pCi/m^3, respectively, for the South Field. The location of the on-subunit maximum was 1,379,600 ft East and 478,000 ft North (1927 State Planar coordinates). The location of the off-property maximum was 1,378,210 ft East and 477,659 ft North.

The maximum value is approximately three orders of magnitude below the EPA action level of 4000 pCi/m^3 (4 pCi/l) for indoor radon concentrations. The maximum value is over two orders of magnitude below the annual average U.S. residential radon concentration of 1250 pCi/m^3 (Marcinowski and Napolitano 1993).

Modeled concentrations of uranium-238 typically represented one of the more prevalent radionuclides in the particulate phase. The maximum on-subunit and off-property concentrations of uranium-238 were modeled at 2.68 x 10^{-5} and 1.37 x 10^{-6} pCi/m^3, respectively, for the South Field. The location of the on-subunit maximum was 1,379,000 ft East and 477,600 ft North. The location of the off-property maximum was 1,378,520 ft East and 477,044 ft North.

TABLE D.5.1-8

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	2.81×10^{-5}	1.22×10^{-5}	1.30×10^{-6}
Ra-226	7.19×10^{-6}	3.21×10^{-6}	4.69×10^{-7}
Ra-228	6.60×10^{-6}	2.92×10^{-6}	3.98×10^{-7}
Rn-222	3.76×10^{0}	3.47×10^{0}	1.73×10^{-1}
Tc-99	0	0	0
Th-228	5.53×10^{-6}	2.44×10^{-6}	3.22×10^{-7}
Th-230	9.60×10^{-6}	3.94×10^{-6}	6.78×10^{-7}
Th-232	5.06×10^{-6}	2.24×10^{-6}	3.00×10^{-7}
U-234	2.08×10^{-5}	9.12×10^{-6}	1.08×10^{-6}
U-235/236	1.27×10^{-6}	5.54×10^{-7}	6.26×10^{-8}
U-238	2.68×10^{-5}	1.17×10^{-5}	1.37×10^{-6}

TABLE D.5.1-9

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE INACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	9.18×10^{-7}	8.60×10^{-7}	8.14×10^{-8}
Ra-226	4.74×10^{-6}	4.74×10^{-6}	4.32×10^{-7}
Ra-228	3.18×10^{-6}	3.18×10^{-6}	2.82×10^{-7}
Rn-222	2.52×10^{0}	3.05×10^{0}	2.82×10^{-1}
Tc-99	0	0	0
Th-228	3.12×10^{-6}	3.12×10^{-6}	2.63×10^{-7}
Th-230	1.01×10^{-5}	9.24×10^{-6}	8.87×10^{-7}
Th-232	2.74×10^{-6}	2.74×10^{-6}	2.31×10^{-7}
U-234	5.28×10^{-6}	4.70×10^{-6}	4.58×10^{-7}
U-235/236	3.83×10^{-7}	3.35×10^{-7}	3.30×10^{-8}
U-238	6.79×10^{-6}	5.82×10^{-6}	5.80×10^{-7}

TABLE D.5.1-10

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE ACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Np-237	1.34×10^{-5}	9.65×10^{-6}	6.87×10^{-7}
Ra-226	7.54×10^{-6}	4.11×10^{-6}	3.22×10^{-7}
Ra-228	6.12×10^{-6}	3.37×10^{-6}	2.63×10^{-7}
Rn-222	3.45×10^{0}	1.94×10^{0}	1.73×10^{-1}
Tc-99	0	0	0
Th-228	1.22×10^{-5}	6.79×10^{-6}	5.28×10^{-7}
Th-230	1.77×10^{-5}	9.67×10^{-6}	7.58×10^{-7}
Th-232	8.78×10^{-6}	4.95×10^{-6}	3.83×10^{-7}
U-234	7.61×10^{-6}	4.33×10^{-6}	3.34×10^{-7}
U-235/236	1.81×10^{-7}	9.01×10^{-8}	7.31×10^{-9}
U-238	7.46×10^{-6}	4.16×10^{-6}	3.23×10^{-7}

TABLE D.5.1-11

RADIONUCLIDE DEPOSITION RATES FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	8.94×10^{-1}	4.48×10^{-1}	5.63×10^{-2}
Ra-226	2.38×10^{-1}	1.20×10^{-1}	1.99×10^{-2}
Ra-228	2.16×10^{-1}	1.09×10^{-1}	1.70×10^{-2}
Tc-99	0	0	0
Th-228	1.80×10^{-1}	9.07×10^{-2}	1.38×10^{-2}
Th-230	3.24×10^{-1}	1.49×10^{-1}	2.86×10^{-2}
Th-232	1.65×10^{-1}	8.33×10^{-2}	1.28×10^{-2}
U-234	6.70×10^{-1}	3.36×10^{-1}	4.65×10^{-2}
U-235/236	4.06×10^{-2}	2.04×10^{-2}	2.70×10^{-3}
U-238	8.61×10^{-1}	4.32×10^{-1}	5.91×10^{-2}

TABLE D.5.1-12

RADIONUCLIDE DEPOSITION RATES FROM THE INACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	3.16×10^{-2}	3.16×10^{-2}	3.28×10^{-3}
Ra-226	1.74×10^{-1}	1.74×10^{-1}	1.74×10^{-2}
Ra-228	1.17×10^{-1}	1.17×10^{-1}	1.14×10^{-2}
Tc-99	0	0	0
Th-228	1.15×10^{-1}	1.15×10^{-1}	1.06×10^{-2}
Th-230	3.41×10^{-1}	3.39×10^{-1}	3.57×10^{-2}
Th-232	1.01×10^{-1}	1.01×10^{-1}	9.34×10^{-3}
U-234	1.78×10^{-1}	1.72×10^{-1}	1.84×10^{-2}
U-235/236	1.29×10^{-2}	1.23×10^{-2}	1.33×10^{-3}
U-238	2.28×10^{-1}	2.13×10^{-1}	2.33×10^{-2}

TABLE D.5.1-13

RADIONUCLIDE DEPOSITION RATES FROM THE ACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Np-237	5.13×10^{-1}	3.88×10^{-1}	2.78×10^{-2}
Ra-226	2.54×10^{-1}	1.58×10^{-1}	1.27×10^{-2}
Ra-228	2.07×10^{-1}	1.30×10^{-1}	1.04×10^{-2}
Tc-99	0	0	0
Th-228	4.15×10^{-1}	2.62×10^{-1}	2.09×10^{-2}
Th-230	5.98×10^{-1}	3.72×10^{-1}	2.99×10^{-2}
Th-232	3.00×10^{-1}	1.91×10^{-1}	1.51×10^{-2}
U-234	2.61×10^{-1}	1.68×10^{-1}	1.32×10^{-2}
U-235/236	5.88×10^{-3}	3.40×10^{-3}	2.86×10^{-4}
U-238	2.54×10^{-1}	1.61×10^{-1}	1.28×10^{-2}

TABLE D.5.1-14

CHEMICAL CONCENTRATIONS IN AIR FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	0	0	0
Aroclor 1260	0	0	0
Arsenic	5.44×10^{-5}	2.44×10^{-5}	3.77×10^{-6}
Benzo(a)anthracene	0	0	0
Benzo(a)pyrene	0	0	0
Benzo(b)fluoranthene	0	0	0
Benzo(k)fluoranthene	0	0	0
Beryllium	4.38×10^{-6}	1.91×10^{-6}	2.02×10^{-7}
Chromium	1.21×10^{-4}	5.33×10^{-5}	6.60×10^{-6}
Chrysene	0	0	0
Dibenzo(a,h)anthracene	0	0	0
Dieldrin	0	0	0
Indeno(1,2,3-cd)pyrene	0	0	0
Uranium (Total)	1.13×10^{-4}	5.05×10^{-5}	7.32×10^{-6}

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TABLE D.5.1-15

CHEMICAL CONCENTRATIONS IN AIR FROM THE INACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	3.02×10^{-5}	3.02×10^{-5}	2.70×10^{-6}
Beryllium	5.87×10^{-6}	5.87×10^{-6}	5.15×10^{-7}
Dibenzo(a,h)anthracene	0	0	0
Uranium (Total)	2.88×10^{-5}	2.60×10^{-5}	2.51×10^{-6}

TABLE D.5.1-16

CHEMICAL CONCENTRATIONS IN AIR FROM THE ACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	1.47×10^{-4}	9.05×10^{-5}	6.78×10^{-6}
Beryllium	1.94×10^{-5}	1.29×10^{-5}	9.40×10^{-7}
Uranium (Total)	4.36×10^{-5}	2.67×10^{-5}	2.01×10^{-6}

TABLE D.5.1-17

CHEMICAL DEPOSITION RATES FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	0	0	0
Aroclor 1260	0	0	0
Arsenic	1.81×10^{0}	9.16×10^{-1}	1.60×10^{-1}
Benzo(a)anthracene	0	0	0
Benzo(a)pyrene	0	0	0
Benzo(b)fluoranthene	0	0	0
Benzo(k)fluoranthene	0	0	0
Beryllium	1.39×10^{-1}	6.98×10^{-2}	8.78×10^{-3}
Chromium	3.92×10^{0}	1.97×10^{0}	2.84×10^{-1}
Chrysene	0	0	0
Dibenzo(a,h)anthracene	0	0	0
Dieldrin	0	0	0
Indeno(1,2,3-cd)pyrene	0	0	0
Uranium (Total)	3.75×10^{0}	1.89×10^{0}	3.11×10^{-1}

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TABLE D.5.1-18

CHEMICAL DEPOSITION RATES FROM THE INACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	1.11×10^{0}	1.11×10^{0}	1.09×10^{-1}
Beryllium	2.16×10^{-1}	2.16×10^{-1}	2.08×10^{-2}
Dibenzo(a,h)anthracene	0	0	0
Uranium (Total)	9.71×10^{-1}	9.52×10^{-1}	1.01×10^{-1}

TABLE D.5.1-19

CHEMICAL DEPOSITION RATES FROM THE ACTIVE FLYASH PILE CONSOLIDATION/CONTAINMENT ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	5.32×10^{0}	3.56×10^{0}	2.71×10^{-1}
Beryllium	7.13×10^{-1}	5.12×10^{-1}	3.78×10^{-2}
Uranium (Total)	1.55×10^{0}	1.05×10^{0}	8.00×10^{-2}

TABLE D.5.1-20

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	4.21×10^{-4}	1.83×10^{-4}	1.94×10^{-5}
Ra-226	9.45×10^{-5}	4.21×10^{-5}	6.16×10^{-6}
Ra-228	8.67×10^{-5}	3.84×10^{-5}	5.23×10^{-6}
Rn-222	3.76×10^{0}	3.47×10^{0}	1.73×10^{-1}
Tc-99	0	0	0
Th-228	7.26×10^{-5}	3.21×10^{-5}	4.23×10^{-6}
Th-230	1.26×10^{-4}	5.17×10^{-5}	8.91×10^{-6}
Th-232	6.65×10^{-5}	2.94×10^{-5}	3.95×10^{-6}
U-234	2.74×10^{-4}	1.20×10^{-4}	1.42×10^{-5}
U-235/236	1.67×10^{-5}	7.28×10^{-6}	8.22×10^{-7}
U-238	3.52×10^{-4}	1.54×10^{-4}	1.80×10^{-5}

TABLE D.5.1-21

RADIONUCLIDE DEPOSITION RATES FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	1.34×10^{1}	6.71×10^{0}	8.43×10^{-1}
Ra-226	3.12×10^{0}	1.58×10^{0}	2.62×10^{-1}
Ra-228	2.84×10^{0}	1.43×10^{0}	2.23×10^{-1}
Tc-99	0	0	0
Th-228	2.37×10^{0}	1.19×10^{0}	1.81×10^{-1}
Th-230	4.26×10^{0}	1.96×10^{0}	3.76×10^{-1}
Th-232	2.17×10^{0}	1.09×10^{0}	1.69×10^{-1}
U-234	8.80×10^{0}	4.42×10^{0}	6.11×10^{-1}
U-235/236	5.33×10^{-1}	2.68×10^{-1}	3.55×10^{-2}
U-238	1.13×10^{1}	5.68×10^{0}	7.77×10^{-1}

TABLE D.5.1-22

CHEMICAL CONCENTRATIONS IN AIR FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	0	0	0
Aroclor 1260	0	0	0
Arsenic	7.15×10^{-4}	3.20×10^{-4}	4.95×10^{-5}
Benzo(a)anthracene	0	0	0
Benzo(a)pyrene	0	0	0
Benzo(b)fluoranthene	0	0	0
Benzo(k)fluoranthene	0	0	0
Beryllium	4.43×10^{-5}	1.93×10^{-5}	2.05×10^{-6}
Chromium	1.59×10^{-3}	7.00×10^{-4}	8.68×10^{-5}
Chrysene	0	0	0
Dibenzo(a,h)anthracene	0	0	0
Dieldrin	0	0	0
Indeno(1,2,3-cd)pyrene	0	0	0
Uranium (Total)	1.49×10^{-3}	6.64×10^{-4}	9.62×10^{-5}

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TABLE D.5.1-23

CHEMICAL DEPOSITION RATES FROM THE SOUTH FIELD CONSOLIDATION/CONTAINMENT ALTERNATIVES UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	0	0	0
Aroclor 1260	0	0	0
Arsenic	2.38×10^1	1.20×10^1	2.10×10^0
Benzo(a)anthracene	0	0	0
Benzo(a)pyrene	0	0	0
Benzo(b)fluoranthene	0	0	0
Benzo(k)fluoranthene	0	0	0
Beryllium	1.41×10^0	7.06×10^{-1}	8.88×10^{-2}
Chromium	5.15×10^1	2.59×10^1	3.73×10^0
Chrysene	0	0	0
Dibenzo(a,h)anthracene	0	0	0
Dieldrin	0	0	0
Indeno(1,2,3-cd)pyrene	0	0	0
Uranium (Total)	4.92×10^1	2.48×10^1	4.09×10^0

D.5.1.9.2 On-Property Disposal Cell Alternatives

The modeled maximum annual average radionuclide concentrations for all exposure scenarios, except for the on-property resident farmer, under the On-Property Disposal Cell alternatives are presented in Tables D.5.1-24 through D.5.1-26, and radionuclide deposition rates are presented in Tables D.5.1-27 through D.5.1-29. The maximum annual average chemical concentrations for all exposure scenarios, except the on-property farmer, are presented in Tables D.5.1-30 through D.5.1-32, and chemical deposition rates are presented in Tables D.5.1-33 through D.5.1-35.

The maximum annual average radionuclide and chemical concentrations for the on-property resident farmer scenario are presented in Tables D.5.1-36 and D.5.1-37, respectively. The maximum radionuclide and chemical deposition rates for the on-property farmer scenario are presented in Tables D.5.1-38 and D.5.1-39, respectively.

Gaseous radon-222 emissions resulted in the highest activity concentrations of any radionuclide analyzed by at least three orders of magnitude. The maximum on-subunit and off-property (fenceline) concentrations of radon-222 were modeled at 12.6 and 1.18 pCi/m^3, respectively, for the South Field. The location of the on-subunit maximum was 1,379,600 ft East and 478,000 ft North (1927 State Planar coordinates). The location of the off-property maximum was 1,383,274 ft East and 478,091 ft North.

The maximum value is over two orders of magnitude below the EPA action level of 4000 pCi/m^3 (4 pCi/l) for indoor radon concentrations. The maximum value is approximately two orders of magnitude below the annual average U.S. residential radon concentration of 1250 pCi/m^3 (Marcinowski and Napolitano 1993).

Modeled concentrations of uranium-238 typically represented one of the more prevalent radionuclides in the particulate phase. The maximum on-subunit and off-property concentrations of uranium-238 were modeled at 4.31 x 10^{-4} and 1.63 x 10^{-5} pCi/m^3, respectively, for the South Field. The location of the on-subunit maximum was 1,379,600 ft East and 478,000 ft North. The location of the off-property maximum was 1,378,210 ft East and 477,659 ft North.

TABLE D.5.1-24

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE SOUTH FIELD ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	5.11×10^{-6}	2.64×10^{-6}	1.84×10^{-7}
Np-237	2.95×10^{-5}	7.33×10^{-6}	1.38×10^{-6}
Ra-226	7.06×10^{-5}	3.67×10^{-5}	2.78×10^{-6}
Ra-228	1.69×10^{-5}	8.85×10^{-6}	8.13×10^{-7}
Rn-222	1.26×10^{1}	6.61×10^{0}	1.18×10^{0}
Tc-99	6.65×10^{-6}	3.43×10^{-6}	2.93×10^{-7}
Th-228	1.47×10^{-5}	7.70×10^{-6}	6.95×10^{-7}
Th-230	1.05×10^{-4}	5.47×10^{-5}	4.09×10^{-6}
Th-232	9.71×10^{-5}	5.03×10^{-5}	3.65×10^{-6}
U-234	5.86×10^{-4}	3.03×10^{-4}	2.17×10^{-5}
U-235/236	3.04×10^{-5}	1.57×10^{-5}	1.13×10^{-6}
U-238	4.31×10^{-4}	2.23×10^{-4}	1.53×10^{-5}

TABLE D.5.1-25

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE INACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	9.18×10^{-7}	8.60×10^{-7}	8.14×10^{-8}
Ra-226	4.74×10^{-6}	4.74×10^{-6}	4.32×10^{-7}
Ra-228	3.18×10^{-6}	3.18×10^{-6}	2.82×10^{-7}
Rn-222	2.39×10^{0}	3.36×10^{0}	1.23×10^{0}
Tc-99	0	0	0
Th-228	3.12×10^{-6}	3.12×10^{-6}	2.63×10^{-7}
Th-230	1.01×10^{-5}	9.24×10^{-6}	8.87×10^{-7}
Th-232	2.74×10^{-6}	2.74×10^{-6}	2.31×10^{-7}
U-234	5.28×10^{-6}	4.70×10^{-6}	4.58×10^{-7}
U-235/236	3.83×10^{-7}	3.35×10^{-7}	3.30×10^{-8}
U-238	6.79×10^{-6}	5.82×10^{-6}	5.80×10^{-7}

000951

TABLE D.5.1-26

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE ACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Np-237	1.36×10^{-5}	9.77×10^{-6}	7.02×10^{-7}
Ra-226	8.82×10^{-6}	4.82×10^{-6}	4.11×10^{-7}
Ra-228	7.08×10^{-6}	3.93×10^{-6}	3.33×10^{-7}
Rn-222	3.52×10^{0}	1.96×10^{0}	4.09×10^{-1}
Tc-99	0	0	0
Th-228	1.41×10^{-5}	7.87×10^{-6}	6.64×10^{-7}
Th-230	2.07×10^{-5}	1.13×10^{-5}	9.67×10^{-7}
Th-232	1.01×10^{-5}	5.69×10^{-6}	4.77×10^{-7}
U-234	8.67×10^{-6}	4.96×10^{-6}	4.12×10^{-7}
U-235/236	2.43×10^{-7}	1.11×10^{-7}	9.97×10^{-9}
U-238	8.58×10^{-6}	4.82×10^{-6}	4.05×10^{-7}

000952

TABLE D.5.1-27

RADIONUCLIDE DEPOSITION RATES FROM THE SOUTH FIELD ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	1.64×10^{-1}	9.74×10^{-2}	7.66×10^{-3}
Np-237	9.41×10^{-1}	2.82×10^{-1}	5.98×10^{-2}
Ra-226	2.28×10^{0}	1.36×10^{0}	1.16×10^{-1}
Ra-228	5.61×10^{-1}	3.31×10^{-1}	3.50×10^{-2}
Tc-99	2.14×10^{-1}	1.27×10^{-1}	9.97×10^{-3}
Th-228	4.87×10^{-1}	2.87×10^{-1}	2.96×10^{-2}
Th-230	3.39×10^{0}	2.02×10^{0}	1.70×10^{-1}
Th-232	3.13×10^{0}	1.86×10^{0}	1.52×10^{-1}
U-234	1.89×10^{1}	1.12×10^{1}	9.03×10^{-1}
U-235/236	9.78×10^{-1}	5.80×10^{-1}	4.70×10^{-2}
U-238	1.39×10^{1}	8.24×10^{0}	6.77×10^{-1}

TABLE D.5.1-28

RADIONUCLIDE DEPOSITION RATES FROM THE INACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	0	0	0
Np-237	3.16×10^{-2}	3.16×10^{-2}	3.28×10^{-3}
Ra-226	1.74×10^{-1}	1.74×10^{-1}	1.74×10^{-2}
Ra-228	1.17×10^{-1}	1.17×10^{-1}	1.14×10^{-2}
Tc-99	0	0	0
Th-228	1.15×10^{-1}	1.15×10^{-1}	1.06×10^{-2}
Th-230	3.41×10^{-1}	3.39×10^{-1}	3.57×10^{-2}
Th-232	1.01×10^{-1}	1.01×10^{-1}	9.34×10^{-3}
U-234	1.78×10^{-1}	1.72×10^{-1}	1.84×10^{-2}
U-235/236	1.29×10^{-2}	1.23×10^{-2}	1.33×10^{-3}
U-238	2.28×10^{-1}	2.13×10^{-1}	2.33×10^{-2}

TABLE D.5.1-29

RADIONUCLIDE DEPOSITION RATES FROM THE ACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Np-237	5.21×10^{-1}	3.93×10^{-1}	2.84×10^{-2}
Ra-226	3.19×10^{-1}	1.86×10^{-1}	1.62×10^{-2}
Ra-228	2.55×10^{-1}	1.52×10^{-1}	1.31×10^{-2}
Tc-99	0	0	0
Th-228	4.99×10^{-1}	3.04×10^{-1}	2.62×10^{-2}
Th-230	7.47×10^{-1}	4.37×10^{-1}	3.80×10^{-2}
Th-232	3.51×10^{-1}	2.20×10^{-1}	1.88×10^{-2}
U-234	3.01×10^{-1}	1.92×10^{-1}	1.63×10^{-2}
U-235/236	8.69×10^{-3}	4.23×10^{-3}	3.89×10^{-4}
U-238	3.03×10^{-1}	1.86×10^{-1}	1.60×10^{-2}

TABLE D.5.1-30

CHEMICAL CONCENTRATIONS IN AIR FROM THE SOUTH FIELD ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	2.59×10^{-7}	1.33×10^{-7}	9.29×10^{-9}
Aroclor 1260	2.59×10^{-7}	1.33×10^{-7}	9.29×10^{-9}
Arsenic	8.14×10^{-5}	3.90×10^{-5}	5.26×10^{-6}
Benzo(a)anthracene	8.13×10^{-6}	4.20×10^{-6}	2.92×10^{-7}
Benzo(a)pyrene	1.33×10^{-5}	6.86×10^{-6}	4.78×10^{-7}
Benzo(b)fluoranthene	1.18×10^{-5}	6.10×10^{-6}	4.25×10^{-7}
Benzo(k)fluoranthene	1.18×10^{-5}	6.10×10^{-6}	4.25×10^{-7}
Beryllium	8.23×10^{-6}	4.28×10^{-6}	4.11×10^{-7}
Chromium	1.91×10^{-4}	9.49×10^{-5}	1.05×10^{-5}
Chrysene	1.03×10^{-5}	5.34×10^{-6}	3.72×10^{-7}
Dibenzo(a,h)anthracene	3.25×10^{-6}	1.68×10^{-6}	1.17×10^{-7}
Dieldrin	7.17×10^{-8}	3.70×10^{-8}	2.58×10^{-9}
Indeno(1,2,3-cd)pyrene	4.58×10^{-6}	2.36×10^{-6}	1.65×10^{-7}
Uranium (Total)	2.23×10^{-3}	1.16×10^{-3}	8.40×10^{-5}

TABLE D.5.1-31

CHEMICAL CONCENTRATIONS IN AIR FROM THE INACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	3.02×10^{-5}	3.02×10^{-5}	2.70×10^{-6}
Beryllium	5.87×10^{-6}	5.87×10^{-6}	5.15×10^{-7}
Dibenzo(a,h)anthracene	0	0	0
Uranium (Total)	2.88×10^{-5}	2.60×10^{-5}	2.51×10^{-6}

TABLE D.5.1-32

CHEMICAL CONCENTRATIONS IN AIR FROM THE ACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	1.62×10^{-4}	6.77×10^{-5}	7.88×10^{-6}
Beryllium	2.05×10^{-5}	6.51×10^{-6}	1.03×10^{-6}
Uranium (Total)	4.82×10^{-5}	2.05×10^{-5}	2.34×10^{-6}

000957

TABLE D.5.1-33

CHEMICAL DEPOSITION RATES FROM THE SOUTH FIELD ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	8.31×10^{-3}	4.92×10^{-3}	3.88×10^{-4}
Aroclor 1260	8.31×10^{-3}	4.92×10^{-3}	3.88×10^{-4}
Arsenic	2.71×10^{0}	1.47×10^{0}	2.25×10^{-1}
Benzo(a)anthracene	2.61×10^{-1}	1.55×10^{-1}	1.22×10^{-2}
Benzo(a)pyrene	4.27×10^{-1}	2.53×10^{-1}	1.99×10^{-2}
Benzo(b)fluoranthene	3.80×10^{-1}	2.25×10^{-1}	1.77×10^{-2}
Benzo(k)fluoranthene	3.80×10^{-1}	2.25×10^{-1}	1.77×10^{-2}
Beryllium	2.75×10^{-1}	1.60×10^{-1}	1.70×10^{-2}
Chromium	6.24×10^{0}	3.56×10^{0}	4.51×10^{-1}
Chrysene	3.32×10^{-1}	1.97×10^{-1}	1.55×10^{-2}
Dibenzo(a,h)anthracene	1.04×10^{-1}	6.19×10^{-2}	4.87×10^{-3}
Dieldrin	2.30×10^{-3}	1.36×10^{-3}	1.07×10^{-4}
Indeno(1,2,3-cd)pyrene	1.47×10^{-1}	8.72×10^{-2}	6.87×10^{-3}
Uranium (Total)	7.20×10^{1}	4.28×10^{1}	3.50×10^{0}

000958

TABLE D.5.1-34

CHEMICAL DEPOSITION RATES FROM THE INACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	1.11×10^{0}	1.11×10^{0}	1.09×10^{-1}
Beryllium	2.16×10^{-1}	2.16×10^{-1}	2.08×10^{-2}
Dibenzo(a,h)anthracene	0	0	0
Uranium (Total)	9.71×10^{-1}	9.52×10^{-1}	1.01×10^{-1}

TABLE D.5.1-35

CHEMICAL DEPOSITION RATES FROM THE ACTIVE FLYASH PILE ON-PROPERTY DISPOSAL CELL ALTERNATIVES LIMITED EROSION WITH 85% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Arsenic	5.78×10^{0}	3.90×10^{0}	3.13×10^{-1}
Beryllium	7.56×10^{-1}	5.39×10^{-1}	4.11×10^{-2}
Uranium (Total)	1.72×10^{0}	1.15×10^{0}	9.30×10^{-2}

TABLE D.5.1-36

RADIONUCLIDE CONCENTRATIONS IN AIR FROM THE SOUTH FIELD
ON-PROPERTY DISPOSAL CELL ALTERNATIVES
UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Radionuclide (pCi/m^3)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	6.72×10^{-5}	3.47×10^{-5}	2.41×10^{-6}
Np-237	4.40×10^{-4}	1.07×10^{-4}	2.05×10^{-5}
Ra-226	9.28×10^{-4}	4.83×10^{-4}	3.65×10^{-5}
Ra-228	2.21×10^{-4}	1.16×10^{-4}	1.07×10^{-5}
Rn-222	3.76×10^{0}	3.47×10^{0}	1.73×10^{-1}
Tc-99	8.74×10^{-5}	4.51×10^{-5}	3.15×10^{-6}
Th-228	1.96×10^{-4}	1.03×10^{-4}	9.27×10^{-6}
Th-230	1.38×10^{-3}	7.18×10^{-4}	5.38×10^{-5}
Th-232	1.28×10^{-3}	6.61×10^{-4}	4.79×10^{-5}
U-234	7.70×10^{-3}	3.98×10^{-3}	2.85×10^{-4}
U-235/236	3.99×10^{-4}	2.07×10^{-4}	1.48×10^{-5}
U-238	5.85×10^{-3}	3.03×10^{-3}	2.21×10^{-4}

TABLE D.5.1-37

RADIONUCLIDE DEPOSITION RATES FROM THE SOUTH FIELD ON-PROPERTY DISPOSAL CELL ALTERNATIVES UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Radionuclide ($pCi/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Cs-137	2.16×10^0	1.28×10^0	1.01×10^{-1}
Np-237	1.40×10^1	4.13×10^0	8.88×10^{-1}
Ra-226	3.00×10^1	1.79×10^1	1.52×10^0
Ra-228	7.34×10^0	4.33×10^0	4.59×10^{-1}
Tc-99	2.81×10^0	1.66×10^0	1.31×10^{-1}
Th-228	6.52×10^0	3.85×10^0	3.94×10^{-1}
Th-230	4.46×10^1	2.66×10^1	2.24×10^0
Th-232	4.11×10^1	2.44×10^1	2.00×10^0
U-234	2.48×10^2	1.47×10^2	1.19×10^1
U-235/236	1.28×10^1	7.63×10^0	6.18×10^{-1}
U-238	1.89×10^2	1.12×10^2	9.19×10^0

TABLE D.5.1-38

CHEMICAL CONCENTRATIONS IN AIR FROM THE SOUTH FIELD ON-PROPERTY DISPOSAL CELL ALTERNATIVES UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Chemical ($\mu g/m^3$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	5.06×10^{-6}	2.63×10^{-6}	2.59×10^{-7}
Aroclor 1260	3.69×10^{-6}	1.90×10^{-6}	1.33×10^{-7}
Arsenic	1.07×10^{-3}	5.12×10^{-4}	6.91×10^{-5}
Benzo(a)anthracene	1.07×10^{-4}	5.51×10^{-5}	3.84×10^{-6}
Benzo(a)pyrene	6.09×10^{-4}	1.99×10^{-4}	2.89×10^{-5}
Benzo(b)fluoranthene	1.55×10^{-4}	8.02×10^{-5}	5.58×10^{-6}
Benzo(k)fluoranthene	1.55×10^{-4}	8.02×10^{-5}	5.58×10^{-6}
Beryllium	7.59×10^{-5}	3.94×10^{-5}	3.89×10^{-6}
Chromium	2.51×10^{-3}	1.25×10^{-3}	1.37×10^{-4}
Chrysene	1.36×10^{-4}	7.02×10^{-5}	4.88×10^{-6}
Dibenzo(a,h)anthracene	4.27×10^{-5}	2.21×10^{-5}	1.53×10^{-6}
Dieldrin	9.42×10^{-7}	4.86×10^{-7}	3.38×10^{-8}
Indeno(1,2,3-cd)pyrene	6.02×10^{-5}	3.11×10^{-5}	2.16×10^{-6}
Uranium (Total)	2.94×10^{-2}	1.52×10^{-2}	1.10×10^{-3}

TABLE D.5.1-39

CHEMICAL DEPOSITION RATES FROM THE SOUTH FIELD ON-PROPERTY DISPOSAL CELL ALTERNATIVES UNLIMITED EROSION WITH 50% VEGETATIVE COVER

Chemical ($\mu g/m^2/yr$)	Maximum On-Subunit	Maximum On-Property	Maximum Off-Property
Aroclor 1254	1.70×10^{-1}	9.82×10^{-2}	1.08×10^{-2}
Aroclor 1260	1.19×10^{-1}	7.03×10^{-2}	5.53×10^{-3}
Arsenic	3.56×10^{1}	1.94×10^{1}	2.95×10^{0}
Benzo(a)anthracene	3.43×10^{0}	2.03×10^{0}	1.60×10^{-1}
Benzo(a)pyrene	1.95×10^{1}	7.57×10^{0}	1.26×10^{0}
Benzo(b)fluoranthene	4.99×10^{0}	2.96×10^{0}	2.33×10^{-1}
Benzo(k)fluoranthene	4.99×10^{0}	2.96×10^{0}	2.33×10^{-1}
Beryllium	2.54×10^{0}	1.47×10^{0}	1.62×10^{-1}
Chromium	8.19×10^{1}	4.68×10^{1}	5.93×10^{0}
Chrysene	4.37×10^{0}	2.59×10^{0}	2.04×10^{-1}
Dibenzo(a,h)anthracene	1.37×10^{0}	8.14×10^{-1}	6.40×10^{-2}
Dieldrin	3.03×10^{-2}	1.79×10^{-2}	1.41×10^{-3}
Indeno(1,2,3-cd)pyrene	1.93×10^{0}	1.15×10^{0}	9.02×10^{-2}
Uranium (Total)	9.46×10^{2}	5.62×10^{2}	4.60×10^{1}

ATTACHMENT D.5.1-I

RAECOM MODEL OUTPUT

OU2 RESIDUAL EMISSIONS: AFP, EXPOSED GMA

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.2624	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.3682E-01	.6750	.3000E-06	22.40

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.2624E+00	.0000E+00	.7845

000965

OU2 RESIDUAL EMISSIONS: AFP, EXPOSED TILL

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.4977	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.2180E-01	.6140	.8000E-06	26.00

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.4977E+00	.0000E+00	.6734

000966

OU2 RESIDUAL EMISSIONS: AFP, CLAY CAP

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	3	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	1.928	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.2180E-01	.6140	.3100E-05	26.00
2	30.	.2180E-01	.6140	.0000E+00	26.00
3	60.	.6747E-02	.4130	.0000E+00	15.80

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.7321E+00	.9158E+04	.6734
2	30.	.4046E+00	.7893E+04	.6734
3	60.	.2506E+00	.0000E+00	.5513

000967

OU2 RESIDUAL EMISSIONS: IFP, EXPOSED GMA

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.5047	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.2276E-01	.5420	.9000E-06	16.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.5047E+00	.0000E+00	.7147

000968

OU2 RESIDUAL EMISSIONS: IFP, EXPOSED TILL

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.4339	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.3350E-01	.6990	.5000E-06	30.10

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.4339E+00	.0000E+00	.7410

000969

OU2 RESIDUAL EMISSIONS: IFP, CLAY CAP

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	3	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	16.83	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.3350E-01	.6990	.1940E-04	30.10
2	30.	.3350E-01	.6990	.0000E+00	30.10
3	60.	.6747E-02	.4130	.0000E+00	15.80

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.5348E+01	.6303E+05	.7410
2	30.	.2697E+01	.5790E+05	.7410
3	60.	.1671E+01	.0000E+00	.5513

OU2 RESIDUAL EMISSIONS: SF, EXPOSED GMA

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	.1030	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.6550E-03	.3240	.1800E-05	14.90

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.1030E+00	.0000E+00	.3789

000571

OU2 RESIDUAL EMISSIONS: SF, EXPOSED TILL

********** INPUT PARAMETERS **********

NUMBER OF LAYERS: 1
RADON FLUX INTO LAYER 1: .000 pCi/m2/sec
SURFACE RADON CONCENTRATION: .000 pCi/LITER

LAYER 1 EXCEEDS SATURATION. MOISTURE CHANGED FROM .216 TO .186

BARE SOURCE FLUX (Jo) FROM LAYER 1: .4269E-01pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.4650E-04	.3360	.2700E-05	18.55

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.4269E-01	.0000E+00	.2674

OU2 RESIDUAL EMISSIONS: SF, EXPOSED FILL

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	1	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	1.855	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.1662E-02	.4310	.1530E-04	22.00

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.1855E+01	.0000E+00	.4197

000973

OU2 RESIDUAL EMISSIONS: SF, CLAY CAP

********** INPUT PARAMETERS **********

NUMBER OF LAYERS:	3	
RADON FLUX INTO LAYER 1:	.000	pCi/m2/sec
SURFACE RADON CONCENTRATION:	.000	pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:	4.353	pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.1662E-02	.4310	.3590E-04	22.00
2	30.	.1662E-02	.4310	.0000E+00	22.00
3	60.	.6747E-02	.4130	.0000E+00	15.80

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.2312E+01	.8013E+05	.4197
2	30.	.1144E+01	.1391E+05	.4197
3	60.	.7087E+00	.0000E+00	.5513

000974

OU2 RESIDUAL EMISSIONS: SWL, IN SITU CONTAINMENT

********** INPUT PARAMETERS **********

NUMBER OF LAYERS: 3
RADON FLUX INTO LAYER 1: .000 pCi/m2/sec
SURFACE RADON CONCENTRATION: .000 pCi/LITER

LAYER 1 EXCEEDS SATURATION. MOISTURE CHANGED FROM .160 TO .143

LAYER 2 EXCEEDS SATURATION. MOISTURE CHANGED FROM .160 TO .143

BARE SOURCE FLUX (Jo) FROM LAYER 1: .8737E-01pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.4056E-04	.2800	.7100E-05	14.26
2	30.	.4056E-04	.2800	.0000E+00	14.26
3	60.	.6747E-02	.4130	.0000E+00	15.80

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.4368E-01	.1690E+05	.2674
2	30.	.9291E-04	.7197E+00	.2674
3	60.	.5754E-04	.0000E+00	.5513

000975

OU2 RESIDUAL EMISSIONS: LSP, IN SITU CONTAINMENT

********** INPUT PARAMETERS **********

NUMBER OF LAYERS: 3
RADON FLUX INTO LAYER 1: .000 pCi/m2/sec
SURFACE RADON CONCENTRATION: .000 pCi/LITER

LAYER 1 EXCEEDS SATURATION. MOISTURE CHANGED FROM .312 TO .220

LAYER 2 EXCEEDS SATURATION. MOISTURE CHANGED FROM .312 TO .220

BARE SOURCE FLUX (Jo) FROM LAYER 1: .1230 pCi/m2/sec

LAYER	THICKNESS (cm)	DIFF COEFF (cm2/SEC)	POROSITY	SOURCE (pCi/cm3/sec)	MOISTURE (dry wt. %)
1	300.	.5189E-04	.3750	.6600E-05	22.00
2	30.	.5189E-04	.3750	.0000E+00	22.00
3	60.	.6747E-02	.4130	.0000E+00	15.80

***** RESULTS OF RADON DIFFUSION CALCULATION*****

LAYER	THICKNESS (cm)	EXIT FLUX (pCi/m2/sec)	EXIT CONC. (pCi/liter)	MIC
1	300.	.6151E-01	.1571E+05	.2674
2	30.	.2858E-03	.2214E+01	.2674
3	60.	.1770E-03	.0000E+00	.5513

ATTACHMENT D.5.1-II

FIVE-YEAR COMPOSITE JOINT FREQUENCY DISTRIBUTION FOR THE FEMP

JOINT FREQUENCY DISTRIBUTION

August 30, 1993

Stability Class	Wind Direction	Wind Speed (kts) ≤3	≤6	≤10	≤16	≤21	≥21
A	N	0.000263	0.000904	0.000904	0.000058	0.000000	0.000000
	NNE	0.000292	0.001546	0.000671	0.000000	0.000000	0.000000
	NE	0.000817	0.002888	0.001196	0.000029	0.000000	0.000000
	ENE	0.001430	0.004434	0.002042	0.000117	0.000000	0.000000
	E	0.001050	0.002013	0.000204	0.000146	0.000000	0.000000
	ESE	0.000700	0.000817	0.000058	0.000000	0.000000	0.000000
	SE	0.000467	0.000438	0.000000	0.000000	0.000000	0.000000
	SSE	0.000583	0.000554	0.000000	0.000000	0.000000	0.000000
	S	0.000700	0.001575	0.001196	0.000000	0.000000	0.000000
	SSW	0.001021	0.004347	0.003793	0.000146	0.000000	0.000000
	SW	0.001284	0.005076	0.004755	0.000554	0.000000	0.000000
	WSW	0.001750	0.004755	0.003647	0.000204	0.000000	0.000000
	W	0.000992	0.003880	0.003267	0.000467	0.000000	0.000000
	WNW	0.000613	0.001809	0.002626	0.000525	0.000000	0.000000
	NW	0.000583	0.001575	0.001400	0.000117	0.000000	0.000000
	NNW	0.000350	0.001313	0.001284	0.000058	0.000000	0.000000
B	N	0.000029	0.000817	0.000700	0.000117	0.000000	0.000000
	NNE	0.000117	0.000525	0.000496	0.000058	0.000000	0.000000
	NE	0.000350	0.000963	0.000613	0.000058	0.000000	0.000000
	ENE	0.000321	0.001459	0.000554	0.000146	0.000000	0.000000
	E	0.000467	0.000671	0.000175	0.000029	0.000000	0.000000
	ESE	0.000263	0.000263	0.000029	0.000000	0.000000	0.000000
	SE	0.000233	0.000204	0.000029	0.000000	0.000000	0.000000
	SSE	0.000263	0.000467	0.000088	0.000029	0.000000	0.000000
	S	0.000408	0.001138	0.000321	0.000000	0.000000	0.000000
	SSW	0.000525	0.001546	0.001313	0.000175	0.000000	0.000000
	SW	0.000613	0.002042	0.002071	0.000233	0.000000	0.000000
	WSW	0.000613	0.001692	0.001284	0.000175	0.000000	0.000000
	W	0.000671	0.001167	0.001225	0.000146	0.000000	0.000000
	WNW	0.000233	0.000788	0.000875	0.000204	0.000000	0.000000
	NW	0.000263	0.000671	0.001021	0.000204	0.000000	0.000000
	NNW	0.000146	0.000642	0.000904	0.000088	0.000000	0.000000
C	N	0.000204	0.000846	0.001079	0.000233	0.000000	0.000000
	NNE	0.000175	0.001313	0.000729	0.000058	0.000000	0.000000
	NE	0.000408	0.001488	0.001021	0.000088	0.000000	0.000000
	ENE	0.000700	0.001721	0.000438	0.000263	0.000000	0.000000
	E	0.001050	0.000875	0.000204	0.000058	0.000000	0.000000
	ESE	0.000671	0.000583	0.000058	0.000000	0.000000	0.000000
	SE	0.000321	0.000467	0.000088	0.000000	0.000000	0.000000
	SSE	0.000146	0.000467	0.000058	0.000058	0.000000	0.000000
	S	0.000321	0.001167	0.000554	0.000058	0.000000	0.000000
	SSW	0.000554	0.001750	0.001575	0.000058	0.000029	0.000000
	SW	0.000904	0.002742	0.001750	0.000175	0.000000	0.000000
	WSW	0.000759	0.002421	0.001254	0.000204	0.000000	0.000000
	W	0.000788	0.001284	0.001138	0.000321	0.000000	0.000000
	WNW	0.000321	0.001342	0.001254	0.000204	0.000000	0.000000
	NW	0.000233	0.001342	0.001138	0.000117	0.000029	0.000000
	NNW	0.000233	0.001079	0.000963	0.000029	0.000000	0.000000

JOINT FREQUENCY DISTRIBUTION

August 30, 1993

Stability Class	Wind Direction	Wind Speed (kts) ≤3	≤6	≤10	≤16	≤21	≥21
D	N	0.002101	0.008723	0.009219	0.001079	0.000000	0.000000
	NNE	0.002830	0.010532	0.008256	0.001138	0.000000	0.000000
	NE	0.004464	0.013420	0.007498	0.000496	0.000000	0.000000
	ENE	0.006331	0.017825	0.009161	0.002042	0.000000	0.000000
	E	0.004493	0.006127	0.001079	0.000088	0.000000	0.000000
	ESE	0.003238	0.002976	0.000117	0.000000	0.000000	0.000000
	SE	0.002626	0.002626	0.000350	0.000000	0.000000	0.000000
	SSE	0.002801	0.003618	0.001109	0.000204	0.000000	0.000000
	S	0.003063	0.006593	0.002888	0.000321	0.000000	0.000000
	SSW	0.005806	0.014091	0.007439	0.001809	0.000000	0.000000
	SW	0.007848	0.014470	0.008023	0.001050	0.000058	0.000000
	WSW	0.008373	0.011203	0.006272	0.001167	0.000000	0.000000
	W	0.007060	0.011553	0.009482	0.001430	0.000000	0.000000
	WNW	0.004785	0.010415	0.010619	0.001546	0.000000	0.000000
	NW	0.003734	0.009044	0.007264	0.000963	0.000088	0.000000
	NNW	0.002976	0.008840	0.005631	0.001050	0.000058	0.000000
E	N	0.003618	0.003880	0.000759	0.000029	0.000000	0.000000
	NNE	0.002596	0.003092	0.000788	0.000175	0.000000	0.000000
	NE	0.002976	0.003472	0.000438	0.000000	0.000000	0.000000
	ENE	0.008694	0.009219	0.001809	0.000000	0.000000	0.000000
	E	0.008198	0.002742	0.000233	0.000000	0.000000	0.000000
	ESE	0.004785	0.001254	0.000146	0.000000	0.000000	0.000000
	SE	0.004843	0.001721	0.000292	0.000000	0.000000	0.000000
	SSE	0.005572	0.003413	0.001284	0.000204	0.000000	0.000000
	S	0.006973	0.007673	0.003355	0.000642	0.000000	0.000000
	SSW	0.011582	0.014033	0.006798	0.001692	0.000000	0.000000
	SW	0.018496	0.018263	0.007410	0.000671	0.000000	0.000000
	WSW	0.017796	0.010328	0.003297	0.000642	0.000000	0.000000
	W	0.012486	0.010007	0.004143	0.000146	0.000000	0.000000
	WNW	0.009482	0.007614	0.003297	0.000583	0.000000	0.000000
	NW	0.008344	0.004668	0.001109	0.000175	0.000000	0.000000
	NNW	0.006214	0.003822	0.001079	0.000263	0.000000	0.000000
F	N	0.004988	0.000117	0.000000	0.000000	0.000000	0.000000
	NNE	0.005251	0.000088	0.000029	0.000000	0.000000	0.000000
	NE	0.005076	0.000117	0.000000	0.000000	0.000000	0.000000
	ENE	0.009102	0.001605	0.000117	0.000000	0.000000	0.000000
	E	0.013361	0.000904	0.000000	0.000000	0.000000	0.000000
	ESE	0.008927	0.000058	0.000000	0.000000	0.000000	0.000000
	SE	0.005922	0.000321	0.000000	0.000000	0.000000	0.000000
	SSE	0.005456	0.000175	0.000000	0.000000	0.000000	0.000000
	S	0.007002	0.000467	0.000000	0.000000	0.000000	0.000000
	SSW	0.011815	0.001196	0.000263	0.000000	0.000000	0.000000
	SW	0.019576	0.002101	0.000029	0.000000	0.000000	0.000000
	WSW	0.026811	0.001867	0.000058	0.000000	0.000000	0.000000
	W	0.029757	0.000671	0.000029	0.000000	0.000000	0.000000
	WNW	0.029319	0.000233	0.000029	0.000000	0.000000	0.000000
	NW	0.022785	0.000758	0.000058	0.000000	0.000000	0.000000
	NNW	0.011523	0.000876	0.000058	0.000000	0.000000	0.000000

D.5.2 SHORT-TERM AIR TRANSPORT MODELING FOR REMEDIAL EXCAVATION

This section presents the approach, methodology, and results of the short-term air transport analysis of the Operable Unit 2 preferred remedial alternatives. The objective of this analysis was to determine the maximum occupational air concentrations of contaminants released to the atmosphere during excavation of the Operable Unit 2 subunits. These concentrations were used for the occupational exposure risk assessment described in this FS.

This analysis was conducted in accordance with Section 6.3.1.1 of the FEMP Risk Assessment Work Plan Addendum (RAWPA) (DOE 1992). The methodology uses a dust loading factor and contaminant concentrations in exposed soil to estimate airborne contaminant concentrations. The model uses the following equations to calculate air concentrations (DOE 1992):

(radionuclides) $C_a = (D_l)(C_s)$ (1)

(chemicals) $C_a = (D_l)(C_s)(CF)$ (2)

where

C_a = Contaminant concentration in air (pCi/m^3); (mg/m^3)
D_l = Dust loading factor (g of soil/m^3 of air)
C_s = Contaminant concentrations in soil (pCi/g); (μg/g)
CF = Conversion factor (10^{-3} mg/μg)

The default dust loading factors presented in RAWPA for various activities are (DOE 1992):

Construction work = 6×10^{-4} g/m^3
Construction traffic = 4×10^{-4} g/m^3
Farming = 2×10^{-4} g/m^3
Other activities = 1×10^{-4} g/m^3

To generate worst case 8-hour average occupational exposure point concentrations, the dust loading factor for construction work was used for all calculations.

The exposure point concentrations in air were calculated separately for surface and subsurface soil concentrations. The surface and subsurface soil concentrations used in the analysis are presented in Tables D.5.2-1 and D.5.2-2, respectively. The calculated air concentrations for exposure to surface and subsurface soil are presented in Tables D.5.2-3 and D.5.2-4.

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TABLE D.5.2-1

CONTAMINANT SOURCE TERM CONCENTRATIONS IN SURFACE SOIL[a]

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Radionuclides (pCi/g)					
Cs-137	0.257	0.702	NC	0.462	0.499
Np-237	1.189	0.72	5.500	0.797	0.228
Pu-238	0.772	0.576	0.700	0.081	0.120
Pu-239	0.082	0.135	0.300	0.021	0.051
Pu-240	0.082	0.135	0.300	0.021	0.051
Ra-226	1.397	1.919	4.600	1.975	30.800
Ra-228	1.681	1.639	3.200	2.242	3.880
Sr-90	0.955	0.785	4.500	0.870	1.000
Tc-99	NC	NC	NC	NC	142.000
Th-228	1.626	2.910	3.800	2.710	4.410
Th-230	6.476	44.800	3.700	2.770	13.800
Th-232	1.511	1.306	2.700	2.330	3.990
U-234	42.120	21.003	3.600	8.649	8.658
U-235	2.838	1.743	0.200	0.420	0.419
U-236	2.838	1.743	0.200	0.420	0.419
U-238	77.150	71.388	3.600	8.867	9.311

See footnotes at end of table.

TABLE D.5.2-1 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Inorganics (mg/kg)					
Antimony	NC	NC	2.100	NC	1.900
Arsenic	6.668	7.190	89.800	33.200	7.268
Barium	91.280	93.709	253.900	85.670	90.770
Beryllium	0.698	1.518	4.700	2.273	0.942
Cadmium	0.850	1.200	NC	3.100	NC
Chromium	15.460	16.579	13.300	11.360	13.900
Cobalt	7.714	9.707	18.800	7.889	13.900
Copper	29.750	36.000	73.800	33.950	16.620
Cyanide	NC	0.820	0.300	0.700	0.320
Lead	19.010	27.563	55.400	23.930	24.580
Manganese	623.400	1210.000	463.000	656.000	2650.000
Mercury	NC	0.270	NC	NC	NC
Molybdenum	5.818	1.600	8.600	7.200	6.200
Nickel	17.620	22.100	40.100	17.330	17.100
Selenium	0.420	0.370	5.900	8.200	0.720
Silver	5.993	NC	NC	4.386	5.384
Thallium	NC	NC	2.700	NC	NC
Thorium (Total)	13.780	25.100	22.000	21.400	36.700
Uranium (Total)	225.200	214.320	12.600	26.200	29.580
Vanadium	33.600	26.250	50.200	25.570	26.590
Zinc	61.340	62.195	78.300	47.820	52.730

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See footnotes at end of table.

TABLE D.5.2-1 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Organics, Pesticides and PCBs (mg/kg)					
2-Methylnaphthalene	NC	NC	NC	0.160	NC
4,4-DDE	0.012	NC	NC	NC	NC
Acenaphthylene	NC	NC	NC	1.800	1.200
Aroclor-1254	NC	0.590	NC	NC	0.089
Aroclor-1260	NC	NC	NC	NC	0.052
Benzo(a)anthracene	0.366	0.910	NC	NC	5.500
Benzo(a)pyrene	0.340	1.100	NC	NC	9.400
Benzo(b)fluoranthene	0.710	1.000	NC	NC	6.200
Benzo(g,h,i)perylene	0.500	0.630	NC	NC	6.200
Benzo(k)fluoranthene	0.385	0.800	NC	NC	7.300
Bis(2-ethylhexyl)phthalate	0.048	10.000	NC	NC	0.110
Carbazole	0.077	0.140	NC	0.510	0.170
Chrysene	0.453	1.100	NC	NC	6.000
Dieldrin	NC	NC	NC	NC	0.010
Di-n-octyl phthalate	NC	0.087	NC	NC	NC
Dibenzo(a,h)anthracene	0.200	0.320	NC	2.200	1.900
Dibenzofuran	0.056	0.042	NC	0.250	0.130
Endrin ketone	NC	NC	NC	NC	0.006
Indeno(1,2,3-cd)pyrene	0.480	0.720	NC	NC	6.000
Methylene chloride	NC	NC	NC	NC	0.005
Phenanthrene	0.531	1.600	NC	NC	2.300

NC = Not characterized.

[a]From OU2 RI Report (DOE 1994).

TABLE D.5.2-2

CONTAMINANT SOURCE TERM CONCENTRATIONS IN SUBSURFACE SOIL[a]

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Radionuclides (pCi/g)					
Cs-137	0.250	0.165	NC	0.240	0.240
Np-237	0.357	0.338	0.450	0.489	0.489
Pb-210	1.030	NC	1.630	6.014	6.014
Pu-238	0.328	0.209	0.123	0.270	0.270
Pu-239	0.680	0.084	0.110	0.130	0.130
Pu-240	0.680	0.084	0.110	0.130	0.130
Ra-224	2.140	NC	3.740	3.133	3.133
Ra-226	1.550	1.422	5.240	2.919	2.919
Ra-228	2.560	1.470	4.336	1.656	1.656
Ru-106	NC	NC	NC	1.300	1.300
Sr-90	1.580	0.841	0.964	0.560	0.560
Tc-99	0.454	0.890	NC	0.900	0.900
Th-228	3.390	1.460	5.790	1.661	1.661
Th-230	12.300	7.750	5.717	4.263	4.263
Th-232	3.590	1.070	3.866	1.495	1.495
U-234	97.000	5.348	8.903	28.720	28.720
U-235	1.890	0.376	0.600	12.700	12.700
U-236	6.200	0.376	3.520	2.017	2.017
U-238	170.000	6.535	6.911	30.420	30.420

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See footnotes at end of table.

TABLE D.5.2-2 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Inorganics (mg/kg)					
Antimony	22.000	23.800	2.000	18.700	18.700
Arsenic	13.800	6.814	64.270	12.060	12.060
Barium	107.910	96.248	389.100	181.300	181.300
Beryllium	1.075	1.020	3.375	1.438	1.438
Boron	31.133	37.000	NC	30.750	30.750
Cadmium	1.691	1.312	0.790	1.216	1.216
Chromium	20.140	28.100	19.700	16.770	16.770
Cobalt	11.800	10.333	15.160	9.369	9.369
Copper	29.000	24.954	53.480	29.810	29.810
Cyanide	0.500	0.820	0.327	0.780	0.780
Lead	28.300	104.000	45.350	28.080	28.080
Manganese	1130.000	974.000	340.000	525.300	525.300
Mercury	0.240	0.440	0.190	0.440	0.440
Molybdenum	10.080	8.200	10.670	6.694	6.694
Nickel	41.000	19.150	29.240	23.450	23.450
Selenium	0.480	0.260	8.667	4.100	4.100
Silver	15.500	21.700	NC	5.244	5.244
Thallium	0.600	0.330	2.084	0.880	0.880
Thorium (Total)	75.600	9.840	35.070	13.650	13.650
Uranium (Total)	1770.000	20.564	29.960	103.840	103.840
Vanadium	29.660	24.234	37.390	27.680	27.680
Zinc	54.930	58.521	79.320	66.440	66.440

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See footnotes at end of table.

TABLE D.5.2-2 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Organics, Pesticides and PCBs (mg/kg)					
1,2-Dichloroethane	0.006	NC	0.007	NC	NC
1,2-Diethylbenzene	NC	0.041	0.010	NC	NC
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	0.00038	NC	NC	NC	NC
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.000073	NC	NC	NC	NC
1,4-Dioxane	12.900	NC	NC	NC	NC
2-Hexanone	0.001	0.002	NC	0.003	0.003
2-Methylnaphthalene	0.100	NC	0.160	0.056	0.056
4,4-DDD	0.004	NC	NC	NC	NC
Acenaphthylene	2.500	NC	NC	0.410	0.410
Acetonitrile	NC	0.200	NC	NC	NC
Acrylonitrile	NC	0.200	NC	NC	NC
Aroclor-1254	0.050	0.043	NC	0.430	0.430
Aroclor-1260	0.080	NC	NC	0.089	0.089
Benzene	0.003	NC	0.002	NC	NC
Benzo(a)anthracene	7.500	0.001	NC	0.130	0.130
Benzo(a)pyrene	8.200	0.001	NC	0.110	0.110
Benzo(b)fluoranthene	1.500	0.002	NC	0.140	0.140
Benzo(g,h,i)perylene	0.490	0.170	NC	0.059	0.059
Benzo(k)fluoranthene	0.740	0.002	NC	0.084	0.084
Bis(2-ethylhexyl)phthalate	1.700	0.655	2.700	0.860	0.860

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See footnotes at end of table.

TABLE D.5.2-2 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Carbazole	4.200	NC	NC	0.001	0.001
Chlordane	NC	NC	NC	0.007	0.007
Chloroform	NC	NC	0.007	0.003	0.003
Chrysene	5.600	0.043	NC	0.150	0.150
Dieldrin	0.013	NC	NC	0.016	0.016
Di-n-octyl phthalate	0.055	0.087	3.000	0.210	0.210
Dibenzo(a,h)anthracene	0.250	0.110	NC	0.002	0.002
Dibenzofuran	0.340	NC	NC	NC	NC
Dichlorodifluoromethane	0.576	NC	NC	NC	NC
Endosulfan sulfate	0.006	NC	NC	NC	NC
Endrin ketone	0.006	NC	NC	0.005	0.005
Hexane	NC	0.020	NC	NC	NC
Indeno(1,2,3-cd)pyrene	5.500	0.210	NC	0.046	0.046
Methylene chloride	0.006	0.031	0.200	0.054	0.054
Octachlorodibenzo-p-dioxin	0.0137	NC	NC	0.004	0.004
Pentachlorophenol	NC	NC	0.056	NC	NC
Phenanthrene	4.800	0.082	0.072	0.210	0.210
Tetrachloroethene	0.001	NC	NC	0.001	0.001
Tributyl phosphate	NC	NC	NC	0.200	0.200
Trichloroethene	NC	NC	NC	0.002	0.002
Vinyl chloride	0.002	NC	0.015	NC	NC

NC = Not characterized.

[a]From OU2 RI Report (DOE 1994).

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TABLE D.5.2-3

OCCUPATIONAL EXPOSURE AIR CONCENTRATIONS BASED ON SURFACE SOIL SOURCE TERM[a]

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Radionuclides (pCi/m^3)					
Cs-137	1.54E-04	4.21E-04	NC	2.77E-04	2.99E-04
Np-237	7.13E-04	4.32E-04	3.30E-03	4.78E-04	1.37E-04
Pu-238	4.63E-04	3.46E-04	4.20E-04	4.86E-05	7.20E-05
Pu-239	4.92E-05	8.10E-05	1.80E-04	1.26E-05	3.06E-05
Pu-240	4.92E-05	8.10E-05	1.80E-04	1.26E-05	3.06E-05
Ra-226	8.38E-04	1.15E-03	2.76E-03	1.19E-03	1.85E-02
Ra-228	1.01E-03	9.83E-04	1.92E-03	1.35E-03	2.33E-03
Sr-90	5.73E-04	4.71E-04	2.70E-03	5.22E-04	6.00E-04
Tc-99	NC	NC	NC	NC	8.52E-02
Th-228	9.76E-04	1.75E-03	2.28E-03	1.63E-03	2.65E-03
Th-230	3.89E-03	2.69E-02	2.22E-03	1.66E-03	8.28E-03
Th-232	9.07E-04	7.84E-04	1.62E-03	1.40E-03	2.39E-03
U-234	2.53E-02	1.26E-02	2.16E-03	5.19E-03	5.19E-03
U-235	1.70E-03	1.05E-03	1.20E-04	2.52E-04	2.51E-04
U-236	1.70E-03	1.05E-03	1.20E-04	2.52E-04	2.51E-04
U-238	4.63E-02	4.28E-02	2.16E-03	5.32E-03	5.59E-03

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See footnotes at end of table.

TABLE D.5.2-3 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Inorganics (mg/m^3)					
Antimony	NC	NC	1.26E-06	NC	1.14E-06
Arsenic	4.00E-06	4.31E-06	5.39E-05	1.99E-05	4.36E-06
Barium	5.48E-05	5.62E-05	1.52E-04	4.15E-05	5.45E-05
Beryllium	4.19E-07	9.11E-07	2.82E-06	1.36E-06	5.65E-07
Cadmium	5.10E-07	7.20E-07	NC	1.86E-06	NC
Chromium	9.28E-06	9.95E-06	7.98E-06	6.82E-06	8.34E-06
Cobalt	4.63E-06	5.82E-06	1.13E-05	4.73E-06	8.34E-06
Copper	1.79E-05	2.16E-05	4.43E-05	2.04E-05	9.97E-06
Cyanide	NC	4.92E-07	1.80E-07	4.20E-07	1.92E-07
Lead	1.14E-05	1.65E-05	3.32E-05	1.44E-05	1.47E-05
Manganese	3.74E-04	7.26E-04	2.78E-04	3.94E-04	1.59E-03
Mercury	NC	1.62E-07	NC	NC	NC
Molybdenum	3.49E-06	9.60E-07	5.16E-06	4.32E-06	3.72E-06
Nickel	1.06E-05	1.33E-05	2.41E-05	1.04E-05	1.03E-05
Selenium	2.52E-07	2.22E-07	3.54E-06	4.92E-06	4.32E-07
Silver	3.60E-06	NC	NC	2.63E-06	3.23E-06
Thallium	NC	NC	1.62E-06	NC	NC
Thorium (Total)	8.27E-06	1.51E-05	1.32E-05	1.28E-05	2.20E-05
Uranium (Total)	1.35E-04	1.29E-04	7.56E-06	1.57E-05	1.77E-05
Vanadium	2.02E-05	1.58E-05	3.01E-05	1.53E-05	1.60E-05
Zinc	3.68E-05	3.73E-05	4.70E-05	2.87E-05	3.16E-05

See footnotes at end of table.

TABLE D.5.2-3 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Organics, Pesticides and PCBs (mg/m^3)					
2-Methylnaphthalene	NC	NC	NC	9.60E-08	NC
4,4-DDE	7.20E-09	NC	NC	NC	NC
Acenaphthylene	NC	NC	NC	1.08E-06	7.20E-07
Aroclor-1254	NC	3.54E-07	NC	NC	5.34E-08
Aroclor-1260	NC	NC	NC	NC	3.12E-08
Benzo(a)anthracene	2.20E-07	5.46E-07	NC	NC	3.30E-06
Benzo(a)pyrene	2.04E-07	6.60E-07	NC	NC	5.64E-06
Benzo(b)fluoranthene	4.26E-07	6.00E-07	NC	NC	3.72E-06
Benzo(g,h,i)perylene	3.00E-07	3.78E-07	NC	NC	3.72E-06
Benzo(k)fluoranthene	2.31E-07	4.80E-07	NC	NC	4.38E-06
Bis(2-ethylhexyl)phthalate	2.88E-08	6.00E-06	NC	NC	6.60E-08
Carbazole	4.62E-08	8.40E-08	NC	3.06E-07	1.02E-07
Chrysene	2.72E-07	6.60E-07	NC	NC	3.60E-06
Dieldrin	NC	NC	NC	NC	6.00E-09
Di-n-octyl phthalate	NC	5.22E-08	NC	NC	NC
Dibenzo(a,h)anthracene	1.20E-07	1.92E-07	NC	1.32E-06	1.14E-06
Dibenzofuran	3.36E-08	2.52E-08	NC	1.50E-07	7.80E-08
Endrin ketone	NC	NC	NC	NC	3.60E-09
Indeno(1,2,3-cd)pyrene	2.88E-07	4.32E-07	NC	NC	3.60E-06
Methylene chloride	NC	NC	NC	NC	3.00E-09
Phenanthrene	3.19E-07	9.60E-07	NC	NC	1.38E-06

NC = Not calculated.

[a]Calculated based on 600 $\mu g/m^3$ dust loading factor.

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TABLE D.5.2-4

OCCUPATIONAL EXPOSURE AIR CONCENTRATIONS BASED ON SUBSURFACE SOIL SOURCE TERM[a]

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Radionuclides (pCi/m^3)					
Cs-137	1.50E-04	9.90E-05	NC	1.44E-04	1.44E-04
Np-237	2.11E-04	2.03E-04	2.70E-04	2.93E-04	2.93E-04
Pb-210	6.18E-04	NC	9.78E-04	3.61E-03	3.61E-03
Pu-238	1.97E-04	1.25E-04	7.38E-05	1.62E-04	1.62E-04
Pu-239	4.08E-04	5.04E-05	6.60E-05	7.80E-05	7.80E-05
Pu-240	4.08E-04	5.04E-05	6.60E-05	7.80E-05	7.80E-05
Ra-224	1.28E-03	NC	2.24E-03	1.88E-03	1.88E-03
Ra-226	9.30E-04	8.53E-04	2.14E-03	1.75E-03	1.75E-03
Ra-228	1.54E-03	8.82E-04	2.60E-03	9.94E-04	9.94E-04
Ru-106	NC	NC	NC	7.80E-04	7.80E-04
Sr-90	9.48E-04	5.05E-04	5.78E-04	3.36E-04	3.36E-04
Tc-99	2.72E-04	5.34E-04	NC	5.40E-04	5.40E-04
Th-228	2.03E-03	8.76E-04	3.47E-03	9.97E-04	9.97E-04
Th-230	7.38E-03	4.65E-03	3.43E-03	2.56E-03	2.56E-03
Th-232	2.15E-03	6.42E-04	2.32E-03	8.97E-04	8.97E-04
U-234	5.82E-02	3.21E-03	5.34E-03	1.72E-02	1.72E-02
U-235	1.13E-03	2.26E-04	3.60E-04	7.62E-03	7.62E-03
U-236	3.72E-03	2.26E-04	2.11E-03	1.21E-03	1.21E-03
U-238	1.20E-01	3.92E-03	4.15E-03	1.83E-02	1.83E-02

See footnotes at end of table.

TABLE D.5.2-4 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Inorganics (mg/m^3)					
Antimony	1.32E-05	1.43E-05	1.20E-06	1.12E-05	1.12E-05
Arsenic	8.28E-06	4.09E-06	3.86E-05	7.24E-06	7.24E-06
Barium	6.47E-05	5.77E-05	2.33E-04	1.09E-04	1.09E-04
Beryllium	6.45E-07	6.12E-07	2.03E-06	8.63E-07	8.63E-07
Boron	1.87E-05	2.22E-05	NC	1.85E-05	1.85E-05
Cadmium	1.01E-06	7.87E-07	4.74E-07	7.30E-07	7.30E-07
Chromium	1.21E-05	1.69E-05	1.18E-05	1.01E-05	1.01E-05
Cobalt	7.08E-06	6.20E-06	9.10E-06	5.62E-06	5.62E-06
Copper	1.74E-05	1.50E-05	3.21E-05	1.79E-05	1.79E-05
Cyanide	3.00E-07	4.92E-07	1.96E-07	4.68E-07	4.68E-07
Lead	1.70E-05	6.24E-05	2.72E-05	1.68E-05	1.68E-05
Manganese	6.78E-04	5.84E-04	2.04E-04	3.15E-04	3.14E-04
Mercury	1.44E-07	2.64E-07	1.14E-07	2.64E-07	2.64E-07
Molybdenum	6.05E-06	4.92E-06	6.40E-06	4.02E-06	4.02E-06
Nickel	2.46E-05	1.15E-05	1.75E-05	1.41E-05	1.41E-05
Selenium	2.88E-07	1.56E-07	5.20E-06	2.46E-06	2.46E-06
Silver	9.30E-06	1.30E-05	NC	3.15E-06	3.15E-06
Thallium	3.60E-07	1.98E-07	1.25E-06	5.28E-07	5.28E-07
Thorium (Total)	4.54E-05	5.90E-06	2.10E-05	8.19E-06	8.19E-06
Uranium (Total)	1.06E-03	1.23E-05	1.80E-05	6.23E-05	6.23E-05
Vanadium	1.78E-05	1.45E-05	2.24E-05	1.66E-05	1.66E-05
Zinc	3.30E-05	3.51E-05	4.76E-05	3.99E-05	3.99E-05

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See footnotes at end of table.

TABLE D.5.2-4 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Organics, Pesticides and PCBs (mg/m^3)					
1,2-Dichloroethane	3.60E-09	NC	4.20E-09	NC	NC
1,2-Diethylbenzene	NC	2.46E-08	6.00E-09	NC	NC
1,2,3,4,6,7,8-Heptachlorodibenzo-p-dioxin	2.28E-10	NC	NC	NC	NC
1,2,3,4,6,7,8-Heptachlorodibenzofuran	4.38E-11	NC	NC	NC	NC
1,4-Dioxane	7.74E-06	NC	NC	NC	NC
2-Hexanone	6.00E-10	1.20E-09	NC	1.80E-09	1.80E-09
2-Methylnaphthalene	6.00E-08	NC	9.60E-08	3.36E-08	3.36E-08
4,4-DDD	2.40E-09	NC	NC	NC	NC
Acenaphthylene	1.50E-06	NC	NC	2.46E-07	2.46E-07
Acetonitrile	NC	1.20E-07	NC	NC	NC
Acrylonitrile	NC	1.20E-07	NC	NC	NC
Aroclor-1254	3.00E-08	2.58E-08	NC	2.58E-07	2.58E-07
Aroclor-1260	4.80E-08	NC	NC	5.34E-08	5.34E-08
Benzene	1.80E-09	NC	1.20E-09	NC	NC
Benzo(a)anthracene	4.50E-06	6.00E-10	NC	7.80E-08	7.80E-08
Benzo(a)pyrene	4.92E-06	6.00E-10	NC	6.60E-08	6.60E-08
Benzo(b)fluoranthene	9.00E-07	1.20E-09	NC	8.40E-08	8.40E-08
Benzo(g,h,i)perylene	2.94E-07	1.02E-07	NC	3.54E-08	3.54E-08
Benzo(k)fluoranthene	4.44E-07	1.20E-09	NC	5.04E-08	5.04E-08
Bis(2-ethylhexyl)phthalate	1.02E-06	3.93E-07	1.62E-06	5.16E-07	5.16E-07

See footnotes at end of table.

TABLE D.5.2-4 (continued)

Contaminant	Solid Waste Landfill	Lime Sludge Ponds	Active Flyash Pile	Inactive Flyash Pile	South Field
Carbazole	2.52E-06	NC	NC	6.00E-10	6.00E-10
Chlordane	NC	NC	NC	4.20E-09	4.20E-09
Chloroform	NC	NC	4.20E-09	1.80E-09	1.80E-09
Chrysene	3.36E-06	2.58E-08	NC	9.00E-08	9.00E-08
Dieldrin	7.80E-09	NC	NC	9.60E-09	9.60E-09
Di-n-octyl phthalate	3.30E-08	5.22E-08	1.80E-06	1.26E-07	1.26E-07
Dibenzo(a,h)anthracene	1.50E-07	6.60E-08	NC	1.20E-09	1.20E-09
Dibenzofuran	2.04E-07	NC	NC	NC	NC
Dichlorodifluoromethane	3.46E-07	NC	NC	NC	NC
Endosulfan sulfate	3.60E-09	NC	NC	NC	NC
Endrin ketone	3.60E-09	NC	NC	3.00E-09	3.00E-09
Hexane	NC	1.20E-08	NC	NC	NC
Indeno(1,2,3-cd)pyrene	3.30E-06	1.26E-07	NC	2.76E-08	2.76E-08
Methylene chloride	3.60E-09	1.86E-08	1.20E-07	3.24E-08	3.24E-08
Octachlorodibenzo-p-dioxin	8.22E-09	NC	NC	2.40E-09	2.40E-09
Pentachlorophenol	NC	NC	3.36E-08	NC	NC
Phenanthrene	2.88E-06	4.92E-08	4.32E-08	1.26E-07	1.26E-07
Tetrachloroethene	6.00E-10	NC	NC	6.00E-10	6.00E-10
Tributyl phosphate	NC	NC	NC	1.20E-07	1.20E-07
Trichloroethene	NC	NC	NC	1.20E-09	1.20E-09
Vinyl chloride	1.20E-09	NC	9.00E-09	NC	NC

NC = Not calculated.

[a]Calculated based on 600 $\mu g/m^3$ dust loading factor.

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