



ROCKWELL INTERNATIONAL
NORTH AMERICAN SPACE OPERATIONS
ROCKY FLATS PLANT

Feasibility Study Report for High Priority Sites (881 Hillside Area)

Volume II - Appendices

U.S. DEPARTMENT OF ENERGY

**Rocky Flats Plant
Golden, Colorado**

1 MARCH 1988

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By R. B. Hoffman
Date 7-6-90

B.R. Lewis
UCNE @ 6/20/90
"REVIEWED FOR CLASSIFICATION"
By *R.P. Healy*
Date 6/8/90

ADMIN RECORD

APPENDIX 1
RISK ASSESSMENT

RES CONTROL
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Rocky Flats Plant
Aerospace Operations
Rockwell International Corporation
P.O. Box 464
Golden, Colorado 80402-0464
(303) 966-7000



Rockwell
International

Contractor to U.S. Department of Energy

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IAN, L.K.	X	X
RT, J.L.	X	X
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MAN, R.B.	X	X
S. D.M.	X	X
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ERT, K.	X	X
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March 2, 1988

88-RF-0623

Albert E. Whiteman
Area Manager
DOE, RFAO

FEASIBILITY STUDY REPORT FOR
HIGH PRIORITY SITES (881 HILLSIDE AREA)

Enclosed are two (2) copies of the Feasibility Study Report for the High Priority Sites (881 Hillside Area) and a preliminary schedule for implementation of the recommended remedial action. This report and preliminary schedule were submitted to CDH and EPA by March 1, 1988 in accordance with Task 3.10 of the Feasibility Study Report including Risk Assessment as required by the Compliance Agreement. The report will be finalized pending CDH, EPA and public review and comment as part of the RI/FS process.

If you have any questions concerning the report, please call T. C. Greengard at extension 7121.

Kirk McKinley

K. B. McKinley
RCRA/CERCLA Program

Enc. 2

Orig & 2 cc - A. E. Whiteman

"REVIEWED FOR CLASSIFICATION"

By R. B. Hoffman

Date 7-9-90

SECTION 6

REFERENCES

Anderson, E., Browne, N., Puletsky, S., and T. Warn, Development of Statistical Distribution of Ranges of Standard Factors Used in Exposure Assessments (Draft Report). Prepared for the U.S. EPA Office of Health and Environmental Assessment, Contract No. 68-02-3510, Washington, D.C., 1985.

Andrews-Jones, D.A., The application of geochemical techniques to mineral exploration. Mineral Industries Bulletin 116:31., 1968.

Baes, C.F., et. al. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for the U.S. Department of Energy. ORNL-5786; DE85-000287, 1984.

Cothorn, R.C., et al. Estimating risk to human health. Environ. Sci. Technol. 20:111., 1986.

EPA (U.S. Environmental Protection Agency), Water-Related Fate of 129 Priority Pollutants, Vol. 2. PB80-204381, 1979.

----- Compilation of Ambient Particulate Matter Size and Composition Data. Prepared by PEDCO Environmental, Inc., for the Monitoring and Data Analysis Division, U.S. EPA, Research Triangle Park, North Carolina. PN3525-10. January, 1982.

----- "National Primary Drinking Water Regulations; Volatile Synthetic Organic Chemicals." Federal Register 49(114):24330. June 12, 1984.

----- Revised Health and Environmental Effects Data for Appendix VIII Constituents. Memo from Mark A. Salee, Land Disposal Branch, Office of Solid Waste. October 24, 1984.

----- Superfund Public Health Evaluation Manual Office of Emergency and Remedial Response. Washington, D.C. OSWER Directive 9285.4-1, 1986a.

----- Methodology for the Assessment of Health Risks Associated with Multiple Pathway Exposure to Municipal Waste Combustor Emissions. The Office of Air Quality Planning and Standards and the Environmental Criteria and Assessment Office, 1986b.

-----, 40 CFR 741, "Water Pollution Control; National Primary Drinking Water Regulations. Radionuclides: Advance Notice of Proposed Rulemaking." Federal Register 51 (189): 34836. September 30, 1986c.

----- "Guidelines for Carcinogen Risk Assessment." Federal Register 51(185):33992. September 4, 1986d.

----- Health Advisories for Legionella and Seven Inorganics. Office of Drinking Water. PB87-235586, 1987a.

----- Toxicological Profile for Nickel. Draft. Prepared by Syracuse Research Corporation for Agency for Toxic Substances and Disease Registry and U.S. EPA, 1987b.

Health Advisories for 25 Organics. Office of Drinking Water. PB87-235578, 1987c.

EPRI (Electrical Power Research Institute). "Measuring and managing environmental risk." 10:6, 1985.

Feldman, R., and H. Maibach, "Adsorption of Some Organic Compounds Through the Skin in Man." J. Invest. Dermatol., 54:399, 1970.

Gilbert, R.O., Statistical Methods for Environmental Pollution Monitoring. New York: Van Nostrand Reinhold Company, 1987. pp. 26-43.

HEW (U.S. Department of Health, Education, and Welfare). Radiological Health Handbook. Public Health Service. Rockville, Maryland, 1970.

ICRP (International Commission on Radiological Protection). "Radiation Protection: Recommendations of the International Commission on Radiological Protection," ICRP Publication 26, Oxford: Pergamon Press, 1977.

----- "Radiation Protection: Recommendations of the International Commission on Radiological Protection," ICRP Publication 30, Oxford: Pergamon Press, 1979.

La Goy, P.K., "Estimated soil ingestion rates for use in risk assessment." Risk Analysis 7:355, 1987.

National Council on Radiation Protection and Measurement (NCRP). Radiological Assessment: Predicting The Transport, Bioaccumulation, and Uptake by Man of Radionuclides Released to the Environment. Bethesda, Maryland: NCRP, 1984.

National Research Council (NRC), Drinking Water and Health, Volume 6. Washington, D.C.: National Academy Press, 1986.

Ogata, A., Theory of Dispersion in a Granular Medium, Fluid Movement in Earth Materials, U.S. Geological Survey Professional Paper 411-I, 1970.

Paschke, S., Personal Communication. Roy F. Weston, Inc., Lakewood Colorado, 1987.

Poiger, H., and C. Schlatter, "Influence of Solvents and Absorbents on Dermal and Intestinal Absorption of TCDD." Fd. Cosmet. Toxicol, 18:447, 1980.

Rockwell International, Resource Conservation and Recovery Act Part B - Post-Closure Care Permit Application for U.S. DOE Rocky Flats Plant Hazardous and Radioactive Mixed Wastes; U.S. Department of Energy, unnumbered report, 1986.

----- Remedial Investigation Report for High Priority Sites (881 Hillside Area). U.S. Department of Energy, Rocky Flats Plant, Golden Colorado, 1987a.

Schaum, J., Risk Analysis of TCDD-Contaminated Soil. U.S. Environmental Protection Agency, EPA 600/5-84-031, 1984.

USNRC (U.S. Nuclear Regulatory Commission). "Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Regulatory Guide 1.109, 1976.

Wrenn, M.E., J. Lipzstein, P.W. Durbin, E. Still, D.L. Willis, B. Howard, and J. Rundo. "Uranium and Radium Metabolism," Health Physics 48:601, 1985

RISK ASSESSMENT
881 Hillside Area
Rocky Flats Plant

2538B

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SECTION 1

INTRODUCTION

The 881 Hillside, located on the southeast portion of the Rocky Flats Plant (Figure 1-1), is one of four contaminant source areas currently being investigated at the Plant. The investigation is part of Phase 2 of a five-phased Comprehensive Environmental Assessment and Response Program (CEARP) developed by the Albuquerque Operations Office of the U.S. Department Of Energy. Based on the information gathered during Phase 1, 10 Solid Waste Management Units (SWMUs) were identified at the 881 Hillside location as potential contaminant sources. The location of these SWMUs (sites) are shown in Figure 1-4. Detailed information pertaining to the Plant location and history, the CEARP, and the SWMUs are presented in the Introduction (Section 1) of the Feasibility Study.

The purpose of this report is to assess the potential human health and environmental risks posed by the presence of contamination resulting from previous on-site disposal activities at the 881 Hillside location. This assessment is based primarily on information collected for the remedial investigation (Rockwell International, 1988), and it is directed towards providing information to be used in the selection of remedial alternatives for cleanup at the 881 Hillside location.

It is impractical to try to assess the total risk posed by every contaminant through every potential exposure pathway. Therefore, all contaminants and potential exposure routes were evaluated to choose those that reflect the majority of the potential risk associated with the 881 Hillside location. The

risk assessment was conducted in five main steps, utilizing guidelines contained in the Endangerment Assessment Handbook (EPA, 1985) and the Superfund Public Health Evaluation Manual (EPA, 1986a). These steps were as follows:

- Selection of Indicator Chemicals (Section 2) - Over 50 different chemicals have been identified in water and soil samples collected at the 881 Hillside location. In order to reduce these chemicals to a manageable number of substances which represent the contaminants of greatest concern, all reported chemicals were evaluated and a final list of indicator chemicals was selected.
- Environmental Release and Transport (Section 3) - The chemical properties and on- and off-site distribution of the indicator chemicals, along with the hydrogeological characteristics of the site, were examined to determine possible mechanisms by which contaminants might migrate from the site into the adjacent environment. Exposure scenarios were constructed at the site and at the Plant boundary to provide the basis for estimating risks to potentially exposed populations.
- Exposure Evaluation (Section 4) - The major routes by which individuals might be exposed to contaminants were identified. The average daily intake of each contaminant by each exposure route, and through all routes combined, were calculated.

- Toxicity Assessment (Supplement C) - Toxicity profiles were prepared for each of the indicator chemicals. The profiles emphasized animal and human health effects, indicating the dosage levels at which specific adverse effects have been observed. The profiles also included relevant and related human health criteria and constants.
- Risk Characterization (Section 5) - Health risks that might potentially be posed by the indicator chemicals were evaluated. Carcinogenic hazards were assessed by calculating the lifetime cancer risk posed by the contaminants. The noncarcinogenic risks were evaluated by comparing estimated daily intakes of each contaminant to acceptable chronic intakes. Discussion is provided to give perspective to the conclusions drawn from this risk assessment.

SECTION 2

SELECTION OF INDICATOR CHEMICALS

For sites where a large number of chemicals have been identified in sampled media, it is impractical to evaluate the potential risks posed by each chemical. Therefore, all chemicals that were identified at the 881 Hillside location were screened to select indicator chemicals, using guidelines contained in the Superfund Public Health Evaluation Manual (EPA, 1986a). Those chemicals which pose the greatest potential hazards and/or are representative of the risks posed by the chemicals at the site were chosen as the indicator chemicals for evaluation in this risk assessment.

The first part of the selection process was to determine which of the substances identified in the sampled media are or may be related to prior on-site disposal activities. Any substance for which there was insufficient evidence of its having originated from on-site disposal practices was eliminated from further consideration. The list of remaining chemicals then underwent further screening to select the indicator chemicals. The selection process took into consideration the concentration, toxicity, distribution, persistence, and mobility of each of the contaminants.

2.1 Summarization of Data

In order to determine which chemicals may be related to the 881 Hillside location, the most recent sampling data were reviewed. These included data from the last quarter of 1986 and the four quarters of 1987 which are contained in the remedial investigation (RI) report (Rockwell International, 1988). These data

represent the results of the analysis of samples collected from on- and off-site soil, up- and downgradient groundwater, up- and downstream surface water, and on-site ambient air.

The chemicals that were addressed in the screening process were limited to the most toxic groups of chemicals, i.e., organics, heavy metals, and radionuclides. Although information was available concerning the concentrations of salts (e.g., sodium, potassium, chloride) in surface water and groundwater, these parameters were not considered in the selection of indicator chemicals. Data concerning the concentrations of salts in aqueous media are used primarily to evaluate overall water quality. Salts are not usually of primary toxicologic concern, as they have a relatively low toxicity.

The available sampling information was first reviewed to determine which of the sampling locations are relevant to the evaluation of potential contamination originating from the 881 Hillside Area. Table 2-1 lists the groundwater, surface water, and soil sampling locations used to evaluate potential contamination of each medium. The groundwater wells which are located within or adjacent to the 881 Hillside Area SWMUS were used in the evaluation of groundwater contamination at the 881 Hillside area. These are shown in Figure 1-4. Those surface water sampling locations located east/southeast of the 881 Hillside area along the South Interceptor Ditch and Woman Creek were used to evaluate potential surface water contamination from the 881 Hillside Area. These surface water sampling locations are shown in Figure _____. On-site soil sampling locations are shown in Figure 1-4.

Table 2-1

Site-Related Sampling Locations

On-Site Wells		Surface Water Stations	Soil Boreholes
Alluvial	Bedrock		
9-74	59-86	SW-31	BH1-BH17
10-74	62-86	SW-32	BH57
1-82	3-87		BH58
2-82	5-87		BH59
63-86	8-87		BH61
64-86	45-87		BH62
69-86			BH63
2-87			
4-87			
43-87			
44-87			
47-87			
48-87			
49-87			
50-87			
51-87			
52-87			
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54-87			
55-87			

Available data for specific chemicals present in the ambient air at the 881 Hillside location were limited to draeger tube readings for trichloroethene and tetrachloroethene taken during a one day survey in March, 1987. Tetrachloroethene was detected at 2 out of 32 on-site sampling locations at 2 and 3 ppm. Trichloroethene was not detected at any of the locations surveyed. It is unlikely that the positive readings for tetrachloroethene were related to past disposal activities. The results of analyses of soil samples from the 881 Hillside location indicated that tetrachloroethene was neither widely distributed in the soil, nor present at high concentrations. Tetrachloroethene was measured above detection limits in 8 out of 91 soil samples at a maximum concentration of 0.190 ppm (0.013 ppm average). In view of this information and the fact that the positive readings occurred near a current collection area for solvents (Rockwell International, 1987a), the air sampling data are unlikely to be associated with previous disposal activities and were not considered in the selection of indicator chemicals or in the subsequent risk analysis.

The most recent data collected from each relevant sampling location were summarized. Sampling data were organized according to the three general categories of contaminants (metals, organics, radionuclides), and the media in which they were found (groundwater, surface water, and soil). The ranges and averages of the concentrations of metals and organics and the activities of radionuclides measured in each medium were determined. In computing average concentrations of metals and organics, if a chemical was not detected in a sample above the minimum detection limit, it was assumed that it was present at one half of the detection limit (Gilbert, 1987). It should be noted that as a result of assuming nondetected values to be one-half of the detection limit, that in some cases in which a

substance was detected in only a small proportion of the samples, the calculated "average" may be higher than the maximum reported concentration. Average activities for radionuclides were calculated using only those activities that were detected. The ranges of background concentrations of metals and background activities of radionuclides were also determined. The data and approaches used in determining background for the 881 Hillside Area are presented in the RI report (Rockwell International, 1988). The background concentrations of organics were assumed to be zero.

The sampling data and background data are summarized in Tables 2-2 through 2-5 (metals), Tables 2-6 through 2-9 (organics), and Tables 2-10 through 2-13 (radionuclides). To simplify the summarization process, only those contaminants that were identified in site-related samples above the minimum detection limit are listed in the tables. Complete sets of data listing all assayed chemicals are contained in the RI report.

Several limitations/qualifications regarding the sampling data should be noted. Groundwater data were subdivided according to the water bearing zones in which the sampled wells were completed. Two water bearing zones are present at the site: 1) a shallow zone within the alluvial, valley fill, and slope wash materials; and 2) bedrock sandstone. Wells 9-74 and 10-74 are completed in both alluvial material and bedrock claystone. The chemical concentrations and radioactivities in the groundwater at these wells is likely to be representative of alluvial groundwater. Therefore, these wells were considered alluvial wells for the purposes of determining the ranges and averages of chemical concentrations and radioactivities in the groundwater.

Table 2-2

Concentrations of Metals in Alluvial Wells
(mg/L)

Chemical	Background		Site-Related	
	Range ¹	Average ²	Range ¹	Average ²
Aluminum	0.0309-0.8289	0.128	0.0321-2.3	0.150
Antimony	0.058	0.023	0.006J-0.208	0.034
Arsenic	0.004	0.004	0.008J-0.009	0.004
Barium	0.0461-0.5163	0.101	0.0545-0.1774	0.103
Beryllium	0.011-0.037	0.004	0.001J-0.023	0.003
Cadmium	0.0003J-0.007	0.002	0.0003J-0.0013	0.001
Cesium	0.360	0.073	0.04J	0.04
Chromium	0.0114-0.1356	0.011	0.0127-0.0782	0.010
Cobalt	0.10	0.014	0.14	0.018
Copper	0.0068-0.0463	0.010	0.0078-0.0364	0.012
Iron	0.0078-0.5953	0.113	0.0128-1.31	0.094
Lead	0.002J-0.054	0.008	0.006-0.037	0.006
Manganese	0.0065-0.547	0.076	0.0075-0.9586	0.144
Mercury	0.0007-0.003	0.0001	0.0001J-0.006	0.0001
Molybdenum	0.0222-0.510	0.034	0.0252-0.0533	0.020
Nickel	0.029-0.077	0.021	0.0370-0.4380	0.080
Selenium	0.002	0.002	0.002J-2.1	0.276
Silver	0.004	0.004	0.0094-0.031	0.005
Strontium	0.068-0.205	0.123	0.4237-2.43	1.324
Thallium	0.007	0.005	0.016	0.006
Vanadium	0.024-0.850	0.040	0.0302-0.0368	0.014
Zinc	0.005-0.49	0.044	0.005-0.5827	0.055

¹Range of detected concentrations.

²Includes nondetected values calculated as 0.5 of the minimum detection limit.

J = Estimated value. Substance was detected below EPA minimum detection (quantitation) limit.

NDA = No data available.

Table 2-3

Concentrations of Metals in Bedrock Wells
(mg/L)

Chemical	Background		Site-Related	
	Range ¹	Average ²	Range ¹	Average ¹
Aluminum	0.0329-0.7932	0.107	0.0314-4.750	0.328
Antimony	0.021	0.021	0.058-0.185	0.030
Arsenic	0.003J-0.004J	0.004	0.004J	0.004
Barium	0.0357-0.2224	0.103	0.0191-0.926	0.121
Beryllium	0.003	0.003	0.009-0.029	0.004
Cadmium	0.0003J-0.0005J	0.002	0.0003J-0.0058	0.002
Cesium	0.057	0.057	0.055	0.055
Chromium	0.015	0.006	0.0128-0.0453	0.013
Cobalt	0.011	0.011	0.013	0.013
Copper	0.0083-0.0477	0.012	0.0083-0.0166	0.009
Iron	0.0087-0.5391	0.063	0.0120-2.90	0.187
Lead	0.011-0.029	0.007	0.01-0.024	0.005
Manganese	0.013-0.2275	0.057	0.0207-0.1833	0.042
Mercury	0.0003	0.0001	0.0001J-0.002	0.0001
Molybdenum	0.0224-0.0553	0.023	0.0222-0.0650	0.022
Nickel	0.017	0.017	0.0370-0.1494	0.047
Selenium	0.002J-0.009	0.003	0.003J-0.15	0.042
Silver	0.004	0.004	0.004	0.004
Strontium	0.117-0.8713	0.426	0.2063-3.0625	1.094
Thallium	0.005	0.005	0.005	0.005
Vanadium	0.0304-0.0467	0.017	0.012	0.012
Zinc	0.0231-0.09	0.021	0.012-0.07	0.022

¹Range of detected concentrations.

²Includes nondetected values calculated as 0.5 of the minimum detection limit.

NDA = No data available.

J = Estimated value. Substance was detected below EPA minimum detection (quantitation) limit.

Table 2-4

Concentrations of Metals in Surface Waters

Chemical	Background		Interceptor Ditch		Site-Related		Woman Creek Average ¹
	Range	Average ¹	Range	Average	Range	Average	
Aluminum	0.150-0.54	0.34	0.20-3.47	1.79	0.20	0.1	0.1
Antimony	0.037J-0.06U	0.034	0.06U	0.03	0.06U	0.03	0.03
Arsenic	0.02U	0.01	0.002U-0.01U	0.003	0.01U	0.005	0.005
Barium	0.1U	0.05	0.1U-0.2U	0.075	0.2U	0.1	0.1
Beryllium	0.005U	0.0025	0.09	0.09	NDA	NDA	NDA
Cadmium	0.005U	0.0025	0.005U-0.006	0.0043	0.005U	0.0025	0.0025
Cesium	0.170-0.340	0.255	0.2U	0.1	0.2U	0.1	0.1
Chromium	0.01U	0.005	0.01U	0.005	0.01U	0.005	0.005
Cobalt	0.05U	0.025	0.05U	0.025	0.05U	0.025	0.025
Copper	0.02U	0.01	0.025U-0.04U	0.016	NDA	NDA	NDA
Iron	0.130-0.135	0.133	0.01U-0.20	0.053	NDA	NDA	NDA
Lead	0.005U-0.05	0.026	0.005U	0.0025	0.05U	0.0025	0.0025
Manganese	0.005U-0.013	0.0078	0.037-0.07	0.054	0.015U	0.0075	0.0075
Mercury	0.0002U-0.0005	0.0003	0.0002U	0.0001	0.0002U	0.0001	0.0001
Molybdenum	0.450-0.680	0.565	0.04U	0.02	0.04U	0.02	0.02
Nickel	0.043-0.082	0.0625	0.04U	0.02	0.04U	0.02	0.02
Selenium	0.005U	0.0025	0.005U	0.0025	0.005U	0.0025	0.0025
Silver	0.01U-0.022	0.0135	0.01U	0.005	0.01U	0.005	0.005
Strontium	0.005U-0.110	0.056	0.38-0.40	0.39	0.02U	0.01	0.01
Thallium	0.01U	0.005	0.01U	0.005	0.01U	0.005	0.005
Vanadium	0.045-1.2	0.623	0.05U	0.025	0.05U	0.025	0.025
Zinc	0.005-0.016	0.011	0.02U-0.589	0.30	0.02U	0.01	0.01

¹Includes nondetected values calculated as 0.5 of the minimum detection limit.

J = Estimated value. Substance was detected below EPA minimum detection (quantitation) limit.

NDA = No data available.

U = Substance not detected above indicated minimum detection limit.

Table 2-5

Concentrations of Metals in Soil
(mg/kg)

Chemical	Background		Site-Related	
	Range	Average	Range ¹	Average ²
Aluminum	6,540-9,190	7,990	3,500-22,000	11,483
Antimony	37U-41U	19.3	21-24	6
Arsenic	6.1-10	3.84	2.2-2.4	8
Barium	122U-135U	64.2	35J-811	120
Beryllium	3.0U-3.4U	1.6	0.5J-1.9	0.764
Cadmium	3.0U-3.4U	1.6	1-9	2
Cesium	NDA	NDA	NDA	NDA
Chromium	5.6-13	9.3	2.9-27.8	12
Cobalt	12U-25	10.9	3.8J-36	8
Copper	6.6J-10J	8.7	4.8J-29.8	13
Iron	9,080-12,400	10,719	2,220-67,200	15,171
Lead	15-48	28.3	3.4-35.2	13
Manganese	196-337	267	9.8-563	193
Mercury	0.1U	0.05	0.08-2.07	0.179
Molybdenum	NDA	NDA	NDA	NDA
Nickel	13U-16J	10.9	3.5J-71	13
Selenium	3.0U-3.4U	1.6	0.499	0.499
Silver	3.0U-3.4U	1.6	0.897	0.897
Strontium	NDA	NDA	209	66
Thallium	6.1U-6.8U	3.2	0.934	0.934
Vanadium	30U-38	18.5	5-51.6	28
Zinc	20-49	32.7	8.4-185	54

¹Range of detected concentrations.

²Includes nondetected values calculated as 0.5 of the minimum detection limit.

NDA = No data available.

U = Substance not detected above indicated minimum detection limit.

Table 2-6

**Concentrations of Organics in Alluvial Wells
(ug/L)**

Chemical	On-Site	
	Range ¹	Average ²
Acetone	2BJ-130B	19
2-Butanone	22	9
Carbon tetrachloride	5-28,000	830
Chloroform	5-32J	4
1,1-Dichloroethane	35-342	23
1,2-Dichloroethane	4-16,000	506
1,1-Dichloroethene	3J-48,000	3,775
t-1,2-Dichloroethene	42-5,070	125
Methylene chloride	1J-48	10
Tetrachloroethene	3J-13,200	1,089
1,1,1-Trichloroethane	2J-30,250	2,918
1,1,2-Trichloroethane	48-139	12
Trichloroethene	12-72,000	4,146
Toluene	11-67	9

¹Range of detected concentrations.

²Includes nondetected values calculated as 0.5 of the minimum detection limit.

B = Substance was also detected in the blank.

J = Estimated value. Substance was detected below EPA minimum detection (quantitation) limit.

Table 2-7

Concentrations of Organics Detected in Bedrock Wells
(ug/L)

Chemical	On-Site	
	Range ¹	Average ²
Acetone	2BJ-210B	33
Chloroform	4J-37B	4
1,2-Dichloroethane	6	3
1,1-Dichloroethene	2J ³	3
Methylene chloride	2J-23JB	5
Toluene	1J-2J	4

¹Range of detected concentrations.

²Includes nondetected values calculated as 0.5 of the minimum detection limit.

B = Substance was also detected in the blank.

J = Estimated value. Substance was detected below EPA minimum detection (quantitation) limit.

Table 2-8

Concentrations of Organics Detected in Surface Water
(ug/L)

Chemical	Interceptor Ditch		Woman Creek	
	Range	Average ¹	Range	Average ¹
Carbon tetrachloride	4U-5U	2.3	4U-6	3.3
Toluene	NDA	NDA	12	12
Trichloroethene	4U-5U	2.3	4U-26	8.3

¹Includes nondetected values calculated as 0.5 of the minimum detection limit.

NDA = No data available

U = Not detected above the indicated minimum detection (quantitation) limit.

Table 2-9

**Concentrations of Organics in Soil
(ug/kg)**

Chemical	On-Site	
	Range ¹	Average ²
Acetone	2JB-650B	112
Aroclor-1254	43-70	25
Bis(2-ethylhexyl)phthalate	85JB-7214	1,236
Bromomethane	6J	16
2-Butanone	3J-390	43
Dibromochloromethane	1J	8
1,2-Dichloroethane	5J-10J	8
1,1-Dichloroethene	8J	8
t-1,2-Dichloroethene	18J	8
Diethyl phthalate	26-31	133
Di-n-butyl phthalate	35J-3643	380
Di-n-octyl phthalate	170J-265	136
Methylene chloride	2J-590B	41
4-Methyl-2-pentanone	68	17
N-nitrosodiphenylamine	36J-160J	457
PAH (total) ³	777J-1939	1,914
Tetrachloroethene	5J-190	13
Toluene	6J-25	8
1,1,1-Trichloroethane	10J-110	11
1,1,2-Trichloroethane	6J-27	8
Trichloroethene	7J-150	11

¹Range of detected concentrations.

²Includes nondetected values calculated as 0.5 of the minimum detection limit.

³Minimum/maximum (i.e., range) and average concentrations are the sums of the minimum/maximum and average concentrations reported for 13 individual PAH.

B = Substance was also detected in the blank.

J = Estimated value. Substance was detected below EPA minimum detection (quantitation) limit.

Table 2-10

**Radionuclide Activities in Alluvial Wells
(pCi/L \pm counting error)**

Radionuclide	Background		On-Site	
	Range	Average ¹	Range	Average ¹
Americium-241	BMDA	BMDA	0.0 \pm 1.6-0.7 \pm 0.86	0.039
Cesium-137	NDA	NDA	1.4-3.1	2
Plutonium-239,240	BMDA	BMDA	0.0 \pm 0.59-0.9 \pm 1.1	0.085
Strontium-89,90	NDA	NDA	0.6-5.6	2
Tritium	NDA	NDA	0.0 \pm 0.21-3000	565
Uranium-233,234	BMDA- 3.5 \pm 0.9	3.5 \pm 0.9	1.7 \pm 1.0-29.3 \pm 3.9	13
Uranium-235	BMDA	BMDA	0.0 \pm 0.36-1.3 \pm 0.6	0.470
Uranium-238	BMDA- 5.5 \pm 2.1	5.5 \pm 2.1	2.1 \pm 1.0-33 \pm 5	10

¹For activities above detection only.

BMDA = Below minimum detectable activity.

NDA = No data available.

Table 2-11

Radionuclide Activities in Bedrock Wells
(pCi/L ± counting error)

Radionuclide	Background		On-Site	
	Range	Average ¹	Range	Average ¹
Americium-241	BMDA	BMDA	0.0±0.18-0.25±0.32	0.011
Cesium-137	NDA	NDA	0.3-2.2	2
Plutonium-239,240	BMDA	BMDA	0.0±0.63-1.7±1.9	0.215
Strontium-89,90	NDA	NDA	0.44-3.4	2
Tritium	NDA	NDA	2.1-450	187
Uranium-233,234	BMDA-	6.6±1.8	0.0±1.0-15±2	5
		6.6±1.8		
Uranium-235	BMDA		0.0±0.36-0.75±0.54	0.280
Uranium-238	BMDA-	7.5±1.7	0.0±0.5-11±2	5
		7.5±1.7		

¹For activities above detection only.

BMDA = Below minimum detectable activity.

NDA = No data available.

Table 2-12

Radionuclide Activities in Surface Waters
(pCi/L \pm counting error)

Radionuclide	Background		Interceptor Ditch		Woman Creek	
	Range	Average ¹	Range	Average ¹	Range	Average ¹
Americium-241	0.02 \pm 0.03- 0.06 \pm 0.04	0.04	0.0 \pm 0.06- 0.0 \pm 1.3	0.0	0.0 \pm 1.2 0.01 \pm 0.03	0.0
Cesium-137	NDA	NDA	BMDA	BMDA	BMDA	BMDA
Plutonium-239,240	0.02 \pm 0.04- 0.01 \pm 0.06	0.015	0.0 \pm 0.28- 0.39 \pm 0.84	0.195	0.23 \pm 0.87- 0.26 \pm 0.82	0.25
Strontium-89,90	NDA	NDA	3.43	3.43	3.15	3.15
Tritium	20 \pm 220- 80 \pm 220	50	BMDA- 180 \pm 240	180	BMDA- 50 \pm 220	50
Uranium-233,234	0.13 \pm 0.09- 0.38 \pm 0.14	0.26	3.1 \pm 0.4- 5.5 \pm 1.3	4.3	0.03 \pm 0.13- 2.9 \pm 1.9	1.5
Uranium-235	NDA	NDA	NDA	NDA	NDA	NDA
Uranium-238	0.06 \pm 0.06- 0.12 \pm 0.08	0.09	10 \pm 1- 14 \pm 2	12	0.04 \pm 0.11- 1.2 \pm 1.3	0.6

¹For activities above detection only.

BMDA = Below minimum detectable activity.

NDA = No data available.

Table 2-13

**Radionuclide Activities in Soil
(pCi/g \pm counting error)¹**

Radionuclide	Background Range	On-Site	
		Range	Average ¹
Americium-241	0.0 \pm 0.03-0.28 \pm 0.16	0.0 \pm 0.8-0.15 \pm 0.13	0.012
Cesium-137	NDA	0.0 \pm 0.8-2.6 \pm 0.9	0.252
Plutonium-239,240	0.01 \pm 0.10-0.1 \pm 0.2	0.0 \pm 0.14-0.91 \pm 0.38	0.007
Strontium-89,90	NDA	0.0 \pm 0.8-1.9 \pm 1.5	0.173
Tritium	0.0 \pm 0.22-0.28 \pm 0.27	0.0 \pm 0.20-0.73 \pm 0.21	0.155
Uranium-233,234	0.66 \pm 0.16-1.4 \pm 0.2	0.42 \pm 0.13-2.2 \pm 0.2	0.954
Uranium-235	NDA	NDA	NDA
Uranium-238	0.62 \pm 0.16-1.2 \pm 0.2	0.35 \pm 0.12-1.9 \pm 0.2	0.896

¹Except for tritium which is expressed as pCi/ml soil water.

NDA = No data available.

The available on-site soils data were limited to, and reflected the analysis of, composite samples taken at various depths, starting at the surface and extending down into the bedrock. By contrast, the available background soils data represented the analyses of composite surface soil samples collected at depths ranging from 0 to 1 foot. However, in the absence of on-site surface soils data (i.e., specific 0 to 1 foot data), the on-site soils data collected up to a depth of 10 feet, and which did not reach the point of contact with the bedrock, were summarized and subsequently compared to the background surface soils data in the indicator chemical selection process.

Only two surface water sampling locations could be identified on either the Interceptor Ditch or Woman Creek which potentially reflect contamination specific to the 881 Hillside location. There were sampling stations SW-31 (Interceptor Ditch) and SW-32 (Woman Creek). Although other surface water sampling locations might be impacted by contamination from the 881 Hillside Area, they might also potentially be impacted by other areas of the Rocky Flats Plant. The evaluation of surface water contamination was, therefore, limited to data from these two locations.

2.2 DETERMINATION OF SITE-RELATED CONTAMINANTS

2.2.1 Metals and Organics

To determine which metals might be related to on-site disposal activities, the site-related data were compared to the appropriate available background data. Those metals for which the average site-related concentration exceeded the average background concentration in one or more media were considered to be site-related contaminants. The results of this comparison are summarized in Tables 2-14.

Table 2-14

Metals Present above Background Levels in
Site-Related Samples

Chemical	Groundwater		Surface Water		Soil
	Alluvium	Bedrock	Interceptor Ditch	Woman Creek	
Aluminum	X	X	X		X
Antimony	X	X			
Barium		X			
Beryllium		X	X	I	
Cadmium			X		
Chromium		X			X
Copper			X	I	X
Iron		X		I	X
Manganese	X		X		
Mercury					X
Nickel	X	X			X
Selenium	X	X			
Strontium	X	X	X		I
Vanadium					X
Zinc	X		X		X

NDA = No on-site or background data available.

X = Chemical measured above background level.

I = Insufficient information to determine if the compound is above background due to a lack of background or on-site sampling data.

On the basis of the comparison to background, seven metals were found which did not exceed background levels in the media for which data were available and were therefore eliminated from the process of indicator chemical selection. These were:

- arsenic
- cesium
- cobalt
- lead
- molybdenum
- silver
- thallium

Because the background for organics was assumed to be zero, any organic that was detected above the minimum detection limit in one or more site-related sample was assumed to be above background and was included in the indicator chemical selection process. A list of these compounds and the media in which they were detected are presented in Table 2-15.

2.2.2 Radionuclides

To determine which radionuclides might be related to on-site disposal activities, site-related data were compared to the most appropriate available background data. Data from the down-gradient alluvial and bedrock wells were compared to data from alluvial and bedrock wells located hydrologically upgradient of the Plant. Radionuclides for which the concentration less the counting error (i.e., two standard deviations) exceeded the maximum background value plus its counting error were considered site related contaminants. The procedure is further outlined in the 881 Hillside Remedial Investigation Report. The results of this comparison are summarized in Table 2-16.

On the basis of the comparison to background, only three radionuclides were found to significantly exceed background concentrations. These were uranium-233-234, uranium-235 and uranium-238.

Table 2-15

Organics Present in Site-Related Samples

Chemical	Groundwater		Surface Water		Soil
	Alluvium	Bedrock	Interceptor Ditch	Woman Creek	
Acetone	X	X			X
Aroclor-1254					X
Bis(2-ethylhexyl) phthalate					X
Bromomethane					X
2-Butanone	X				X
Carbon tetrachloride	X			X	
Chloroform	X	X			X
Dibromochloromethane					X
1,1-Dichloroethane	X				
1,2-Dichloroethane	X	X			X
1,1-Dichloroethene	X	X			X
t-1,2-Dichloroethene	X				X
d-n-butyl phthalate					X
d-n-octyl phthalate					X
4-Methyl-2-pentanone					X
Methylene chloride	X	X			X
N-nitrosodiphenyl- amine					X
PAH (total)					X
Tetrachloroethene	X			X	
Toluene	X	X		X	X
1,1,1-Trichloro- ethane	X				X
1,1,2-Trichloro- ethane	X				X
Trichloroethene	X			X	X

X = Compound measured above background level.

Table 2-16

Radionuclides Measured Above Background Levels
in Site-Related Samples

Chemical	Groundwater		Surface Water		Soil
	Alluvium	Bedrock	Interceptor Ditch	Woman Creek	
U-233,234	X	X	X		
U-235	X	X	NDA		
U-238	X	X	X		

X = Compound measured above background level.
NDA = No data available.

Radionuclides which were measured but not found to exceed background concentrations were:

- americium-241
- cesium-137
- plutonium-239,240
- strontium-89,90
- tritium

2.3 Scoring for Indicator Chemicals

The metals and organics which were detected above background were ranked according to guidelines in the Superfund Public Health Evaluation Manual (SPHEM) (EPA, 1986a). Based on the availability of toxicity constants (EPA, 1986a). Of the 40 chemicals detected above background, 16 were ranked for non-carcinogenic effects only, 4 for carcinogenic effects only, and 7 for both noncarcinogenic and carcinogenic effects. Toxicity constants were not available for the remaining 13 chemicals.

The computation of the indicator scores and the ranking numbers are summarized in Supplement A, Tables A-1 (noncarcinogenic effects) and A-2 (carcinogenic effects). The average and maximum contaminant concentrations used in the scoring were taken from Tables 2-2 to 2-9. The toxicity constants are summarized in Supplement A, Table A-3.

In order to reduce the list of scored chemicals to those of greatest potential concern, the chemicals that ranked in the top 50 percent according to average and/or maximum concentrations were examined further to select the final list of indicator chemicals. These chemicals, listed in Supplement A, Table A-4, included the top 12 of the 22 ranked for noncarcinogenic effects and the top 6 of the 11 ranked for carcinogenic effects. Parameters considered in the final screening included mobility, persistence, and contaminant distribution on- and off-site.

In addition, the chemicals for which toxicity constants were not available (see Supplement A, Table A-5) were evaluated on the basis of toxicity information, reported concentrations, and on- and off-site distribution. The reported site-related concentrations and background concentrations were also evaluated further for all of the contaminants under final consideration as indicator chemicals.

As a result of these evaluations, the list of indicator chemicals, shown in Table 2-17, was chosen. This list includes all of the top (upper 50 percent) ranking carcinogens (Supplement A, Table A-4), all of which were present at high concentrations in groundwater, in which they are highly mobile. Four of these compounds (carbon tetrachloride, 1,1-dichloroethene, trichloroethene and tetrachloroethene) were also among the top (upper 50 percent) compounds ranked for noncarcinogenic effects (Supplement A, Table A-4). Of the remaining 8 top-ranking chemicals on the noncarcinogenic effects list, selenium, nickel, and t-1,2-dichloroethene were included on the final list of indicator chemicals. Selenium was measured at concentrations exceeding the federal primary Maximum Contaminant Level of 10 ug/L in several site-related alluvial monitoring wells. Nickel was measured in site-related alluvial groundwater samples at concentrations exceeding a Lifetime Health Advisory of 150 mg/L for drinking water (EPA, 1987a). Trans-1,2-dichloroethene was detected at elevated concentrations (up to 5,000 ug/l) in groundwater in which it is highly mobile. The reasons for the elimination of the other 5 top-ranking chemicals on the noncarcinogenic effects list from consideration as indicator chemicals are summarized in Supplement A, Table A-6. Of the 12 substances which could not be ranked because they had no toxicity constants, strontium was selected as an indicator chemical because of its presence above background levels in both

Table 2-17

Indicator Chemicals

Organics

Bis(2-ethylhexyl)phthalate (DEHP)

Carbon tetrachloride

1,2-Dichloroethane

1,1-Dichloroethene

t-1, Dichloroethene

Tetrachloroethene

Trichloroethene

Inorganics

Selenium

Strontium

Radionuclides

Uranium-233, 234

Uranium-235

Uranium-238

groundwater and surface water samples. The reasons for the elimination of the remaining 11 chemicals without toxicity constants from the final indicator chemical list are summarized in Supplement A, Table A-7. It was also decided to include bis(2-ethylhexyl) phthalate (DEHP) as an indicator chemical. Although the lowest ranking of the carcinogens identified on site, DEHP appeared to be widely distributed in soil samples collected at the 881 Hillside location. DEHP will also be used to represent other organics that were detected only in on-site soil samples (e.g., N-nitrosodiphenylamine, di-n-octyl phthalate; see Supplement A, Table A-7).

The list of indicator chemicals also includes uranium. No formalized procedure comparable to that developed by EPA for selecting indicator chemicals (EPA, 1986a) has been developed for radionuclides. Uranium was chosen as an indicator chemical because its activity was measured above background in both alluvial and bedrock groundwater samples (see Section 2.2.2).

Toxicity profiles for the indicator chemicals are presented in Supplement B. The profiles describe the toxic effects associated with these chemicals and the dosage levels at which they have been reported to occur.

SECTION 3

ENVIRONMENTAL RELEASE AND TRANSPORT

In Section 2, the nature and extent of contamination at the 881 Hillside location was examined and indicator chemicals were selected. In order for a hazard to exist, however, these chemicals must have the potential for coming into contact with humans or other sensitive receptors. Contact might occur directly (i.e., through direct exposure to contaminated materials on site), or indirectly (i.e., through exposure to chemicals that have migrated off site). This section addresses the potential for contaminant migration, including the general mechanisms by which contaminants might be released into the environment and the pathways through which they might be dispersed. Those pathways which are of greatest potential concern are identified.

3.1 CONTAMINANT RELEASE SOURCES AND MIGRATION PATHWAYS

An examination of the sampling data presented in Section 2 revealed that contaminants were distributed on site primarily in the groundwater and, to a lesser extent, in the soil. Therefore two main release sources are expected to exist at the 881 Hillside location: groundwater and soil. From these two sources, media contaminants might potentially migrate from the site through three pathways: groundwater, surface water, and ambient air. These pathways are briefly described below. More detailed information concerning the hydrogeology and meteorology of the Rocky Flats Plant may be found in a previous report (Rockwell International, 1986). Details of the hydrogeology specific to the 881 Hillside location are contained within the Remedial Investigation Report for High Priority Sites (881 Hillside) (Rockwell International, 1988).

The potential contaminant release mechanisms and migration pathways at the 881 Hillside location are summarized in Figure 3-1.

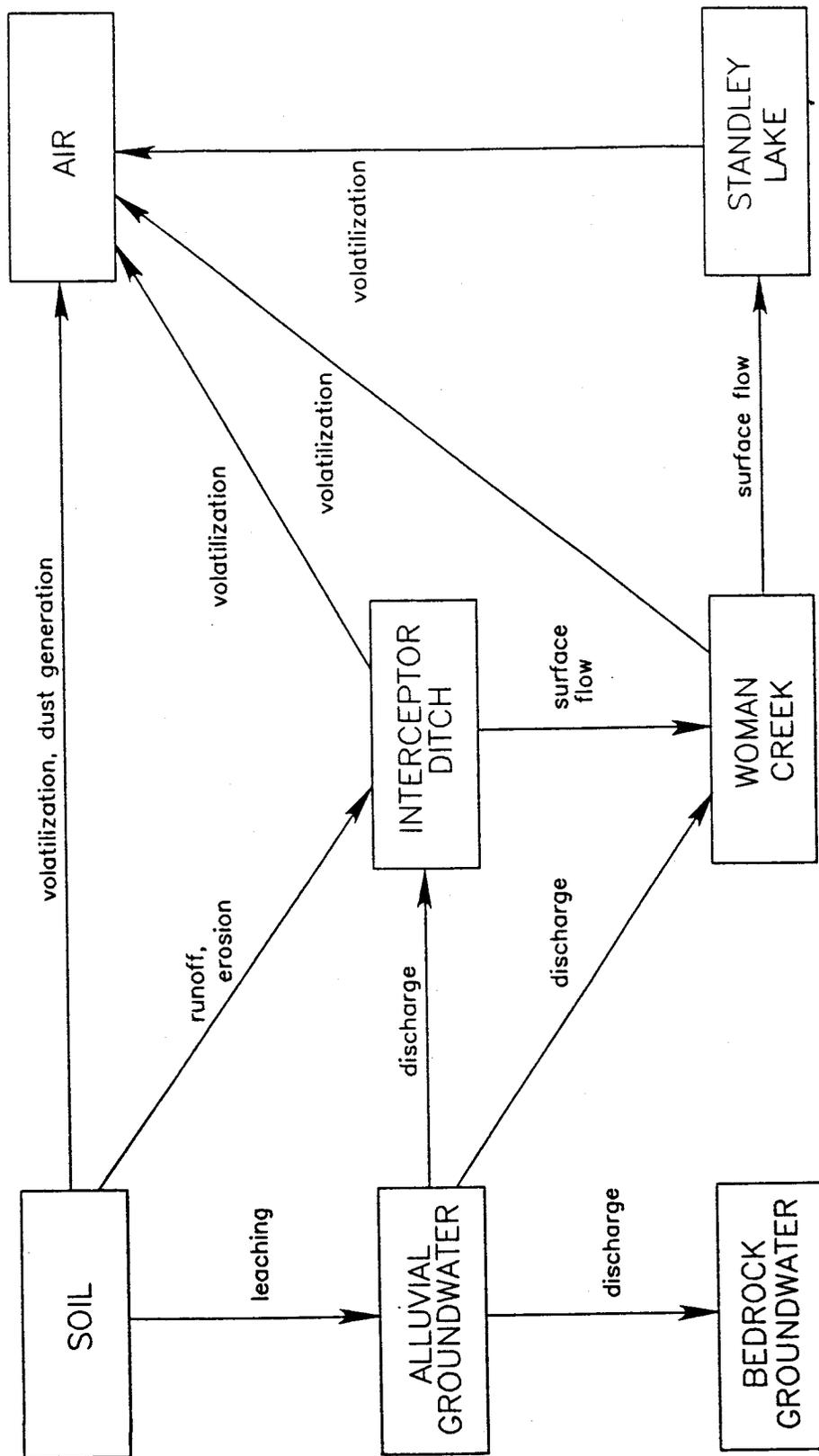


FIGURE 3--1 POTENTIAL CONTAMINANT RELEASE MECHANISMS AND MIGRATION PATHWAYS

3.1.1 Groundwater Pathway

Two hydraulically-connected water bearing zones are present at the 881 Hillside location. A shallow water bearing zone is contained within surficial alluvial and colluvial materials, and a deeper water bearing zone is contained within the underlying bedrock (Arapahoe formation). Groundwater flow within the shallow water bearing zone is towards the southeast. Flow in the bedrock water bearing zone is towards the east. Contaminants in the groundwater may leave the site through four pathways (Rockwell International, 1987a):

- From the colluvium to the valley fill alluvium, discharging to Woman Creek.
- From the colluvium to the alluvium, exiting as subsurface flow.
- Through the colluvium, discharging to the interceptor ditch.
- From the colluvium to the bedrock, exiting through the bedrock water bearing zone.

3.1.2 Surface Water Pathway

Two intermittent surface waters are located adjacent to the 881 Hillside location. These are the South Interceptor Ditch, located directly to the south of the Plant, and Woman Creek, situated to the south of the ditch. The interceptor ditch receives surface water runoff from the southern portion of the Plant, including the 881 Hillside location. It also receives groundwater discharge from the colluvial materials (shallow

aquifer). The interceptor ditch flows into a retention pond (Pond C-2), located to the southeast of the 881 Hillside, the contents of which are periodically discharged to Woman Creek in accordance with the Plant's NPDES permit. Woman Creek, in addition to receiving discharges from the interceptor ditch, may also receive contaminants from the site through shallow groundwater discharge from on-site alluvial materials. Another retention pond (Pond C-1) from which discharges are also monitored and controlled in accordance with the Plant's NPDES permit, is located on Woman Creek, to the southeast of the Hillside. Woman Creek enters Standley Lake approximately four miles from the Plant boundary. The locations of the site-adjacent surface waters are shown in Figure ___.

3.1.3 Air Pathway

Contaminants might potentially be released directly from the site to the ambient air through volatilization or the generation of fugitive dusts from the soil. Release of contaminants to the air might also occur indirectly through volatilization from impacted surface waters. Winds at the Plant are predominantly from the northwest (Rockwell International, 1988).

3.2 IDENTIFICATION OF MIGRATION PATHWAYS OF CONCERN

Although all of the pathways shown in Figure 3-1 could potentially lead to the off-site migration of contaminants, this risk assessment will address only those that pose the greatest potential for release and/or transport. Therefore, all of the possible release mechanisms and migration pathways were examined to determine which might result in the significant off-site movement of contaminants.

3.2.1 Groundwater Migration

The migration pathway of the greatest potential concern is contaminant transport through the groundwater. Elevated concentrations of volatile organics, metals, and radionuclides have been identified in the alluvial groundwater (shallow water bearing zone) at the site. Groundwater transport of contaminants will therefore be considered in assessing potential risks associated with the 881 Hillside location.

Based on current sampling data, the leaching of chemicals from the soil to the groundwater would be expected to have a negligible impact, if any, upon future groundwater contaminant levels. The concentrations of volatile organics measured in the soil (maximum of 0.15 ppm) are orders of magnitude lower than those measured in the groundwater (maximum of 72 ppm). The inorganic indicator chemicals, selenium and strontium, were not present at unusual concentrations in the soil. Selenium was not measured above background in on-site soil samples. Although there was insufficient background data to determine if strontium was present in on-site soil samples above background levels, the concentrations measured in on-site soils were within ranges reported to be typical of clayey and sandy soils (Kabata-Pendias and Pendias, 1984). Uranium concentrations in soils were at or near background levels. Therefore, release of uranium to groundwater is also expected to have negligible impact. Significant leaching of bis(2-ethylhexyl)phthalate would also not be expected. Bis(2-ethylhexyl)phthalate has not been detected in samples from on-site monitoring wells at levels above the EPA-required minimum detection limit (Rockwell International, 1986). The potential for the future degradation of the groundwater with bis(2-ethylhexyl)phthalate would be expected to be low since: 1) soil concentrations are relatively low (maximum of 7.2 mg/kg, 0.085 mg/kg average) and; 2) it has a low solubility in water (solubilities of 0.4 mg/l and 1.3 mg/l have been

reported (U.S. EPA, 1979)). Because the levels of soil contaminants would not be expected to significantly impact upon the groundwater in the future, the leaching of contaminants from the soil was considered not to be a release mechanism/migration pathway of concern.

3.2.2 Surface Water Migration

The potential importance of the surface water pathway in the off-site migration of contaminants depends largely upon the future potential for its degradation since, with the possible exception of uranium-238, current concentrations of the indicator chemicals in site-adjacent surface waters are relatively low and are not of concern. None of the organic indicator chemicals were detected above detection limits in surface water samples collected downgradient of the site. Of the metals, selenium was not detected above background in downstream aqueous samples and downstream sediment concentrations (0.17 mg/kg, average) in Woman Creek were similar to those measured upstream (0.11 mg/kg, average). The range of strontium concentrations in downstream samples from the interceptor ditch and Woman Creek (0.17-0.46 mg/l) was similar to that in upstream samples (<0.02-0.42 mg/l). Downstream sediment concentrations in Woman Creek (46 mg/kg average), although higher than upstream concentrations (2.6 mg/kg, average) are not unusual for sediments (Andrews-Jones, 1968). Surface waters collected from the Interceptor Ditch were found to contain concentrations of U-238 above background. Samples collected upgradient of the 881 Hillside Area had higher concentrations than those collected downgradient. Therefore, there is insufficient data to link the U-238 contamination to the 881 Hillside Area. Surface water samples collected from Woman Creek were found to be indistinguishable from background for uranium.

The two main mechanisms which could potentially lead to surface water contamination in the future are soil erosion/surface runoff and groundwater discharge. Because of the relatively low concentrations of contaminants in on-site soils (Section 3.2.1), soil erosion/surface runoff from the 881 Hillside location would not be expected to impact upon the site-adjacent surface waters in the future. Groundwater discharge would also be anticipated to have limited impacts. Although high levels of volatile organics were measured in the groundwater, these chemicals would not be expected to persist in surface waters after they are discharged because of their short half-lives and the shallowness of the receiving waters (i.e., South Interceptor Ditch and Woman Creek). Half-lives of the volatile organic indicator chemicals in surface water have been reported to be in the range of minutes to days (EPA, 1979 and EPA, 1986). Rapid evaporation would be expected to be facilitated by the intermittent nature of the site-adjacent surface waters and the shallowness of these waters during times of flow. Depth in these waters, then flowing, average from one to two feet (Personal communication with Suzanne Paschke, 1987). The prediction that volatiles released to surface waters will evaporate quickly is supported by recent sampling data (Rockwell International, 1988). Although volatile organics were present in the drainage from the footings of Building 881 (maximum of 128 ug/l), none were detected in the interceptor ditch into which the drainage flows.

The potential for future impacts of the metal contaminants contained in the groundwater upon the site-adjacent surface waters would also be expected to be minimal. It is anticipated that these contaminants would be attenuated by a number of processes, including the sorption and dilution, of contaminants, as the groundwater flows towards discharge zones and

after the ground-water discharges to the surface. It is unlikely that elevated levels of metals and radionuclides will migrate from the 881 Hillside location as a result of future groundwater discharge to surface water.

Because the current levels of indicator chemicals in site adjacent surface waters are low or below detection limits and because the future potential for contaminants at the 881 Hillside impacting upon these surface waters is low, the potential for off-site exposure to contaminants as a result of surface water migration is also low. Therefore, the surface water pathway will not be addressed as a migration pathway of concern in this risk assessment.

3.2.3 Air Migration

Air migration pathways (volatilization and dispersion of contaminated dusts) would be expected to be of negligible consequence at the 881 Hillside location. Although volatile organics were measured in on-site soils, it is not expected that the evaporation of these chemicals would result in ambient air concentrations high enough to be of human health concern. Information regarding the concentrations of contaminants at the soil surface was not available (see Section 2.1.1). However, it is unlikely that there are measurable quantities of volatile organics in surface soil for the following reasons: 1) the analysis of composite soil samples revealed that volatile organics were not widely distributed nor present at high concentrations in the soil (see Section 2.1.1); 2) limited ambient air sampling conducted on-site did not indicate the presence of organics in the ambient air at concentrations above detection limits (i.e., ppm range) (see Section 2.1.1) and; 3) it would be expected that any volatiles that may have been present at the soil surface due to past disposal practices would

have almost entirely evaporated. Based on the low concentrations of volatiles measured in composite soil samples taken up to 10 feet in depth, it is also unlikely that significant volatile contaminant release could occur from subsurface soils.

Similarly, the volatilization of organics from surface waters is also unlikely to result in ambient air contaminant concentrations that are of concern. Evidence indicates that volatiles that are being discharged from the groundwater are evaporating at a sufficiently rapid rate to prevent measurable quantities from accumulating in surface waters (see Section 3.2.2). It is, therefore, unlikely that significant levels of organic contaminants will build up in the ambient air at or off the site as a result of volatilization from surface waters.

The migration of fugitive dusts also poses a negligible potential for contaminant exposure since the concentrations of contaminants in the soil are either low or not unusual (see Section 3.2.1). Although the migration of contaminants through dust dispersion will not be considered in this assessment, a worst-case scenario, (i.e., exposure to dusts by individuals who might live at the site in the future), will be addressed in Section 4.3.4.

3.2.4 Final Selection of Migration Routes of Concern

Based on the concentrations of the indicator chemicals measured in media at the 881 Hillside location and on their chemical and physical properties, the greatest potential for off-site exposure to these chemicals is posed by groundwater migration. The transport of contaminants through groundwater flow will be addressed in Section 4.2.2

Off-site contaminant transport through surface water and air are anticipated to result in negligible exposure potential and will not be addressed in this risk evaluation. However, exposure to contaminants through "limited" migration on-site (e.g., inhalation of fugitive dusts, skin contact with contaminated soils) will be addressed in Section 4.3.

SECTION 4

EXPOSURE EVALUATION

The purpose of the exposure evaluation is to determine the possible extent of human exposure to the indicator chemicals. The evaluation involves the identification of exposed populations, the determination of contaminant concentrations at exposure points, and the estimation of contaminant intake through potential exposure routes. These estimated contaminant intakes are subsequently used in the risk characterization (Section 5).

4.1 IDENTIFICATION OF EXPOSED POPULATIONS

4.1.1 Currently Exposed Populations

Based on the existing information, on-site workers are the only population may be potentially exposed to contaminants at, or emanating from, the 881 Hillside location. It is not the purpose of this risk assessment to address occupational hazards posed by on-site contaminants, but rather to address potential hazards to nonworker populations. However, it may be noted that worker exposure, if any, is expected to be extremely limited. Workers currently are not exposed to media containing high contaminant concentrations (i.e., groundwater). Exposure to other contaminated media (i.e., surface water and soil) is possible, although limited, and contaminant concentrations in these media are low. Groundwater is not currently used at the Plant and there are no workers who routinely have direct skin contact with the soil. Similarly, the site-adjacent surface waters (South Interceptor Ditch and Woman Creek) are not currently used, nor do workers routinely have direct contact with these surface waters. Some worker exposure may occur through the inhalation of

fugitive dusts generated from contaminated soil. Based on the reported soil contaminant concentrations, contaminant exposure through inhalation would be expected to be very low.¹ Workers who might potentially come into contact with contaminated media on a regular basis, such as individuals engaged in on-site investigations or remedial activities, are adequately protected by health and safety procedures.

There is no evidence to suggest that contaminants from the 881 Hillside location are currently reaching nonworker populations. Groundwater contamination with organics is still restricted to the immediate vicinity of the site. The nearest registered² off-site downgradient wells whose presence could be verified are located approximately 2.6 miles from the 881 Hillside location. The nearest downstream surface water with a known usage is Standley Lake, located approximately 4 miles from the Plant boundary. Site-related surface water contamination, if any, appears to be limited to slightly increased concentrations of some metals (see Tables 2-1 through 2-3; Supplement A). These increases are expected to have no measurable impacts on Standley Lake due to the relatively low contaminant concentrations at the site, the distance to the lake, and the dilution of the contaminants as they flow towards the lake.

¹Although this risk assessment does not directly address worker hazards, the risks posed by the inhalation of on-site airborne contaminants and dermal contact with soil will be covered as part of the evaluation of a hypothetical future on-site scenario (see Section 4.2.1). This scenario which assumes that individuals reside at the site provides upper-bound risk estimates associated with dermal and inhalation exposure to contaminants on site. Risk to workers would be expected to be lower because of less frequent contact.

²Colorado State Engineer's Office.

Nonworker exposure through inhalation is also extremely unlikely. As mentioned above, soil contaminant concentrations are relatively low, and the nearest residence to the 881 Hillside is located at a distance of 2.1 miles. Any inhalation exposure is expected to be negligible.

4.1.2 Future Exposed Populations

A risk assessment must not only evaluate the current potential for exposure, but must also consider possible future exposure situations. To assess future risks posed by contaminants at the 881 Hillside location, a scenario involving a suburban housing development was chosen to represent possible future land usage. Two scenarios were addressed. The first, a "worst case" scenario (Scenario A), assumes that at some time in the future the Plant will be closed and residential houses will be constructed over the former 881 Hillside. The second scenario, Scenario B, assumes that housing will be constructed hydrologically down-gradient of the Plant at the Plant boundary. Scenario B represents a "more-likely case" scenario. Future land usage in the area will depend upon numerous factors, including possible legalized land use restrictions. The scenarios used in this risk assessment must thus be viewed as possibilities, but not necessarily probabilities¹. Because of the lack of current receptor populations (see Section 4.1.1), the remainder of this exposure evaluation and the risk characterization that follows will address the potential risks associated with these two hypothetical exposure scenarios.

¹The selection of a housing development and the two exposure scenarios (i.e., on-site and at the Plant boundary) as a basis from which to model potential future risks was agreed upon by representatives of U.S. EPA-Region VIII, the Colorado Department of Health, and Rockwell International at a meeting on November 9, 1987, at the offices of U.S. EPA-Region VIII in Denver, Colorado.

Several potential exposure routes which were considered the most likely means of contaminant exposure in a suburban residential setting were evaluated for each scenario. The routes included:

- Use of groundwater as a drinking water source.
- Showering/bathing with groundwater.
- Ingestion of vegetables from home gardens irrigated with groundwater.
- Inhalation of fugitive dusts.
- Dermal contact with soil/surface water.
- Soil ingestion.

All of these potential exposure routes were assessed for Scenario A. Because groundwater movement is considered to be the only critical migration pathway at the 881 Hillside area (see Section 3.2), only those exposure routes associated with groundwater usage (i.e., drinking water ingestion, showering/bathing, vegetable ingestion) were addressed for Scenario B, which assumes that potential exposure occurs at the Plant boundary.

Because the flow in Woman Creek and the South Interceptor Ditch is intermittent, potential exposure to contaminants through future use of these surface waters as a drinking water source, for showering/bathing, or for watering home gardens is highly unlikely. Therefore potential contaminant exposure through these surface water mediated routes was not addressed in this assessment.

4.2 ESTIMATION OF EXPOSURE POINT CONCENTRATIONS

4.2.1 Scenario A - On-Site

Scenario A assumes that the exposed individuals are residing at the 881 Hillside location and that no changes in contaminant concentrations, as reported in Section 1.0, have occurred. Two exposure situations, the maximally and average exposed individual, were considered.

For the maximally exposed individual, the exposure point concentrations and estimated contaminant intakes are based on the maximum concentration of each of the indicator chemicals that was reported in on-site groundwater and soil samples. This scenario will be used to evaluate the worst case risks potentially posed by contaminants at the 881 Hillside. For the average exposed individual, exposure concentrations and intakes are based on the average reported concentrations. This scenario is used to evaluate risks potentially posed by a more typical exposure situation.

It was assumed in Scenario A that the alluvial groundwater is used for domestic purposes. Based on information gathered during the remedial investigation at the 881 Hillside location, it is unlikely that the alluvial groundwater could yield sufficient quantities of water to make it a practical water source (Rockwell International, 1988). However, data from the alluvial groundwater were used in preference to the bedrock data for two reasons: 1) the alluvial groundwater contains higher concentrations of contaminants than the bedrock, representing a more

conservative estimate of exposure; and 2) the alluvial groundwater will be used to model the off-site migration of contaminants through the groundwater (see Section 4.2.2).¹

The maximum and average contaminant concentrations that are used to estimate contaminant intakes (Section 4.3) are summarized in Table 4-1. Sampling data for the uranium isotopes in alluvial groundwater and soil are reported as pCi/l and pCi/g, respectively (Tables 2-10 and 2-13). Because noncarcinogenic risk will be evaluated in terms of intakes expressed in mg/kg/day, these data are also expressed as mg/l and mg/kg, respectively, (HEW, 1970). The concentrations and activities of the individual uranium isotopes (i.e., U-233, 234, U-235, U-238) were added to give total uranium concentrations and activities.

4.2.2 Scenario B - Plant Boundary

Scenario B assumes that the potentially exposed individuals are residing at the Plant boundary hydrologically downgradient of the 881 Hillside location. The transport of contaminants through the groundwater has been selected as the contaminant migration pathway of concern at the 881 Hillside location (Section 3.2). Therefore, potential exposure to contaminants in Scenario B depends upon potential groundwater contaminant concentrations at the boundary.

Based on available hydrogeological information, it is estimated that the maximum contaminant concentrations that could potentially reach the alluvial groundwater at the plant boundary

¹There is insufficient hydrogeologic data to model the bed-rock water bearing zone at the site. In addition, according to Resource Conservation and Recovery Act (RCRA) guidelines, modeling should be performed on the shallowest aquifer (40 CFR, 265, 264).

Table 4-1

Exposure Point Concentrations Used in the
Estimation of Contaminant Intakes - Scenario A

Indicator Chemical	Alluvial Groundwater (mg/l)		Soil (mg/kg)	
	Average	Maximum	Average	Maximum
<u>Organics</u>				
Bis(2-ethylhexyl)phthalate	NA	NA	1.24	7.21
Carbon Tetrachloride	0.83	28.00	0.008	0.008
1,2-Dichloroethane	0.506	16.00	0.008	0.01
1,1-Dichloroethene	3.78	48.00	0.008	0.008
t-1,2-Dichloroethene	0.125	5.07	0.008	0.018
Tetrachloroethene	1.09	13.20	0.013	0.19
Trichloroethene	4.15	72.00	0.011	0.15
<u>Inorganics</u>				
Nickel	0.080	0.438	13.0	71.0
Selenium	0.276	2.10	0.49	0.49
Strontium	1.00	2.42	66.0	209
<u>Radionuclides</u>				
Uranium (total)	0.036 (22.5 pCi/l)	0.113 (63.6 pCi/l)	3.14 (1.85E+03 pCi/kg)	6.73 (4.1E+03 pCi/kg)

NA = Not applicable. Contaminant not reported above minimum
detection limit in any on-site sample from this medium.

would be approximately 1/38 of the contaminant concentrations present in the alluvial groundwater beneath the 881 Hillside location. This estimate assumes that no physical or chemical process (e.g., volatilization, sorption), other than dilution, would attenuate the groundwater contaminant concentrations as the contaminants migrate from the site to the boundary.

It has also been estimated that it would take between 80 and 200 years for the maximum contaminant concentrations (i.e., 1/38 of the on-site concentrations) to reach the property boundary. Approximately 1/2 of the maximum contaminant concentrations (i.e., $0.5 \times 1/38$ of the on-site concentrations) is expected to reach the plant boundary in approximately 80 years.

The approach and assumptions used in predicting the potential contaminant concentrations and migration times are presented in Supplement E. Details of the hydrogeology of the site are presented in Section 5 of the Remedial Investigation Report.

Based on the predicted dilution factor of 38, potential exposure concentrations for Scenario B were estimated by dividing the average and maximum groundwater concentrations for Scenario A (Table 4-1) by 38. The exposure concentrations that were used to assess potential risk for Scenario B are summarized in Table 4-2.

4.3 ESTIMATION OF CONTAMINANT INTAKES

The following is a description of the methodologies used in the estimation of the average daily intake of each indicator chemical through the exposure routes listed in Section 4.1.2.

Table 4-2

Exposure Point Concentrations Used in the
Estimation of Contaminant Intakes - Scenario B

Indicator Chemical	Groundwater (mg/l)	
	Average	Maximum
<u>Organics</u>		
Bis(2-ethylhexyl)phthalate	NA	NA
Carbon Tetrachloride	2.18E-02	7.37E-01
1,2-Dichloroethane	1.33E-02	4.21E-01
1,1-Dichloroethene	9.95E-02	1.26E+00
t-1,2-Dichloroethene	3.29E-03	1.33E-01
Tetrachloroethene	2.87E-02	3.47E-01
Trichloroethene	1.09E-01	1.89E+00
<u>Inorganics</u>		
Nickel	2.11E-03	1.15E-02
Selenium	7.26E-03	5.53E-02
Strontium	2.63E-02	6.37E-02
<u>Radionuclides</u>		
Uranium (mg/l)	9.47E-04	2.97E-03

NA = Not applicable. Contaminant not reported above minimum detection limit in any on-site sample from this medium.

Intakes were calculated for both adults and children. Children are considered to be a potentially sensitive subpopulation for three reasons: 1) children may be more vulnerable than adults to the toxic effects of some chemicals due to differences in their ability to absorb, metabolize, and/or excrete these substances; 2) their behavioral patterns may result in increased exposure; and 3) children are in a formative stage, and bone-seeking chemicals (e.g., uranium) have a longer retention period than in adults. Two exposure routes which are potentially of greater concern in children than in adults are soil ingestion and dermal absorption. Children may consume greater quantities of outdoor soil than adults due to their tendency to place their fingers and/or other objects which have come into contact with soil into their mouths. Dermal absorption through soil or surface water contact may also be of greater concern in children than in adults since children regularly play outside during the warmer months of the year.

Contaminant intakes for children were based on exposure factors estimated for a child aged 1-6 years. This is the age group most likely to exhibit pica (ingestion of nonfood materials) and, therefore, the most likely to be subject to additional exposure. Calculated contaminant intakes for adults and children were expressed as mg/kg (body weight)/day. A 70 kg body weight was used for adults and a 15 kg body weight was used for children (La Goy, 1987).

4.3.1 Drinking Water

Daily contaminant intakes resulting from drinking water ingestion were calculated using the following equation:

Contaminant Intake Through Drinking Water Ingestion (mg/kg/day)	=	Volume of Water Ingested (l/day)	x	Groundwater Contaminant Concentration (mg/l)
		Body Weight (kg)		

It was assumed that an adult consumes 2 liters of water/day and that a child consumes 1 liter/day (NRC, 1986).

The estimated drinking water contaminant intakes for Scenarios A and B are summarized in Tables 4-3 and 4-4, respectively. Drinking water intakes were calculated for all indicator chemicals except bis(2-ethylhexyl)phthalate. Bis(2-ethylhexyl)phthalate has not been reported above EPA minimum detection limits in groundwater samples downgradient of the 881 Hillside location (Rockwell International, 1986).

4.3.2 Showering/Bathing

The domestic use of groundwater can potentially result in contaminant exposure not only through use as a drinking water source, but also through other water uses such as bathing, showering, and cooking. Of particular potential concern is exposure to volatile organics through inhalation as a result of prolonged hot showers. The combination of elevated temperature and the spray from the shower head could result in high vapor concentrations, particularly in confined areas such as an enclosed shower. The elevated temperature would also be expected to facilitate dermal absorption. It has been estimated that the amount of volatile organics absorbed by an adult through the inhalation of enclosed shower air could be equivalent to that absorbed through drinking water ingestion (Cothorn et al., 1986). Similarly, the National Research Council has suggested that until definitive data are developed, that it be assumed that daily contaminant intake through "other" groundwater usages is equal to the daily intake through drinking water ingestion (NRC, 1986). Therefore, it was assumed in this exposure evaluation that the daily intakes of volatile organics through non-ingestion usages of groundwater were equal to those calculated for drinking water (Tables 4-3 and 4-4).

Table 4-3

**Daily Contaminant Intakes Through
Drinking Water Ingestion - Scenario A
(mg/kg/day)**

Indicator Chemical	Adult		Child	
	Average	Maximum	Average	Maximum
<u>Organics</u>				
Carbon tetrachloride	2.37E-02	8.00E-01	5.53E-02	1.87E+00
1,2-Dichloroethane	1.45E-02	4.57E-01	3.37E-02	1.07E+00
1,1-Dichloroethene	1.08E-01	1.37E+00	2.52E-01	3.20E+00
t-1,2-Dichloroethene	3.57E-03	1.45E-01	8.33E-03	3.38E-01
Tetrachloroethene	3.11E-02	3.77E-01	7.27E-02	8.80E-01
Trichloroethene	1.19E-01	2.06E+00	2.77E-01	4.80E+00
<u>Inorganics</u>				
Nickel	2.29E-03	1.25E-02	5.33E-03	2.92E-02
Selenium	7.89E-03	6.00E-02	1.84E-02	1.40E-01
Strontium	2.86E-02	6.91E-02	6.67E-02	1.61E-01
<u>Radionuclides</u>				
Uranium (total)	1.03E-03	3.23E-03	2.40E-03	7.53E-03

Table 4-4

Daily Contaminant Intakes Through
Drinking Water Ingestion - Scenario B.
(mg/kg/day)

Indicator Chemical	Adult		Child	
	Average	Maximum	Average	Maximum
<u>Organics</u>				
Carbon tetrachloride	6.24E-04	2.11E-02	1.46E-03	4.91E-02
1,2-Dichloroethane	3.80E-04	1.20E-02	8.88E-04	2.81E-02
1,1-Dichloroethene	2.84E-03	3.61E-02	6.63E-03	8.42E-02
t-1,2-Dichloroethene	9.40E-05	3.81E-03	2.19E-04	8.89E-03
Tetrachloroethene	8.20E-04	9.92E-03	1.91E-03	2.32E-02
Trichloroethene	3.12E-03	5.41E-02	7.28E-03	1.26E-01
<u>Inorganics</u>				
Nickel	6.02E-05	3.29E-04	1.40E-04	7.68E-04
Selenium	2.08E-04	1.58E-03	4.84E-04	3.68E-03
Strontium	7.52E-04	1.82E-03	1.75E-03	4.25E-03
<u>Radionuclides</u>				
Uranium (total)	2.71E-05	8.50E-05	6.32E-05	1.98E-04

Estimated daily contaminant intakes through showering/bathing and other noningestion groundwater usages are summarized for Scenarios A and B in Tables 4-5 and 4-6, respectively. Inhalation and dermal absorption of the metals and radionuclides present in the groundwater would be expected to be negligible during showering/bathing since these substances are not volatilized and they do not readily pass across the skin. Thus, the noningestion groundwater exposure routes were not addressed for these chemicals.

4.3.3 Vegetable Ingestion

Two locally-grown food crops were chosen to represent the potential for the intake of contaminants through the ingestion of home-grown vegetables that are irrigated with contaminated groundwater. Carrots were selected to represent a root vegetables and lettuce was selected to represent a leafy vegetable.

Of the indicator chemicals identified in groundwater samples, only selenium, strontium, and uranium are considered to be of potential concern through vegetable ingestion. Evidence is lacking for the bioaccumulation of the volatile organics in natural foodchains. The amount of volatile organics that could potentially be ingested through vegetable consumption is expected to be negligible in comparison to other exposure routes such as drinking water ingestion. Therefore, the intake of the volatile organic indicator chemicals through vegetable ingestion is not considered in this assessment.

The potential average daily intake of contaminants through vegetable ingestion was estimated using the following equations:

Table 4-5

Daily Contaminant Intakes Through
Showering/Bathing - Scenario A
(mg/kg/day)

Indicator Chemical	Adult		Child	
	Average	Maximum	Average	Maximum
<u>Organics</u>				
Carbon tetrachloride	2.37E-02	8.00E-01	5.53E-02	1.87E+00
1,2-Dichloroethane	1.45E-02	4.57E-01	3.37E-02	1.07E+00
1,1-Dichloroethene	1.08E-01	1.37E+00	2.52E-01	3.20E+00
t-1,2-Dichloroethene	3.57E-03	1.45E-01	8.33E-03	3.38E-01
Tetrachloroethene	3.11E-02	3.77E-01	7.27E-02	8.80E-01
Trichloroethene	1.19E-01	2.06E+00	2.77E-01	4.80E+00

Table 4-6

Daily Contaminant Intakes Through
Showering/Bathing - Scenario B
(mg/kg/day)

Indicator Chemical	Adult		Child	
	Average	Maximum	Average	Maximum
<u>Organics</u>				
Carbon tetrachloride	6.24E-04	2.11E-02	1.46E-03	4.91E-02
1,2-Dichloroethane	3.80E-04	1.20E-02	8.88E-04	2.81E-02
1,1-Dichloroethene	2.84E-03	3.61E-02	6.63E-03	8.42E-02
t-1,2-Dichloroethene	9.40E-05	3.81E-03	2.19E-04	8.89E-03
Tetrachloroethene	8.20E-04	9.92E-03	1.91E-03	2.32E-02
Trichloroethene	3.12E-03	5.41E-02	7.28E-03	1.26E-01

$$\begin{array}{l} \text{Contaminant} \\ \text{Intake Through} \\ \text{Vegetable} \\ \text{Ingestion} \\ \text{(mg/kg/day)} \end{array} = \begin{array}{l} \text{Contaminant} \\ \text{Intake Through} \\ \text{Carrot} \\ \text{Ingestion} \\ \text{(mg/kg/day)} \end{array} + \begin{array}{l} \text{Contaminant} \\ \text{Intake Through} \\ \text{Lettuce} \\ \text{Ingestion} \\ \text{(mg/kg/day)} \end{array}$$

where,

$$\begin{array}{l} \text{Contaminant} \\ \text{Intake Through} \\ \text{Carrot/Lettuce} \\ \text{Ingestion} \\ \text{(mg/kg/day)} \end{array} = \begin{array}{l} \text{Carrot/Lettuce} \\ \text{Contaminant} \\ \text{Concentration} \\ \text{(mg/kg vegetable)} \end{array} \times \begin{array}{l} \text{Carrot/Lettuce} \\ \text{Ingestion Rate} \\ \text{(kg vegetable/} \\ \text{kg/day)} \end{array}$$

The approach used in determining contaminant concentrations in vegetables is described in Supplement D. The carrot and lettuce ingestion rates for adults and children were based upon data for ingestion of leafy vegetables and root vegetables (kg dry weight/day) by adult males aged 25 to 65 years, and children aged 2 years, respectively (EPA, 1986b). These data were adjusted by converting to kg wet weight (Baes, et al, 1984) and by assuming that 50 percent of the carrots and lettuce consumed during the year were homegrown. It is expected that a typical suburban household grows a smaller percentage of its vegetables than a rural household. Rural households have been reported to grow approximately 60 percent of their vegetables (EPA, 1986b). The average daily ingestion rate of carrots was estimated to be 3.11E-04 kg carrots/kg/day for children and 1.21E-04 kg carrots/kg/day for adults. For lettuce, the ingestion rates were estimated to be 4.82E-04 kg lettuce/kg/day for children and 3.35E-04 kg lettuce/kg/day for adults.

The estimated daily intakes of contaminants through vegetable ingestion are summarized for Scenario A in Tables 4-7 (adult) and 4-8 (child). Estimated daily intakes for Scenario B are presented in Tables 4-9 (adult) and 4-10 (child).

Table 4-7

Daily Contaminant Intakes Through Vegetable Consumption
 Scenario A - Adult
 (mg/kg/day)

Indicator Chemical	Average			Maximum		
	Carrots	Lettuce	Total	Carrots	Lettuce	Total
<u>Inorganics</u>						
Nickel	1.82E-04	5.03E-04	6.85E-04	9.92E-04	2.75E-03	3.74E-03
Selenium	2.52E-04	6.98E-04	9.50E-04	1.91E-03	5.28E-03	7.19E-03
Strontium	3.06E-03	8.46E-02	8.77E-02	8.88E-03	2.46E-01	2.55E-01
<u>Radionuclides</u>						
Uranium (total)	9.36E-06	5.51E-05	6.45E-05	2.79E-05	1.64E-04	1.92E-04

Table 4-8

Daily Contaminant Intakes Through Vegetable Consumption
 Scenario A - Child
 (mg/kg/day)

Indicator Chemical	Average			Maximum		
	Carrots	Lettuce	Total	Carrots	Lettuce	Total
<u>Inorganics</u>						
Nickel	4.67E-04	7.23E-04	1.19E-03	2.55E-03	3.95E-03	6.50E-03
Selenium	6.48E-04	1.00E-03	1.65E-03	4.91E-03	7.60E-03	1.25E-02
Strontium	7.86E-03	1.22E-01	1.30E-01	2.29E-02	3.54E-01	3.77E-01
<u>Radionuclides</u>						
Uranium (total)	2.41E-05	7.92E-05	1.03E-04	7.17E-05	2.36E-04	3.08E-04

Table 4-9

Daily Contaminant Intakes Through Vegetable Consumption
 Scenario B - Adult
 (mg/kg/day)

Indicator Chemical	Average			Maximum		
	Carrots	Lettuce	Total	Carrots	Lettuce	Total
<u>Inorganics</u>						
Nickel	9.67E-05	2.68E-04	3.65E-04	5.28E-04	1.46E-03	1.99E-03
Selenium	8.07E-06	2.24E-05	3.05E-05	5.16E-05	1.43E-04	1.95E-04
Strontium	2.02E-03	5.60E-02	5.80E-02	6.39E-03	1.77E-01	1.83E-01
<u>Radionuclides</u>						
Uranium (total)	1.73E-06	1.02E-05	1.19E-05	3.90E-06	2.30E-05	2.69E-05

Table 4-10

Daily Contaminant Intakes Through Vegetable Consumption
 Scenario B - Child
 (mg/kg/day)

Indicator Chemical	Average			Maximum		
	Carrots	Lettuce	Total	Carrots	Lettuce	Total
<u>Inorganics</u>						
Nickel	2.49E-04	3.85E-04	6.34E-04	1.36E-03	2.10E-03	3.46E-03
Selenium	2.08E-05	3.22E-05	5.30E-05	1.33E-04	2.06E-04	3.39E-04
Strontium	5.21E-03	8.06E-02	8.58E-02	1.64E-02	2.55E-01	2.71E-01
<u>Radionuclides</u>						
Uranium (total)	4.44E-06	1.46E-05	1.90E-05	1.00E-05	3.31E-05	4.31E-05

4.3.4 Inhalation of Fugitive Dusts

To determine potential contaminant intakes through the inhalation of fugitive dusts, the following equation was used:

Contaminant Intake Through Dust Inhalation (mg/kg/day)	= Soil Contaminant Concentration (mg/kg)	x	Concentration of Ambient Airborne Particles (mg/m ³)	x	Breathing Rate (m ³ /day)	x	10 ⁻⁶ kg/mg
Body Weight (kg)							

The average concentration of ambient airborne particles is assumed to be 0.017 mg/m³. This is the mean concentration of particles less than 2.5 microns in diameter reported for a rural setting (EPA, 1982). It is assumed that the suspended airborne particles have the same relative contaminant concentrations as the soil. This approach also conservatively assumes that 100 percent of the inhaled contaminants are absorbable. Breathing rates of 20 m³/day (EPA, 1986) and 5 m³/day (NCRP, 1984 and EPA, 1986) were used for the adult and child, respectively.

Estimates of contaminant intakes through dust inhalation are summarized for Scenario A in Table 4-11. It should be noted that for the fugitive dust and other soil related exposure pathways (i.e., dermal contact and soil ingestion), the average and maximum soil concentrations used in the estimation of daily contaminant intakes are based upon the analysis of composite soil samples that were collected at depths of up to 10 feet. The concentrations of the indicator chemicals at the soil surface are not known. Although it is unlikely that measurable

Table 4-11

**Daily Contaminant Intakes Through Fugitive
Dust Inhalation - Scenario A
(mg/kg/day)**

Indicator Chemical	Adult		Child	
	Average	Maximum	Average	Maximum
<u>Organics</u>				
bis(2-ethylhexyl)- phthalate	6.02E-09	3.50E-08	7.03E-09	4.09E-08
Carbon tetrachloride	3.89E-11	3.89E-11	4.53E-11	4.53E-11
1,2-Dichloroethane	3.89E-11	4.86E-11	4.53E-11	5.67E-11
1,1-Dichloroethene	3.89E-11	3.89E-11	4.53E-11	4.53E-11
t-1,2-Dichloroethene	3.89E-11	8.74E-11	4.53E-11	1.02E-10
Tetrachloroethene	6.31E-11	9.23E-10	7.37E-11	1.08E-09
Trichloroethene	5.34E-11	7.29E-10	6.23E-11	8.50E-10
<u>Inorganics</u>				
Nickel	6.31E-08	3.45E-07	7.37E-08	4.02E-07
Selenium	2.38E-09	2.38E-09	2.78E-09	2.78E-09
Strontium	3.21E-07	1.02E-06	3.74E-07	1.18E-06
<u>Radionuclides</u>				
Uranium (total)	1.53E-08	3.27E-08	1.78E-08	3.81E-08

quantities of volatile organics are present in surface soil (see Section 3.2), it is conservatively assumed in this risk analysis that the concentrations of volatile organics measured in the composite soil samples are potentially representative of surface soil concentrations as well.

4.3.5 Dermal Contact

Dermal absorption of contaminants might potentially occur through contact with groundwater, surface water, or soil. Dermal contact with groundwater was addressed in Section 4.3.2. Dermal contact with surface water is not an exposure route of concern in this case. Metals were the only indicator chemicals identified above detection limits in surface water samples. Due to the relative impermeability of the skin to these metals, occasional dermal contact with surface water would be expected to result in negligible absorption. Therefore, only dermal contact with soil was addressed as an exposure route in this section.

The average daily intake¹ of contaminants resulting from dermal contact with soil was estimated using the following formula:

$$\frac{\text{Contaminant Intake Through Dermal Contact (mg/kg/day)}}{\text{Body Weight (kg)}} = \frac{\text{No. of Exposures/year} \times \text{Amt. of Contaminant Absorbed per Exposure} \times \text{1 year/365 days}}{\text{Body Weight (kg)}}$$

where,

$$\text{Amount of Contaminant Absorbed/Exposure} = \frac{\text{Soil Concentration (mg/kg)} \times \text{Amt. of Soil Adhering to Skin/Exposure} \times \text{Fractional Absorption} \times 10^{-6}}{\text{kg/mg}}$$

¹Averaged over a one year period.

Table A-2

Scoring for Indicator Chemical Selection Based on Carcinogenic Effects

Chemical	Groundwater CXT		Surface Water CXT		Soil CXT		Indicator Score		Rank	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Organics										
Aroclor-1254	—	—	—	—	7.15E-07	2.00E-06	7.15E-07	2.00E-06	9	9
bis (2-ethylhexyl) phthalate	—	—	—	—	3.53E-08	2.06E-07	3.53E-08	2.06E-07	10	10
Carbon tetrachloride	1.56E+00	5.26E+01	—	—	—	—	1.56E+00	5.26E+01	1	1
Chloroform	2.25E-04	2.08E-03	—	—	—	—	2.25E-04	2.08E-03	7	6
1,2-Dichloroethane	2.97E-02	9.38E-01	—	—	2.34E-08	2.93E-08	2.97E-02	9.38E-01	3	3
1,1-Dichloroethene	4.64E-01	4.90E+00	—	—	4.91E-08	4.91E-08	4.64E-01	4.90E+00	2	2
PAH (as B(a)P)	—	—	—	—	5.36E-04	4.42E-04	5.36E-04	5.36E-04	6	8
Tetrachloroethene	9.65E-03	1.17E-01	—	—	5.76E-09	8.42E-08	9.65E-03	1.17E-01	5	4
1,1,2-Trichloroethane	1.24E-04	1.43E-03	—	—	4.11E-09	1.39E-08	1.24E-04	1.43E-03	9	7
Trichloroethene	1.78E-02	5.66E-02	—	—	2.35E-09	5.78E-09	1.78E-02	5.66E-02	4	5

¹Concentration (C) times toxicity constant (T).

Table A-3

**Toxicity Constants used in Determining
Indicator Scores¹**

Chemical	Noncarcinogenic Effects		Carcinogenic Effects ²	
	Water (1/mg)	Soil (kg/mg)	Water (1/mg)	Soil (kg/mg)
<u>Metals</u>				
Antimony	4.30E+00	2.17E-04	---	---
Barium	4.08E+00	2.04E-04	---	---
Cadmium	4.45E+00	2.23E-04	NC	NC
Copper	7.14E-01	3.57E-05	---	---
Mercury	1.84E+01	9.21E-04	---	---
Nickel	4.26E+00	2.13E-04	NC	NC
Selenium	1.05E+02	5.26E-03	---	---
Silver	2.00E+00	NA	---	---
Vanadium	1.43E-01	7.14E-06	---	---
Zinc	1.07E-01	5.33E-06	---	---
<u>Organics</u>				
Aroclor-1254	NA	NC	5.71E-01	2.86E-05
bis(2-ethylhexyl) phthalate	NA	NC	5.71E-04	2.86E-08
2-Butanone	7.75E-03	3.87E-07	---	---
Carbon tetrachloride	3.17E-01	NA	1.88E+00	NA
Chloroform	NC	NA	5.63E-02	NA
1,2-Dichloroethane	1.76E-02	8.80E-07	5.86E-02	2.93E-06
1,1-Dichloroethene	3.71E-01	1.86E-05	1.23E-01	6.14E-06
t-1,2-Dichloroethene	5.29E-02	2.65E-06	---	---
Di-n-butyl phthalate	NA	1.90E-06	---	---
Methylene chloride	9.20E-04	4.60E-08	NC	NC
PAH (as B(a)P)	NA	1.33E-03	NA	2.28E-04
Tetrachloroethene	9.62E-03	4.81E-07	8.86E-03	4.43E-07
Toluene	5.20E-03	2.60E-07	---	---
1,1,1-Trichloroethane	7.33E-04	3.67E-08	---	---
1,1,2-Trichloroethane	NC	NC	1.03E-02	5.14E-07
Trichloroethene	1.05E+00	5.26E-05	4.29E-03	2.14E-07

NA = Not applicable. Substance not reported above detection limits in this medium. Toxicity constant may or may not be available.
 NC = No constant available. Substance was reported above detection limits in this medium.

¹U.S. EPA, 1986a

²A dash (-) indicates the substance is not a potential carcinogen.

Table A-4

Top-Ranking Contaminants Based on
Indicator Scores ¹

Noncarcinogenic Effects	Carcinogenic Effects
Selenium	Carbon tetrachloride
Antimony	1,1-Dichloroethene
Trichloroethene	1,2-Dichloroethane
1,1-Dichloroethene	Trichloroethene
Barium	Tetrachloroethene
Nickel	
Carbon Tetrachloride	
Zinc	
t-1,2-Dichloroethene	
Mercury	
Tetrachloroethene	
Cadmium	

¹ Listed in order of rank from highest to lowest based on average concentrations.

Table A-5

Chemicals Detected Above Background for which
Toxicity Constants Were Not Available

Metals

Aluminum

Beryllium

Chromium

Iron

Manganese

Strontium

Organics

Acetone

Bromomethane

Dibromochloroethane

di-n-octyl phthalate

4-Methyl-2-pentanone

N-nitrosodiphenylamine

Table A-6

Reasons for Not Including Substances Among the
Top Ranked for Noncarcinogenic Effects,
as Indicator Chemicals

Antimony

- Not reported above background in surface water or soil samples.
- Reported above background in only one alluvial well (69-86) in 1986 Phase II samples only; not reported above background in four quarters of 1987.
- Average bedrock groundwater concentration (0.03 mg/l) only slightly above average background concentration (0.021 mg/l).

Barium

- Not reported above background in alluvial groundwater samples.
- Average bedrock groundwater concentration (0.121 mg/l) only slightly above average background concentration (0.103 mg/l).
- Not detected above minimum detection limit in surface water samples.

Cadmium

- Not reported above background in groundwater or soil samples.
 - Reported slightly above background (0.006 mg/l vs. 0.0025 mg/l) in one surface water sample from the interceptor ditch in 1987; was below minimum detection limit in 1986 and later 1987 samples from the ditch and in all samples from Woman Creek.
-

Table A-6
(continued)

Mercury

- Not reported above background in surface water or groundwater samples.
- Average soil concentration (0.179 mg/kg) not unusual for soils in general (0.17 average) or clayey soils (0.13 av.) (Kabata-Pendias and Pendias, 1984).

Zinc

- Low toxicity.
 - Reported above background in one Interceptor Ditch sample in 1986; not reported in 1987 sample from the ditch or in two 1987 samples from Woman Creek.
 - Average alluvial groundwater concentration (0.055 mg/l) only slightly above average background concentration (0.044 mg/l); not above background in bedrock groundwater; groundwater concentrations do not exceed Federal Secondary Maximum Contaminant Level of 5 mg/l.
 - Average soil concentration (54 mg/kg) only slightly above average background (32.7 mg/kg).
-

Table A-7

Reasons for Not Including Contaminants Among Those Without
Toxicity Constants as Indicator Chemicals

Inorganics

Aluminum

- Low toxicity.
- Reported above background in one 1986 surface water sample from the Interceptor Ditch; was below minimum detection limit in 1987 samples from the Interceptor Ditch and Woman Creek.
- Average concentrations in alluvial and bedrock wells (0.150 mg/l and 0.328 mg/l, respectively), were only slightly above average background (0.128 mg/l and 0.107 mg/l, respectively).

Beryllium

- Not reported above background in soil or groundwater samples.
- Insufficient surface water data; was reported above background in one 1986 sample from the Interceptor Ditch; has not been assayed since.

Chromium

- Not reported above background in surface water or alluvial groundwater samples.
- Average concentration in soil samples only slightly above average background samples (12 mg/kg vs 9.3 mg/kg).
- Average concentration in bedrock groundwater only slightly above average background (0.13 mg/l vs 0.006 mg/l).

Iron

- Low toxicity.
 - Not reported above background in surface water or alluvial well samples.
-

Table A-7
(continued)

-
- Average concentration in bedrock groundwater only slightly above average background (0.197 vs 0.063 mg/l); concentrations do not exceed Federal Secondary Maximum Contaminant Level of 300 mg/l).
 - Average concentration in soil is only slightly above average background (15,171 mg/kg vs 10,719 mg/kg).

Manganese

- Low toxicity.
- Not reported above background in soil samples.
- Average alluvial groundwater concentration only slightly above average background (0.144 vs 0.076 mg/l).
- Low concentrations (0.037 mg/l and 0.070 mg/l) reported in surface water samples from the Interceptor Ditch; not detected above minimum detection limit in samples from Woman Creek.

Organics

Acetone

- Low toxicity.
- Not detected above minimum detection limit in surface water samples.
- Common laboratory contaminant; reported in soil and groundwater laboratory blanks.

Bromomethane

- Not detected above minimum detection limit in groundwater or surface water samples.
 - Reported at a low concentration (estimated at 6.0 ug/kg) in only one soil sample; not detected above the minimum detection limit in 90 soil samples.
-

Table A-7
(continued)

Dibromochloromethane

- Not detected above minimum detection limit in ground-water or surface water samples.
- Reported at a low concentration (estimated at 1 ug/kg) in only one soil sample; not detected above the minimum detection limit in 90 soil samples.

Di-n-octyl phthalate

- Low toxicity.
- Not detected above minimum detection limit in ground-water or surface water samples.
- Will be represented in the risk analysis by bis-(2-ethylhexyl) phthalate, which is more toxic and which was identified in more soil samples and at higher concentrations than di-n-butyl phthalate.

4-methyl-2-pentanone

- Low toxicity.
- Not detected above minimum detection limit in ground-water or surface water samples.
- Reported in only one soil sample at 68 ug/kg; was below the minimum detection limit in 90 soil samples.

N-nitrosodiphenylamine

- Not detected above minimum detection limit in groundwater or surface water samples.
- Low average soil concentration (78 ug/kg).
- Will be represented in the risk analysis by bis (2-ethylhexyl) phthalate which is similar in being a carcinogenic organic compound detected only in on-site soil samples; bis (2-ethylhexyl) phthalate was reported at higher concentrations and was identified in more soil samples than N-nitrosodiphenylamine.

References:

EPA (Environmental Protection Agency), Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response. Washington, DC, OSWER Directive 9285.4-1, 1986.

Kabata-Pendias, A., and H. Pendias, Trace Elements in Soils and Plants, Boca Raton, Florida: CRC Press, Inc., 1984.

SUPPLEMENT B
TOXICITY PROFILES

TOXICITY PROFILES OF THE INDICATOR CHEMICALS

The following sections contain toxicity profiles of the indicator chemicals that were chosen for the 881 Hillside location. The profiles provide information concerning adverse effects associated with these substances and the dosage levels at which they occur. The lowest concentrations at which toxic effects have been reported are stressed. These summaries are not intended to be exhaustive accounts of the toxicological literature, but rather to give a general picture of the toxic effects of these substances.

ABBREVIATIONS/DEFINITIONS

ACGIH	American Conference of Governmental Industrial Hygienists
AADI	Adjusted Acceptable Daily Intake: calculated from an ADI by factoring in the weight of the consumer and the amount of water consumed per day.
ADI	Acceptable Daily Intake: a no-effect level for noncarcinogenic effects based on chronic/lifetime exposure.
AIC	Acceptable Chronic Intake: a no-effect level for noncarcinogenic effects developed by a process similar to that of ADI determination.
AIS	Acceptable Subchronic Intake: a no-effect level for subchronic exposure developed by a process similar to that of ADI development.
Carcinogenic Potency Factor	The additional risk of cancer posed by the ingestion of one mg of a substance per kg of body weight per day over a lifetime.
HA	Health Advisory: nonregulatory drinking water concentration which, if ingested over a specified period of time will not result in noncarcinogenic effects.
MCL	Maximum Contaminant Level: enforceable standard-- for public drinking water supplies set by the U.S. EPA.
MCLG	Maximum Contaminant Level Goal: nonenforceable health goals--protective against adverse health effects.
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit: acceptable worker exposure level.

RfD Reference Dose: estimate of a long-term daily exposure that is unlikely to cause noncarcinogenic effects.

SNARL Suggested-No-Adverse-Response-Level: no-effect level recommended by the National Academy of Science's Safe Drinking Water Committee for a specific exposure duration.

TLV-STEL Threshold Limit Value--Short Term Exposure Limit: fifteen-minute, time-weighted average which should not be exceeded at any time during a work day.

TLV-TWA Threshold Limit Value--Time-Weighted Average: the time-weighted average concentration for an eight-hour workday, forty-hour work week, to which workers may be exposed indefinitely without adverse effect.

BIS(2-ETHYLHEXYL)PHTHALATE (DEHP)

1.0 PHYSICO/CHEMICAL PROPERTIES (Clayton and Clayton, 1981)

Molecular Weight	390.54
Vapor Pressure	1.2 mm Hg (200°C)
Boiling Point	230°C (5 mm Hg)
Melting Point	-50°C

2.0 TOXICOLOGICAL EFFECTS

DEHP has a low acute toxicity. Long-term exposure can affect the liver. High doses may cause toxicity to reproductive organs.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Animal

DEHP has a low acute toxicity. The main acute effect is mild irritation at the site of administration (NAS, 1986). Oral LD₅₀s of approximately 30 g/kg have been reported in rats and rabbits; dermal LD₅₀s of greater than 10 to 25 mg/kg have been observed in guinea pigs and rabbits (Clayton and Clayton, 1981; U.S. EPA, 1980).

2.1.2 Subchronic

Animal

Liver enlargement has been observed in rats that were administered DEHP in corn oil at 2,000 mg/kg/day for 21 days (Lake, et al., 1975). Changes in liver enzyme activity and alterations in subcellular morphology (increase in microbodies, swelling of the smooth endoplasmic reticulum) were also noted. Increased liver size and an increase in the smooth endoplasmic reticulum were also reported in rats fed 5,000 ppm DEHP in their diet for 35 or 49 days (Daniel and Bratt, 1974).

Numerous studies have indicated adverse effects of high doses of DEHP on the testes of rodents. Testicular atrophy has been reported in rats fed 0.2 percent DEHP for 90 days or 1.0 percent DEHP for two weeks (Carter, et al., 1977) and in rats dosed

with approximately 0.9 and 1.9 g/kg/day for 90 days (Shaffer, et al., 1945). A slight decrease in growth was noted in the Shaffer study in animals dosed at 0.4 to 1.9 g/kg/day.

Decreases in testicular weight have also been seen in rats fed 2 percent DEHP in their diet (approximately 1,200 mg/kg/day) for 6 or 17 weeks (Gray, et al., 1977). Histological changes were noted at concentrations as low as 0.2 percent. Testicular sensitivity appears to be age dependent. Testicular lesions have been found in four and ten week old rats fed 2 percent DEHP in the diet, but not in 15 week old rats (Gray and Butterworth, 1980). Male rats fed DEHP in their diet at 5,000 and 20,000 ppm for 60 days exhibited a decrease in total body weight and decreased weight of the testes, epididymis, and prostate; a decreased sperm count and an increase in abnormal sperm were noted in the 20,000 ppm group (Agarwal, et al., 1985).

Decreases in the weight of female reproductive organs have also been reported in rodents exposed to high doses of DEHP. Decreased ovary weights were observed in female rats fed 2 percent DEHP in their diet for 17 weeks, although no histological changes were noted (Gray, et al., 1977). Decreases in uterine and ovarian weights and suppression of fertility occurred in female mice exposed to 0.3 percent DEHP in the diet for 18 weeks (Reel, et al., 1985).

2.1.3 Chronic

Animal

Liver enlargement is a consistent finding in animals that have been chronically exposed to DEHP. Increased liver size has been reported in guinea pigs fed 0.04 and 0.13 percent DEHP in their diet for one year (Carpenter, et al., 1953). An increase in both kidney and liver size was seen in rats that received 0.5 percent DEHP in their feed for three and six months (Harris, et al., 1956) and in parental and first generation rats that had received 0.4 percent DEHP in their feed for two and one years, respectively (Carpenter, et al., 1953).

Decreased body weight has been seen in rats fed 0.5 percent DEHP in their feed for up to two years (Harris, et al., 1956) and in rats fed 0.35 percent DEHP in their feed for 1 year (Nikonorow, et al., 1973).

2.1.4 Teratogenicity

Because of the ubiquity of DEHP, the teratogenic potential of DEHP has been the subject of numerous reproductive studies (see NAS, 1986, for a review). A few of the oral studies are summarized below.

Teratogenic and fetotoxic effects have been produced in laboratory animals at dosages much higher than those that would normally be ingested by humans or those that would be expected to result from clinical practices (e.g., intravenous administration of blood products stored in containers that were manufactured using DEHP as a plasticizer). A decrease in fetal body weight and increased resorptions

were observed in the pups of rat dams that were orally administered 340 or 1,700 mg/kg/day DEHP throughout gestation (Nikonorow, et al., 1973). Gross and skeletal abnormalities were seen in fetuses when pregnant mice were given 2,450 or 7,360 mg/kg DEHP on day 7 or 8 of gestation. Doses of 4,905 or 9,810 mg/kg on day 7 resulted in 100 percent fetal mortality (Yagi, et al., 1980). In a study in which DEHP was administered in the diet at 70 to 2,200 mg/kg/day, decreased maternal weight gain and increased fetal resorptions were seen in all treatment groups (Shista, et al., 1980). One hundred percent mortality was observed in the 830 and 2,200 mg/kg/day groups. An increase in neural tube malformations and other defects were reported in the 830 mg/kg/day group.

2.2 Mutagenicity and Carcinogenicity

DEHP has been classified by the U.S. EPA's Carcinogen Assessment Group as a category B₂ carcinogen (i.e., sufficient evidence of carcinogenicity in animals and inadequate data in humans). DEHP has been shown to produce liver tumors in rats and mice when exposed by the oral route (NTP, 1983). It has also been reported to have second stage promoting activity and weak complete promoting activity in Sencar mouse skin, but to be inactive as a promoter in CD1 mice (Ward, et al., 1986).

DEHP has been extensively tested for mutagenicity in short-term tests. However, positive results have been reported in only a few cases. It has been observed to be a weak inducer of sister chlorinated exchange, to induce aneuploidy in cell cultures, and to induce cell transformation in the Syrian hamster embryo (NAS, 1986).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

RfD	2.00×10^{-2} mg/kg/day	(U.S. EPA, 1986)
Carcinogenic Potency Factor	9.84×10^{-4} (mg/kg/day) ⁻¹	(U.S. EPA, 1986)

3.2 Inhalation

TLV-TWA	5 mg/m ³	(ACGIH, 1987)
TLV-STEL	10 mg/m ³	(ACGIH, 1987)

4.0 REFERENCES

ACGIH (American Conference of Governmental Industrial Hygienists), 1987.
Threshold Limit Values and Biological Exposure Indices for 1987-1988.
 Cincinnati: ACGIH.

For adults, dermal contact with soil is assumed to occur during gardening or other yard work activities. Adults are assumed to work in their yards on an average of two times per week over a 5-month period (May to September), resulting in approximately 45 exposures per year. The amount of soil adhering to skin per exposure has been reported to range from 0.5 to 1.5 mg soil/cm² skin (Schaum, 1984). For the purposes of these calculations, the maximum value was used. Only the hands and arms are assumed to be exposed to soil during gardening and yard work. An arm and hand surface area of 3,190 cm², the figure for an average adult male, was adopted from Anderson (1985). This yields a value of 4,785 mg for the amount of soil adhering to the skin per exposure.

For the young child, dermal contact with soil is assumed to take place during play. Children are assumed to have arm and hand exposure to contaminated soil approximately 5 days per week during the warmer months of the year (May to September). As for the adults, a maximum of 1.5 mg soil/cm² was assumed to adhere to the skin (Schaum, 1984). The area of exposed skin, averaged for 1 to 6 year olds, was calculated to be approximately 1,480 cm² (Anderson, 1985). This yields a value of 2,220 mg for the quantity of soil that adheres to the skin per exposure. Of the indicator chemicals contained in on-site soil samples, only the organics would be anticipated to be of potential concern through dermal absorption. Metals, including the radioisotopes of uranium, although presumably present in surface soils, do not readily penetrate the skin.

Because chemicals that are adsorbed to soil are not readily absorbed through the skin, the estimates of dermal intake must be adjusted for the fraction of the chemical that may be absorbed. There is insufficient data to project the levels of

the organic indicator chemicals that may be absorbed through the skin. Limited data are available, however, for the percent dermal absorption of other organics. Poiger and Schlatter (1980) have calculated that 0.3 to 3 percent of dioxins/furans and chlorinated pesticides that are present in a soil matrix are absorbed through the skin during a single exposure. Feldmann and Maibach (1970) estimate that 3 to 7 percent of polycyclic aromatic hydrocarbons (PAH) are absorbed per exposure. The highest absorption factor that has been reported (7 percent) is assumed in the calculation of dermal intakes for the organic indicator chemicals.

Estimated contaminant intakes through dermal absorption are summarized for Scenario A in Table 4-12.

4.3.6 Soil Ingestion

Soil ingestion is a potentially significant route of contaminant exposure for children aged 1 to 6 years. Ingestion can occur indirectly by placing dirt covered hands or objects in the mouth or, in some cases, directly by eating the soil (pica). The potential for the oral intake of contaminants through soil ingestion is lower for adults than for children. Hand-to-mouth contact occurs less frequently and pica would be expected to be rare.

The average daily intake¹ of contaminants through soil ingestion was calculated using the following equation:

Contaminant Intake Through Soil Ingestion (mg/kg/day)	=	No. of Exposures/ year	x	Soil Contaminant Concentration (mg/kg)	x	Soil Ingestion Rate (mg/day)	x	1 year/ 365 days	x	10 ⁻⁶ kg/mg
				Body Weight (kg)						

¹Averaged over a one year period.

Table 4-12

Daily Contaminant Intakes Through
Dermal Absorption Scenario A
(mg/kg/day)

Indicator Chemical	Adult		Child	
	Average	Maximum	Average	Maximum
<u>Organic</u>				
bis(2-ethylhexyl) phthalate	7.15E-07	4.16E-06	3.87E-06	2.25E-05
Carbon tetrachloride	4.61E-09	4.61E-09	2.50E-08	2.50E-08
1,2-Dichloroethane	4.61E-09	5.77E-09	2.50E-08	3.12E-08
1,1-Dichloroethene	4.61E-09	4.61E-09	2.50E-08	2.50E-08
t-1,2-Dichloroethene	4.61E-09	1.04E-08	2.50E-08	5.62E-08
Tetrachloroethene	7.50E-09	1.10E-07	4.06E-08	5.93E-07
Trichloroethene	6.35E-09	8.65E-08	3.43E-08	4.68E-07

It was assumed that the number of opportunities for contaminant exposure through soil ingestion was the same as that for dermal soil contact (i.e., during the warmer months of the year [May to September] adults might indirectly ingest soil 2 days per week and children might ingest soil 5 days per week). An average soil ingestion rate of 100 mg/day was assumed for children, 25 mg/day for adults (La Goy, 1987). It should be recognized that children exhibiting habitual pica can be expected to ingest greater quantities of soil, possibly as high as 5,000 mg/day (La Goy, 1987). However, such individuals would be expected to comprise only a very small percentage of the population.

Estimates of contaminant intakes through soil ingestion are summarized for Scenario A in Table 4-13.

4.3.7 Summary of Estimated Contaminant Intakes

Estimated contaminant intakes through all exposure routes are summarized for the maximally and average exposed child and adult in Scenario A in Tables 4-13 through 4-17. Estimates of contaminant intakes through all Scenario B potential exposure routes are summarized in Tables 4-18 through 4-21.

Table 4-13

Daily Contaminant Intakes
Through Soil Ingestion-Scenario A
(mg/kg/day)

Indicator Chemical	Adult		Child	
	Average	Maximum	Average	Maximum
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	5.34E-08	3.10E-07	2.49E-06	1.45E-05
Carbon tetrachloride	3.44E-10	3.44E-10	1.61E-08	1.61E-08
1,2-Dichloroethane	3.44E-10	4.31E-10	1.61E-08	2.01E-08
1,1-Dichloroethene	3.44E-10	3.44E-10	1.61E-08	1.61E-08
t-1,2-Dichloroethene	3.44E-10	7.75E-10	1.16E-08	3.62E-08
Tetrachloroethene	5.60E-10	8.18E-09	2.61E-08	3.82E-07
Trichloroethene	4.74E-10	6.46E-09	2.21E-08	3.01E-07
<u>Inorganics</u>				
Nickel	5.60E-07	3.06E-06	2.61E-05	1.43E-04
Selenium	2.11E-08	2.11E-08	9.84E-07	9.84E-07
Strontium	2.84E-06	9.00E-06	1.33E-04	4.20E-04
<u>Radionuclides</u>				
Uranium (total)	1.35E-07	2.90E-07	6.31E-06	1.35E-05

Table 4-14

**Estimation of Contaminant Intakes
(mg/kg/day)**

**Scenario A (On-Site)
Average Exposed Adult**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion
<u>Organics</u>						
bis(2-ethylhexyl) phthalate	NA	NA	NA	6.02E-09	7.15E-07	5.34E-08
Carbon tetrachloride	2.37E-02	2.37E-02	NA	3.89E-11	4.61E-09	3.44E-10
1,2-Dichloroethane	1.45E-02	1.45E-02	NA	3.89E-11	4.61E-09	3.44E-10
1,1-Dichloroethene	1.08E-01	1.08E-01	NA	3.89E-11	4.61E-09	3.44E-10
t-1,2-Dichloroethene	3.57E-03	3.57E-03	NA	3.89E-11	4.61E-09	3.44E-10
Tetrachloroethene	3.11E-02	3.11E-02	NA	6.31E-11	7.50E-09	5.60E-10
Trichloroethene	1.19E-01	1.19E-01	NA	5.34E-11	6.35E-09	4.74E-10
<u>Inorganics</u>						
Nickel	2.29E-03	NA	6.85E-04	6.31E-08	NA	5.60E-07
Selenium	7.89E-03	NA	9.50E-04	2.38E-09	NA	2.11E-08
Strontium	2.86E-02	NA	8.77E-02	3.21E-07	NA	2.84E-06
<u>Radionuclides</u>						
Uranium (total)	1.03E-03	NA	6.45E-05	1.53E-08	NA	1.35E-07

NA = Not applicable

Table 4-15

Estimation of Contaminant Intakes
(mg/kg/day)

Scenario A (On-Site)
Maximally Exposed Adult

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion
<u>Organics</u>						
bis(2-ethylhexyl) phthalate	NA	NA	NA	3.50E-08	4.16E-06	3.10E-07
Carbon tetrachloride	8.00E-01	8.00E-01	NA	3.98E-11	4.16E-09	3.44E-10
1,2-Dichloroethane	4.57E-01	4.57E-01	NA	4.86E-11	5.77E-09	4.31E-10
1,1-Dichloroethene	1.37E+00	1.37E+00	NA	3.89E-11	4.61E-09	3.44E-10
t-1,2-Dichloroethene	1.45E-01	1.45E-01	NA	8.74E-11	1.04E-08	7.75E-10
Tetrachloroethene	3.77E-01	3.77E-01	NA	9.23E-10	1.10E-07	8.18E-09
Trichloroethene	2.06E+00	2.06E+00	NA	7.29E-10	8.65E-08	6.46E-09
<u>Inorganics</u>						
Nickel	1.25E-02	NA	3.74E-03	3.45E-07	NA	3.06E-06
Selenium	6.00E-02	NA	7.19E-03	2.38E-09	NA	2.11E-08
Strontium	6.91E-02	NA	2.55E-01	7.02E-06	NA	9.00E-06
<u>Radionuclides</u>						
Uranium (total)	3.23E-03	NA	1.92E-04	3.27E-08	NA	2.90E-07

NA = Not applicable

Table 4-16

**Estimation of Contaminant Intakes
(mg/kg/day)**

**Scenario A (On-Site)
Average Exposed Child**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion
<u>Organics</u>						
bis(2-ethylhexyl) phthalate	NA	NA	NA	7.03E-09	3.87E-06	2.49E-06
Carbon tetrachloride	5.53E-02	5.53E-02	NA	4.53E-11	2.50E-08	1.61E-08
1,2-Dichloroethane	3.37E-02	3.37E-02	NA	4.53E-11	2.50E-08	1.61E-08
1,1-Dichloroethene	2.52E-01	2.52E-01	NA	4.53E-11	2.50E-08	1.61E-08
t-1,2-Dichloroethene	8.33E-03	8.33E-03	NA	4.53E-11	2.50E-08	1.61E-08
Tetrachloroethene	7.27E-02	7.27E-02	NA	7.37E-11	4.06E-08	2.61E-08
Trichloroethene	2.77E-01	2.77E-01	NA	6.23E-11	3.43E-08	2.21E-08
<u>Inorganics</u>						
Nickel	5.33E-03	NA	1.19E-03	7.37E-08	NA	2.61E-05
Selenium	1.84E-02	NA	1.65E-03	2.78E-09	NA	9.84E-07
Strontium	6.67E-02	NA	1.30E-01	3.74E-07	NA	1.33E-04
<u>Radionuclides</u>						
Uranium (total)	2.40E-03	NA	1.03E-04	1.78E-08	NA	6.31E-06

NA = Not applicable

Table 4-17

Estimation of Contaminant Intakes
(mg/kg/day)

Scenario A (On-Site)
Maximally Exposed Child

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion
<u>Organics</u>						
bis(2-ethylhexyl) phthalate	NA	NA	NA	4.09E-08	2.25E-05	1.45E-05
Carbon tetrachloride	1.87E+00	1.87E+00	NA	4.53E-11	2.50E-08	1.61E-08
1,2-Dichloroethane	1.07E+00	1.07E+00	NA	5.67E-11	3.12E-08	2.01E-08
1,1-Dichloroethene	3.20E+00	3.20E+00	NA	4.53E-11	2.50E-08	1.61E-08
t-1,2-Dichloroethene	3.38E-01	3.38E-01	NA	1.02E-10	5.62E-08	3.62E-08
Tetrachloroethene	8.80E-01	8.80E-01	NA	1.08E-09	5.93E-07	3.82E-07
Trichloroethene	4.80E+00	4.80E+00	NA	8.50E-10	4.68E-07	3.01E-07
<u>Inorganics</u>						
Nickel	2.92E-02	NA	6.50E-03	4.02E-07	NA	1.43E-04
Selenium	1.40E-01	NA	1.25E-02	2.78E-09	NA	9.84E-07
Strontium	1.61E-01	NA	3.77E-01	1.18E-06	NA	4.20E-04
<u>Radionuclides</u>						
Uranium (total)	7.53E-03	NA	3.08E-04	3.81E-08	NA	1.35E-05

NA = Not applicable

Table 4-18

Estimation of Contaminant Intakes
(mg/kg/day)

Scenario B (Off-Site)
Average Exposed Adult

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion
<u>Organics</u>			
bis(2-ethylhexyl) phthalate	NA	NA	
Carbon tetrachloride	6.24E-04	6.24E-04	NA
1,2-Dichloroethane	3.80E-04	3.80E-04	NA
1,1-Dichloroethene	2.84E-03	2.84E-03	NA
t-1,2-Dichloroethene	9.40E-05	9.40E-05	NA
Tetrachloroethene	8.20E-04	8.20E-04	NA
Trichloroethene	3.12E-03	3.12E-03	NA
<u>Inorganics</u>			
Nickel	6.02E-05	NA	3.65E-04
Selenium	2.08E-04	NA	3.05E-05
Strontium	7.52E-04	NA	5.80E-02
<u>Radionuclides</u>			
Uranium (total)	2.71E-05	NA	1.19E-05

NA = Not applicable

Table 4-19

Estimation of Contaminant Intakes
(mg/kg/day)

Scenario B (Off-Site)
Maximally Exposed Adult

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion
<u>Organics</u>			
bis(2-ethylhexyl) phthalate	NA	NA	NA
Carbon tetrachloride	2.11E-02	2.11E-02	NA
1,2-Dichloroethane	1.20E-02	1.20E-02	NA
1,1-Dichloroethene	3.61E-02	3.61E-02	NA
t-1,2-Dichloroethene	3.81E-03	3.81E-03	NA
Tetrachloroethene	9.92E-03	9.92E-03	NA
Trichloroethene	5.41E-02	5.41E-02	NA
<u>Inorganics</u>			
Nickel	3.29E-04	NA	1.99E-03
Selenium	1.58E-03	NA	1.95E-04
Strontium	1.82E-03	NA	1.83E-01
<u>Radionuclides</u>			
Uranium (total)	8.50E-05	NA	2.69E-05

NA = Not applicable

Table 4-20

Estimation of Contaminant Intakes
(mg/kg/day)

Scenario B (Off-Site)
Average Exposed Child

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion
<u>Organics</u>			
bis(2-ethylhexyl) phthalate	NA	NA	NA
Carbon tetrachloride	1.46E-03	1.46E-03	NA
1,2-Dichloroethane	8.88E-04	8.88E-04	NA
1,1-Dichloroethene	6.63E-03	6.63E-03	NA
t-1,2-Dichloroethene	2.19E-04	2.19E-04	NA
Tetrachloroethene	1.91E-03	1.91E-03	NA
Trichloroethene	7.28E-03	7.28E-03	NA
<u>Inorganics</u>			
Nickel	1.40E-04	NA	6.34E-04
Selenium	4.84E-04	NA	5.30E-05
Strontium	1.75E-03	NA	8.58E-02
<u>Radionuclides</u>			
Uranium (total)	6.32E-05	NA	1.90E-05

NA = Not applicable

Table 4-21

Estimation of Contaminant Intakes
(mg/kg/day)

Scenario B (Off-Site)
Maximally Exposed Child

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion
<u>Organics</u>			
bis(2-ethylhexyl) phthalate	NA	NA	NA
Carbon tetrachloride	4.91E-02	4.91E-02	NA
1,2-Dichloroethane	2.81E-02	2.81E-02	NA
1,1-Dichloroethene	8.42E-02	8.42E-02	NA
t-1,2-Dichloroethene	8.89E-03	8.89E-03	NA
Tetrachloroethene	2.32E-02	2.32E-02	NA
Trichloroethene	1.26E-01	1.26E-01	NA
<u>Inorganics</u>			
Nickel	7.68E-04	NA	3.46E-03
Selenium	3.68E-03	NA	3.39E-04
Strontium	4.25E-03	NA	2.71E-01
<u>Radionuclides</u>			
Uranium (total)	1.98E-04	NA	4.31E-05

NA = Not applicable

SECTION 5

RISK CHARACTERIZATION

In this section, potential carcinogenic and noncarcinogenic risks are evaluated based on the daily contaminant intakes estimated in Section 4.0. Of the 13 indicator chemicals, six organics, nickel and uranium are evaluated for carcinogenic risk. In addition, all of the indicator chemicals are assessed for possible noncarcinogenic risk. Following these evaluations, the uncertainties associated with the risk assessment are addressed.

5.1 CARCINOGENIC RISK

5.1.1 Organics

The carcinogenic risk posed by exposure to a chemical depends upon three factors; dosage, the carcinogenic potency of the chemical, and the exposure duration. The dosages (estimated daily intakes) for the carcinogenic indicator chemicals (i.e., the six organics and uranium) were determined in Section 4 and summarized in Tables 4-14 through 4-21. The potency of each of the carcinogens, expressed as a carcinogenic potency factor, is presented in Table 5-1.

It should be noted that the carcinogenic potency of a substance depends, in part, upon its route of entry into the body (e.g., ingestion, inhalation, or dermal). Therefore, potency factors are classified according to the route of administration that is applicable to the experimental or epidemiological data from

Table 5-1

Health Effects Constants
for Determination of Carcinogenic Risk

Indicator Chemicals	Carcinogenic Potency Factor ¹ (mg/kg/day) ⁻¹	
	Oral Route	Inhalation Route
<u>Organics</u>		
bis(2-ethylhexyl)phthalate	6.84E-04	NC
Carbon tetrachloride	1.30E-01	NC
1,2-Dichloroethane	9.10E-02	3.50E-02
1,1-Dichloroethene	5.80E-01	1.16E+00
Tetrachloroethene	5.10E-02	1.70E-03
Trichloroethene	1.10E-02	4.60E-03
<u>Inorganics</u>		
Nickel	NA	1.19E+00

NA = Not applicable.
NC = No constant available.

¹Reference: Superfund Public Health Evaluation Manual (EPA, 1986a).

which they were derived. The EPA has developed potency factors for the oral and/or inhalation routes for some carcinogens (EPA, 1986a). Dermal potency factors have not been derived for any chemicals.

Oral carcinogenic potency factors have been developed for all of the carcinogenic indicator chemicals and inhalation carcinogenic potency factors have been developed for all of the indicator chemicals with the exceptions of carbon tetrachloride and bis(2-ethylhexyl)phthalate. In those cases where a route specific carcinogenic potency factor was not available (i.e., dermal and/or inhalation routes) the oral potency factor was used in the calculation of carcinogenic risk.

The length of exposure to a chemical must also be taken into account in the calculation of carcinogenic risk since carcinogenic potency factors are based on an exposure duration of 70 years (average lifetime exposure), and carcinogenic risk is assumed to be proportional to exposure duration. In this analysis, carcinogenic risk was first calculated separately for the child and for the adult. Total lifetime risk was then estimated by adding the childhood and adulthood risks. For the sake of simplicity, it was assumed that during a 70-year lifetime an individual is exposed to each chemical for 5 years as a child (based on daily contaminant intakes estimated for a child aged 1 to 6 years) and for 65 years as an adult (based on daily contaminant intakes estimated for an adult).

The equations used in the determination of the carcinogenic risk posed by each contaminant through each exposure route are as follows:

$$\begin{array}{rcccl} \text{Lifetime} & & \text{Childhood} & & \text{Adult} \\ \text{Carcinogenic} & = & \text{Risk} & + & \text{Risk} \\ \text{Risk} & & & & \end{array}$$

where,

$$\begin{array}{ccccccc} \text{Childhood/} & & \text{Daily} & & \text{Carcinogenic} & & \text{Exposure} \\ \text{Adult} & = & \text{Contaminant} & \times & \text{Potency} & \times & \text{Duration} \\ \text{Risk} & & \text{Intake} & & \text{Factor} & & \text{Adjustment} \\ & & \text{(mg/kg/day)} & & \text{(mg/kg/day)}^{-1} & & \end{array}$$

Exposure duration adjustments of 5/70 and 65/70 were applied to the calculation of childhood and adult risks, respectively. As mentioned above, the adjustments are necessary to account for exposure periods of less than 70 years. Estimates of carcinogenic risk for the average and maximally exposed adult and child in Scenario A are summarized in Tables 5-2 through 5-5 and in Tables 5-6 through 5-9 for Scenario B. Total lifetime risk estimates for the average and maximally exposed individuals are shown in Tables 5-10 and 5-11 for Scenario A and in Tables 5-12 and 5-13 for Scenario B. In each case, risks were calculated for each contaminant, for each exposure pathway, and for all contaminants through all pathways combined.

When evaluating the potential for carcinogenic risk through nickel exposure, the only exposure pathway that was considered was the inhalation of fugitive dust. Nickel is a known human carcinogen by the inhalation route. However, evidence is lacking for its carcinogenicity either in humans or animals through the oral route. Oral animal carcinogenicity studies have given negative results (EPA, 1987b).

5.1.2 Radionuclides

For determination of the probability of carcinogenesis from exposure to radionuclides, two pieces of information are required: (1) an estimation of the radiation dose received; and (2) a dose-risk model for estimation of the associated risk.

Table 5-2

Estimated Carcinogenic Risk - Scenario A
Average Exposed Adult

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethylhexyl) phthalate	NA	NA	NA	3.83E-12	4.54E-10	3.39E-11	4.92E-10
Carbon tetrachloride	2.86E-03	2.86E-03	NA	4.69E-12	5.57E-10	4.16E-11	5.72E-03
1,2-Dichloroethane	1.22E-03	1.22E-03	NA	3.28E-12	3.90E-10	2.91E-11	2.44E-03
1,1-Dichloroethene	5.82E-02	5.82E-02	NA	2.09E-11	2.49E-09	1.85E-10	1.17E-01
Tetrachloroethene	1.47E-03	1.47E-03	NA	2.99E-12	3.55E-10	2.65E-11	2.94E-03
Trichloroethene	1.21E-03	1.21E-03	NA	5.46E-13	6.48E-11	4.84E-12	2.42E-03
<u>Inorganics</u>							
Nickel	NA	NA	NA	6.98E-08	NA	NA	6.98E-08
TOTAL	6.50E-02	6.50E-02	NA	6.98E-08	4.13E-09	3.21E-10	1.30E-01

NA = Not applicable.

Table 5-3

**Estimated Carcinogenic Risk - Scenario A
Maximally Exposed Adult**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethylhexyl) phthalate	NA	NA	NA	2.22E-11	2.64E-09	1.97E-10	2.86E-09
Carbon tetra- chloride	9.66E-02	9.66E-02	NA	4.69E-12	5.57E-10	4.16E-11	1.93E-01
1,2-Dichloro- ethane	3.86E-02	3.86E-02	NA	4.10E-12	4.87E-10	3.64E-11	7.72E-02
1,1-Dichloro- ethene	7.39E-01	7.39E-01	NA	2.09E-11	2.49E-09	1.85E-10	1.48E+00
Tetrachloro- ethene	1.79E-02	1.79E-02	NA	4.37E-11	5.19E-09	3.87E-10	3.58E-02
Trichloro- ethene	2.10E-02	2.10E-02	NA	7.44E-12	8.84E-10	6.60E-11	4.20E-02
<u>Inorganics</u>							
Nickel	NA	NA	NA	3.81E-07	NA	NA	3.81E-07
TOTAL	9.13E-01	9.13E-01	NA	3.81E-07	1.22E-08	9.13E-10	1.83E+00

NA = Not applicable.

Table 5-4

**Estimated Carcinogenic Risk - Scenario A
Average Exposed Child**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethylhexyl) phthalate	NA	NA	NA	3.43E-13	1.89E-10	1.22E-10	3.11E-10
Carbon tetra- chloride	5.14E-04	5.14E-04	NA	4.21E-13	2.32E-10	1.49E-10	1.03E-03
1,2-Dichloro- ethane	2.19E-04	2.19E-04	NA	2.95E-13	1.62E-10	1.04E-10	4.38E-04
1,1-Dichloro- ethene	1.04E-02	1.04E-02	NA	1.88E-12	1.03E-09	6.66E-10	2.08E-02
Tetrachloro- ethene	2.65E-04	2.65E-04	NA	2.68E-13	1.48E-10	9.51E-10	5.30E-04
Trichloro- ethene	2.17E-04	2.17E-04	NA	4.90E-14	2.70E-11	1.74E-11	4.34E-04
<u>Inorganics</u>							
Nickel	NA	NA	NA	6.26E-09	NA	NA	6.26E-09
TOTAL	1.16E-02	1.16E-02	NA	6.26E-09	1.79E-09	1.15E-09	2.32E-02

NA = Not applicable.

Table 5-5

Estimated Carcinogenic Risk - Scenario A
Maximally Exposed Child

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethylhexyl) phthalate	NA	NA	NA	2.00E-12	1.10E-09	7.08E-10	1.81E-09
Carbon tetra-chloride	1.73E-02	1.73E-02	NA	4.21E-13	2.32E-10	1.49E-10	3.46E-02
1,2-Dichloro-ethane	6.93E-03	6.93E-03	NA	3.68E-13	2.03E-10	1.31E-10	1.39E-02
1,1-Dichloro-ethene	1.33E-01	1.33E-01	NA	1.88E-12	1.03E-09	6.66E-10	2.66E-01
Tetrachloro-ethene	3.21E-03	3.21E-03	NA	3.92E-12	2.16E-09	1.39E-09	6.42E-03
Trichloro-ethene	3.77E-03	3.77E-03	NA	6.68E-13	3.68E-10	2.37E-10	7.54E-03
<u>Inorganics</u>							
Nickel	NA	NA	NA	3.42E-08	NA	NA	3.42E-08
TOTAL	1.64E-01	1.64E-01	NA	3.42E-08	5.09E-09	3.28E-09	3.28E-01

NA = Not applicable.

Table 5-6

**Estimated Lifetime Carcinogenic Risk - Scenario B
Average Exposed Adult**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetra- chloride	7.35E-05	7.53E-05	NA	1.51E-04
1,2-Dichloro- ethane	3.21E-05	3.21E-05	NA	6.42E-05
1,1-Dichloro- ethene	1.53E-03	1.53E-03	NA	3.06E-03
Tetrachloro- ethene	3.88E-05	3.88E-05	NA	7.76E-05
Trichloro- ethene	3.19E-05	3.19E-05	NA	6.38E-05
<u>Inorganics</u>				
Nickel	NA	NA	NA	NA
TOTAL	1.71E-03	1.71E-03	NA	3.42E-03

NA = Not applicable.

Table 5-7

Estimated Lifetime Carcinogenic Risk - Scenario B
Maximally Exposed Adult

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetrachloride	2.54E-03	2.54E-03	NA	5.08E-03
1,2-Dichloroethane	1.02E-03	1.02E-03	NA	2.04E-03
1,1-Dichloroethene	1.94E-02	1.94E-02	NA	3.88E-02
Tetrachloroethene	4.70E-04	4.70E-04	NA	9.40E-04
Trichloroethene	5.53E-04	5.53E-04	NA	1.11E-03
<u>Inorganics</u>				
Nickel	NA	NA	NA	NA
TOTAL	2.40E-02	2.40E-02	NA	4.80E-02

NA = Not applicable.

Table 5-8

Estimated Lifetime Carcinogenic Risk - Scenario B
Average Exposed Child

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetra- chloride	1.35E-05	1.35E-05	NA	2.70E-05
1,2-Dichloro- ethane	5.77E-06	5.77E-06	NA	1.15E-05
1,1-Dichloro- ethene	2.75E-04	2.75E-04	NA	5.50E-04
Tetrachloro- ethene	6.97E-06	6.97E-06	NA	1.39E-05
Trichloro- ethene	5.72E-06	5.72E-06	NA	1.14E-05
<u>Inorganics</u>				
Nickel	NA	NA	NA	NA
TOTAL	3.07E-04	3.07E-04	NA	6.14E-04

NA = Not applicable.

Table 5-9

Estimated Lifetime Carcinogenic Risk - Scenario B
Maximally Exposed Child

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetra- chloride	4.56E-04	4.56E-04	NA	9.12E-04
1,2-Dichloro- ethane	1.82E-04	1.82E-04	NA	3.64E-04
1,1-Dichloro- ethene	3.49E-03	3.49E-03	NA	6.98E-06
Tetrachloro- ethene	8.44E-05	8.44E-05	NA	1.68E-04
Trichloro- ethene	9.92E-05	9.92E-05	NA	1.98E-04
<u>Inorganics</u>				
Nickel	NA	NA	NA	NA
TOTAL	4.31E-03	4.31E-03	NA	8.62E-03

NA = Not applicable.

Table 5-10

**Estimated Lifetime Carcinogenic Risk - Scenario A
Average Exposed Individual**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethylhexyl) phthalate	NA	NA	NA	4.17E-12	6.43E-10	1.56E-10	8.03E-10
Carbon tetra- chloride	3.38E-03	3.38E-03	NA	5.11E-12	7.89E-10	1.91E-10	6.76E-03
1,2-Dichloro- ethane	1.44E-03	1.44E-03	NA	3.58E-12	5.52E-10	1.34E-10	2.88E-03
1,1-Dichloro- ethene	6.86E-02	6.86E-02	NA	2.28E-11	3.52E-09	8.51E-10	1.37E-01
Tetrachloro- ethene	1.74E-03	1.74E-03	NA	3.26E-12	5.03E-10	1.22E-10	3.48E-03
Trichloro- ethene	1.43E-03	1.43E-03	NA	5.95E-13	9.18E-11	2.22E-11	2.86E-03
<u>Inorganics</u>							
Nickel	NA	NA	NA	7.60E-08	NA	NA	7.60E-08
TOTAL	7.66E-02	7.66E-02	NA	7.60E-08	6.10E-09	1.48E-09	1.53E-01

NA = Not applicable.

Table 5-11

**Estimated Lifetime Carcinogenic Risk - Scenario A
Maximally Exposed Individual**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethylhexyl) phthalate	NA	NA	NA	2.42E-11	3.74E-09	9.05E-10	4.67E-09
Carbon tetra- chloride	1.14E-01	1.14E-01	NA	5.11E-12	7.89E-10	1.91E-10	2.28E-01
1,2-Dichloro- ethane	4.56E-02	4.56E-02	NA	4.47E-12	6.90E-10	1.67E-10	9.12E-02
1,1-Dichloro- ethene	8.71E-01	8.71E-01	NA	2.28E-11	3.52E-09	8.51E-10	1.74E+00
Tetrachloro- ethene	2.11E-02	2.11E-02	NA	4.76E-11	7.35E-09	1.78E-09	4.22E-02
Trichloro- ethene	2.48E-02	2.48E-02	NA	8.11E-12	1.25E-09	3.03E-10	4.96E-02
<u>Inorganics</u>							
Nickel	NA	NA	NA	4.15E-07	NA	NA	4.15E-07
TOTAL	1.08E+00	1.08E+00	NA	4.15E-07	1.73E-08	4.20E-09	2.16E+00

NA = Not applicable.

Table 5-12

Estimated Lifetime Carcinogenic Risk - Scenario B
Average Exposed Individual

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetrachloride	8.89E-05	8.89E-05	NA	1.78E-04
1,2-Dichloroethane	3.79E-05	3.79E-05	NA	7.58E-05
1,1-Dichloroethene	1.81E-03	1.81E-03	NA	3.62E-03
Tetrachloroethene	4.58E-05	4.58E-05	NA	9.16E-05
Trichloroethene	3.76E-05	3.76E-05	NA	7.52E-05
<u>Inorganics</u>				
Nickel	NA	NA	NA	NA
TOTAL	2.02E-03	2.02E-03	NA	4.04E-03

NA = Not applicable.

Table 5-13

**Estimated Lifetime Carcinogenic Risk - Scenario B
Maximally Exposed Individual**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetra- chloride	3.00E-03	3.00E-03	NA	6.00E-03
1,2-Dichloro- ethane	1.20E-03	1.20E-03	NA	2.40E-03
1,1-Dichloro- ethene	2.29E-02	2.29E-02	NA	4.58E-02
Tetrachloro- ethene	5.54E-04	5.54E-04	NA	1.11E-03
Trichloro- ethene	6.52E-04	6.52E-04	NA	1.30E-03
<u>Inorganics</u>				
Nickel	NA	NA	NA	NA
TOTAL	2.83E-02	2.83E-02	NA	5.66E-02

NA = Not applicable.

Bone is the major site for accumulation of ingested uranium. Wrenn et al (1985) estimated that 66 percent of the total uranium in the body is deposited in the skeleton. Because uranium accumulates in the bone in a similar manner to radium and emits alpha and gamma radiation, it is reasonable to assume that it will lead to bone sarcoma as does radium. Table 5-14 presents the annual effective dose equivalent to bone and the whole body for an individual exposed to both the average and maximum uranium concentration in drinking water for Scenario A. These values were calculated using the annual dose equivalent rates and weighting factors proposed by EPA (EPA, 1986c).

The EPA estimates the annual dose equivalent (i.e., the amount of radiation absorbed as modified by factors which affect its biological effectiveness) to different organs from uranium in drinking water using the dosimetric models of ICRP Publication 30 (ICRP, 1979). The annual organ dose equivalent is then converted to an effective whole body dose by multiplying the organ dose equivalent by an organ weighting factor which reflects the radiosensitivity of the particular organ. The EPA has derived a set of organ weighting factors using data from the BEIR III (Biological Effects of Ionizing Radiation) Committee of the National Academy of Sciences. These weighting factors differ from those suggested by the ICRP. The different values in the ICRP and EPA models are attributable primarily to a number of different factors, including assumptions concerning the calculations of weighting factors, different risk calculations, and possibly different health data (e.g., ICRP uses world-wide health data whereas EPA uses data for the U.S.). The ICRP uses a time span of 50 years for calculating the dose and associated risks from exposure to ionizing radiation. The EPA uses a time span of 70 years. For this evaluation, the EPA weighting factors are used to calculate the annual effective dose equivalent. The annual effective dose equivalent for each

Table 5-14

Annual Effective Dose Equivalent (mrem/yr)
 Scenario A, Drinking Water Pathway

Radionuclide	Maximally Exposed Individual		Average Exposed Individual	
	Bone	Whole body	Bone	Whole Body
U-234	1.76	2.93	0.72	1.20
U-235	0.08	0.13	0.03	0.05
U-238	1.91	3.30	0.58	0.96
TOTAL	3.75	6.36	1.33	2.21

*Whole body annual effective dose equivalent includes bone.

organ is calculated by multiplying the annual dose equivalent by the assigned weighting factor. The sum of the annual effective dose equivalents for each organ provides an estimate of the total effect of the radiation on the body (ICRP, 1977).

Table 5-15 presents the annual effective dose equivalent to bone for an individual who consumes garden vegetables irrigated with water containing the mean and maximum uranium concentrations in water for Scenario A. These values were calculated for consumption of crops irrigated with contaminated water using the model found in U.S. Nuclear Regulatory Commission Regulatory Guide 1.109 (USNRC, 1976). The dose equivalent calculated by this model was then multiplied by the appropriate organ weighting factor to obtain the annual effective dose equivalent. The approaches used in determining carcinogenic risk through vegetable ingestion are described Supplement E.

As stated previously, a dose-risk model must be used to estimate the associated risk of damage from the exposure to the contaminant. At levels above 100 rem total dose equivalent the deleterious effects of exposure can usually be observed. For low doses, there are no well demonstrated, observable adverse effects. For the purposes of this evaluation a linear, no threshold model was used to determine risk. This model extrapolates data from high dose equivalent to low dose equivalents to estimate the risk of cancer.

The risk of bone sarcoma to the mean and maximally exposed individuals in Scenario A due to ingestion of uranium contaminated drinking water are presented in Table 5-16. The risk was calculated using the method described by the Committee on Metabolism and Dosimetry of High LET Radionuclides at the National Workshop on Radioactivity in Drinking Water. This workshop was held to advise the U.S. Environmental Protection Agency's Office of Drinking Water.

Table 5-15

Annual Effective Dose Equivalent (mrem/yr)
Scenario A, Vegetable Ingestion Pathway

Radionuclide	Maximally Exposed Individual		Average Exposed Individual	
	Bone	Whole body	Bone	Whole Body
U-234	1.10	1.67	0.45	6.68
U-235	0.04	0.06	0.01	0.02
U-238	1.00	1.56	0.36	0.53
TOTAL	2.14	3.19	0.82	1.23

*Whole body annual effective dose equivalent includes bone.

Table 5-16

Lifetime Risk of Bone Sarcoma - Scenario A

	Maximally Exposed Individual	Average Exposed Individual
Drinking Water	3.8E-05	1.4E-05
Vegetable Ingestion	2.0E-05	7.0E-06
TOTAL	5.8E-05	2.1E-05

The average risk, per capita, of bone sarcoma can be related to intake by the following formula assuming linearity of dose and risk:

$$L_R = (IC)k$$

where:

L_R = per capita lifetime risk.

I = per capita average fluid intake in liters per day (2 l/day).

C = average concentration of Uranium isotopes in water consumed (pCi/l).

k = lifetime risk of bone sarcoma induction from 1 pCi/day intake over a lifetime (3×10^{-7} sarcomas/pCi/day).

Dose equivalents were also estimated for the fugitive dust inhalation and soil ingestion pathways for Scenario A. These doses were negligible by comparison to those estimated for the drinking water and vegetable ingestion pathways and would pose a relatively insignificant additional cancer risk. Estimates of annual dose equivalents for the dust inhalation and soil ingestion pathways are presented in Supplement F.

5.2 NONCARCINOGENIC RISK

Noncarcinogenic risk was evaluated by comparing predicted contaminant daily intakes to health criteria (acceptable chronic intakes (AICs) or their equivalent) (EPA 1986a). It is

important to note that the approach used in assessing potential noncarcinogenic health effects, unlike the approach used in the evaluation of carcinogenic risk in Section 5.1, is not a measure of, and cannot be used to determine, quantitative risk (i.e., it does not predict the relative likelihood of adverse effects occurring). If the estimated daily intake of a contaminant exceeds the applicable health criterion (i.e., the ratio exceeds one) it indicates that there is a potential for noncarcinogenic health effects occurring under the defined exposure conditions. Because health criteria incorporate a margin of safety, exceedance of a criterion does not necessarily indicate that an adverse effect will occur.

Another difference between the evaluation of noncarcinogenic and carcinogenic risk is that the noncarcinogenic risk analysis does not take the duration of chronic exposure into consideration. Although the acceptable chronic intakes (AICs) are based upon a lifetime exposure, it is generally assumed that any chronic exposure, regardless of the duration, might potentially result in adverse effects if the health criterion is exceeded. Therefore, the assessment of noncarcinogenic risk for the child is carried out separately from, and is not additive to, the assessment for the adult.

The differences in methodology used in assessing noncarcinogenic and carcinogenic risk are based on the assumptions that noncarcinogenic health effects are threshold phenomena, whereas carcinogenic risk is not. This approach for evaluating carcinogenic risk conservatively assumes that for a carcinogen, exposure to even a small number of molecules (possibly even a single molecule) might potentially cause cellular changes that

can result in cancer. For noncarcinogens, however, the assumption is made that a threshold level of intake must be exceeded before the potential exists for adverse health effects. AICs are recommended thresholds which should not be exceeded.

The potential for noncarcinogenic health effects is posed by all chemicals, both carcinogenic and noncarcinogenic. AICs for four of the indicator chemicals (1,1-dichloroethene, tetrachloroethene, selenium, and bis((2-ethylhexyl)phthalate were listed in the Superfund Public Health Evaluation Manual (EPA, 1986a).

AIC-equivalents (i.e. estimates of a chronic daily exposure that is not likely to cause carcinogenic effects) for the remaining five indicator chemicals were found in other sources or were developed from available data. Reference doses (RfDs) were used for carbon tetrachloride t-1,2-dichloroethene and trichloroethene (EPA, 1987c) and an Adjusted Acceptable Daily Intake (AADI) was used for 1,2 dichloroethane (EPA, 1984). The only chronic health criterion that was available for strontium was an Acceptable Daily Intake (ADI) that has been suggested for strontium sulfide (EPA, 1984). Based on this value and the fact that strontium comprises 73.2 percent of strontium sulfide, an AIC-equivalent was derived for strontium. An AADI for uranium was derived from an AADI of 60 ug/L for natural uranium in drinking water (EPA, 1984), assuming the consumption of 2 liters of water per day and an adult body weight of 70 kg.

The AICs (and equivalents) used in this assessment are summarized in Table 5-17. As in the case of carcinogenic potency factors, AICs are also exposure route specific (i.e., they are derived from data that reflect a particular exposure route and are intended to be applied to exposure through that pathway). Similarly, the EPA has derived oral and/or inhalation AICs for some contaminants. With the exception of an inhalation AIC for

Table 5-17

Health Effects Criteria
for Determination of Noncarcinogenic Effects

Indicator Chemical	Acceptable Chronic Intake (AIC) ¹ (mg/kg/day)	
	Oral Route	Inhalation Route
<u>Organics</u>		
bis(2-ethylhexyl)phthalate	2.00E-02	NC
Carbon tetrachloride	7.00E-04	NC
1,2-Dichloroethane	7.43E-03	NC
1,1-Dichloroethene	9.00E-03	NC
t-1,2-Dichloroethene	1.00E-02	NC
Tetrachloroethene	2.00E-02	NC
Trichloroethene	7.35E-03	NC
<u>Inorganics</u>		
Selenium	3.00E-03	1.00E-03
Strontium	1.32E-02	NC
<u>Radionuclides</u>		
Uranium (total)	1.71E-03	NC

¹For the source of the AIC (or equivalent) see Section 5.2

NC = No constant available.

selenium, inhalation and dermal AICs have not been developed for any of the indicator chemicals. In these cases, contaminant intakes through the dermal and inhalation routes were compared to the oral AIC.

The ratios of estimated daily intakes to AICs are summarized for Scenario A (average and maximally exposed adult and child) in Tables 5-18 through 5-21 and for Scenario B in Tables 5-22 through 5-25.

5.3 RESULTS

5.3.1 Potential Carcinogenic Risk

Based on the assumptions previously described in this report, it is estimated that for Scenario A the total lifetime cancer risk that may be posed to an individual as a result of exposure to nonradioactive chemicals is approximately 1.5 in 10 ($1.53E-01$) for the average individual (Table 5-10) and greater than one ($2.16E+00$) for the maximally exposed individual (Table 5-11). Most of the risk is contributed by potential exposure to the volatile organic compounds through drinking water ingestion and showering/bathing. For Scenario B, the total lifetime risk is estimated at approximately 4 in 1,000 ($4.04E-03$) for the average exposed individual (Table 5-12) and approximately 6 in 100 ($5.66E-02$) for the maximally exposed individual (Table 5-16). All of the potential risk in Scenario B is contributed by exposure to volatile organics through drinking water ingestion and showering/bathing.

Table 5-18

**Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario A
Average Exposed Adult**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethyl- hexyl)phthalate	NA	NA	NA	3.01E-07	3.58E-05	2.67E-06	3.87E-05
Carbon tetra- chloride	3.39E+01	3.39E+01	NA	5.55E-03	6.59E-06	4.92E-07	6.78E+01
1,2-Dichloro- ethane	1.95E+00	1.95E+00	NA	5.23E-09	6.21E-07	4.64E-08	3.90E+00
1,1-Dichloro- ethene	1.20E+01	1.20E+01	NA	4.32E-09	5.13E-07	3.83E-08	2.40E+01
t-1,2-Dichloro- ethene	3.57E-01	3.57E-01	NA	3.89E-09	4.61E-07	3.44E-08	7.14E-01
Tetrachloro- ethene	1.56E+00	1.56E+00	NA	3.16E-09	3.75E-07	2.80E-08	3.12E+00
Trichloro- ethene	1.61E+01	1.61E+01	NA	7.27E-09	8.63E-07	6.44E-08	3.22E+01
<u>Inorganics</u>							
Nickel	2.29E-01	NA	6.85E-02	6.31E-06	NA	5.60E-05	2.98E-01
Selenium	2.63E+00	NA	3.17E-01	2.38E-06	NA	7.03E-06	2.95E+00
Strontium	2.16E+00	NA	6.64E+00	2.43E-05	NA	2.15E-04	8.80E+00
<u>Radionuclides</u>							
Uranium (total)	6.02E-01	NA	3.77E-02	8.92E-06	NA	7.91E-05	6.40E-01
TOTAL	7.68E+00	6.59E+01	7.07E+00	4.23E-05	4.53E-05	3.60E-04	8.12E+01

NA = Not applicable.

Table 5-19

**Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario A
Maximally Exposed Adult**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethyl- hexyl)phthalate	NA	NA	NA	1.75E-06	2.08E-04	1.55E-05	2.25E-04
Carbon tetra- chloride	1.14E+03	1.14E+03	NA	5.55E-08	6.59E-06	4.92E-07	2.28E+03
1,2-Dichloro- ethane	6.15E+01	6.15E+01	NA	6.54E-09	7.76E-07	5.79E-08	1.23E+02
1,1-Dichloro- ethene	1.52E+02	1.52E+02	NA	4.32E-09	5.13E-07	3.83E-08	3.04E+02
t-1,2-Dichloro- ethene	1.45E+01	1.45E+01	NA	8.74E-09	1.04E-06	7.75E-08	2.90E+01
Tetrachloro- ethene	1.89E+01	1.89E+01	NA	4.61E-08	5.48E-06	4.09E-07	3.78E+01
Trichloro- ethene	2.80E+02	2.80E+02	NA	9.91E-08	1.18E-05	8.79E-07	5.60E+02
<u>Inorganics</u>							
Nickel	1.25E+00	NA	3.74E-01	3.45E-05	NA	3.06E-04	1.62E+00
Selenium	2.00E+01	NA	2.40E+00	2.38E-06	NA	7.03E-06	2.24E+01
Strontium	5.24E+00	NA	1.93E+01	7.69E-05	NA	6.82E-04	2.45E+01
<u>Radionuclides</u>							
Uranium (total)	1.89E+00	NA	1.12E-01	1.91E-05	NA	1.69E-04	2.00E+01
TOTAL	1.70E+03	1.67E+03	2.22E+01	1.35E-04	2.34E-04	1.18E-03	3.40E+03

NA = Not applicable.

Table 5-20

**Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario A
Average Exposed Child**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethyl- hexyl)phthalate	NA	NA	NA	3.51E-07	1.94E-04	1.25E-04	3.19E-04
Carbon tetra- chloride	7.90E+01	7.90E+01	NA	6.48E-08	3.57E-05	2.30E-05	1.58E+02
1,2-Dichloro- ethane	4.54E+00	4.54E+00	NA	6.10E-09	3.36E-06	2.16E-06	9.08E+00
1,1-Dichloro- ethene	2.80E+01	2.80E+01	NA	5.04E-09	2.78E-06	1.79E-06	5.60E+01
t-1,2-Dichloro- ethene	8.33E-01	8.33E-01	NA	4.53E-09	2.50E-06	1.61E-06	1.67E+00
Tetrachloro- ethene	3.63E+00	3.63E+00	NA	3.68E-09	2.03E-06	1.31E-06	7.26E+00
Trichloro- ethene	3.76E+01	3.76E+01	NA	8.48E-09	4.67E-06	3.01E-06	7.52E+01
<u>Inorganics</u>							
Nickel	5.33E-01	NA	1.19E-01	7.37E-06	NA	2.61E-03	6.55E-01
Selenium	6.13E+00	NA	5.50E-01	2.78E-06	NA	3.28E-04	6.68E+00
Strontium	5.05E+00	NA	9.82E+00	2.83E-05	NA	1.00E-02	1.49E+01
<u>Radionuclides</u>							
Uranium (total)	1.40E+00	NA	6.04E-02	1.04E-05	NA	3.69E-03	1.46E+00
TOTAL	1.66E+02	1.54E+02	1.06E+01	4.93E-05	2.46E-04	1.68E-02	3.31E+02

NA = Not applicable.

Table 5-21

Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario A
Maximally Exposed Child

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total
<u>Organics</u>							
bis(2-ethyl- hexyl)phthalate	NA	NA	NA	2.04E-06	1.13E-03	7.24E-04	1.86E-03
Carbon tetra- chloride	2.67E+03	2.67E+03	NA	6.48E-08	3.57E-05	2.30E-05	5.34E+03
1,2-Dichloro- ethane	1.44E+02	1.44E+02	NA	7.63E-09	4.20E-06	2.70E-06	2.88E+02
1,1-Dichloro- ethene	3.56E+02	3.56E+02	NA	5.04E-09	2.78E-06	1.79E-06	7.12E+02
t-1,2-Dichloro- ethene	3.38E+01	3.38E+01	NA	1.02E-08	5.62E-06	3.62E-06	6.76E+01
Tetrachloro- ethene	4.40E+01	4.40E+01	NA	5.38E-08	2.97E-05	1.91E-05	8.80E+01
Trichloro- ethene	6.53E+02	6.53E+02	NA	1.16E-07	6.37E-05	4.10E-05	1.31E+03
<u>Inorganics</u>							
Nickel	2.92E+00	NA	6.50E-01	4.02E-05	NA	1.43E-02	3.58E+00
Selenium	4.67E+01	NA	4.17E+00	2.78E-06	NA	3.28E-04	5.09E+01
Strontium	1.22E+01	NA	2.86E+01	8.97E-05	NA	3.18E-02	4.08E+01
<u>Radionuclides</u>							
Uranium (total)	4.41E+00	NA	1.80E-01	2.23E-05	NA	7.91E-03	4.59E+00
TOTAL	3.97E+03	3.90E+03	3.36E+01	1.57E-04	1.28E-03	4.72E-02	7.90E+03

NA = Not applicable.

Table 5-22

**Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario B
Average Exposed Adult**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetra- chloride	8.92E-01	8.92E-01	NA	1.78E+00
1,2-Dichloro- ethane	5.12E-02	5.12E-02	NA	1.02E-01
1,1-Dichloro- ethene	3.16E-01	3.16E-01	NA	6.32E-01
t-1,2-Dichloro- ethene	9.40E-03	9.40E-03	NA	1.88E-02
Tetrachloro- ethene	4.10E-02	4.10E-02	NA	8.20E-02
Trichloro- ethene	4.25E-01	4.25E-01	NA	8.50E-01
<u>Inorganics</u>				
Nickel	6.02E-03	NA	3.65E-02	4.52E-02
Selenium	6.92E-02	NA	1.02E-02	7.94E-02
Strontium	5.70E-02	NA	4.40E+00	4.46E+00
<u>Radionuclides</u>				
Uranium (total)	1.58E-02	NA	6.95E-03	2.28E-02
TOTAL	1.87E+00	1.74E+00	4.41E+00	8.02E+00

NA = Not applicable.

Table 5-23

Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario B
Maximally Exposed Adult

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetrachloride	3.01E+01	3.01E+01	NA	6.02E+01
1,2-Dichloroethane	1.62E+00	1.62E+00	NA	3.24E+00
1,1-Dichloroethene	4.01E+00	4.01E+00	NA	8.02E+00
t-1,2-Dichloroethene	3.81E-01	3.81E-01	NA	7.62E-01
Tetrachloroethene	4.96E-01	4.96E-01	NA	9.92E-01
Trichloroethene	7.37E+00	7.37E+00	NA	1.47E+01
<u>Inorganics</u>				
Nickel	3.29E-02	NA	1.99E-01	2.32E-01
Selenium	5.26E-01	NA	6.49E-02	5.91E-01
Strontium	1.38E-01	NA	1.39E+01	1.40E+01
<u>Radionuclides</u>				
Uranium (total)	4.97E-02	NA	1.57E-02	6.54E-02
TOTAL	4.43E+01	4.36E+01	1.40E+01	1.02E+02

NA = Not applicable.

Table 5-24

**Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario B
Average Exposed Child**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetra- chloride	2.08E+00	2.08E+00	NA	4.16E+00
1,2-Dichloro- ethane	1.19E-01	1.19E-01	NA	2.38E-01
1,1-Dichloro- ethene	7.37E-01	7.37E-01	NA	1.47E+00
t-1,2-Dichloro- ethene	2.19E-02	2.19E-02	NA	4.38E-02
Tetrachloro- ethene	9.56E-02	9.56E-02	NA	1.93E-01
Trichloro- ethene	9.91E-01	9.91E-01	NA	1.98E+00
<u>Inorganics</u>				
Nickel	1.40E-02	NA	6.34E-02	7.74E-02
Selenium	1.61E-01	NA	1.76E-02	1.79E-01
Strontium	1.33E-01	NA	6.51E+00	6.64E+00
<u>Radionuclides</u>				
Uranium (total)	3.69E-02	NA	1.11E-02	4.80E-02
TOTAL	4.35E+00	4.06E+00	6.53E+00	1.49E+01

NA = Not applicable.

Table 5-25

**Ratios of Estimated Daily Intakes to Acceptable
Chronic Intakes - Scenario B
Maximally Exposed Child**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total
<u>Organics</u>				
bis(2-ethylhexyl) phthalate	NA	NA	NA	NA
Carbon tetra- chloride	7.02E+01	7.02E+01	NA	1.40E+02
1,2-Dichloro- ethane	3.78E+00	3.78E+00	NA	7.56E+00
1,1-Dichloro- ethene	9.36E+00	9.36E+00	NA	1.87E+01
t-1,2-Dichloro- ethene	8.89E-01	8.89E-01	NA	1.78E+00
Tetrachloro- ethene	1.16E+00	1.16E+00	NA	2.32E+00
Trichloro- ethene	1.72E+01	1.72E+01	NA	3.44E+01
<u>Inorganics</u>				
Nickel	7.68E-02	NA	3.46E-01	4.23E-01
Selenium	1.23E+00	NA	1.13E-01	1.34E+00
Strontium	3.22E-01	NA	2.06E+01	2.09E+01
<u>Radionuclides</u>				
Uranium (total)	1.16E-01	NA	2.52E-02	1.41E-01
TOTAL	1.03E+02	1.01E+02	2.07E-01	2.25E+02

NA = Not applicable.

In addition to the potential carcinogenic risk posed by the chemical contaminants, an additional lifetime carcinogenic risk of approximately 2 in 100,000 ($2.1E-05$) and 6 in 100,000 ($5.8E-05$) may be posed to the average and maximally exposed individual, respectively, through exposure to radiation from uranium isotopes (Table 5-16). This potential risk is contributed primarily by exposure to uranium through drinking water and vegetable ingestion.

5.3.2 Potential Noncarcinogenic Health Effects

The estimated daily intakes for all of the indicator chemicals with the exception of bis(2-ethylhexyl)phthalate were found to exceed the acceptable chronic intake for one or more exposure situations. These results are summarized for Scenarios A and B in Tables 5-26 and 5-27, respectively. Drinking water ingestion and showering/bathing are the pathways of the greatest potential concern for the volatile organic compounds. Drinking water and vegetable ingestion are the exposure pathways of the greatest potential concern for the inorganics.

5.4 ASSUMPTIONS AND UNCERTAINTIES

The evaluation of the potential risks posed by contaminants associated with the 881 Hillside location is based on numerous assumptions which contribute uncertainty to the risk estimate. In this section, the major assumptions and uncertainties associated with this risk analysis are addressed.

Risk was evaluated for a selected number of contaminants (i.e., the indicator chemicals), and therefore does not represent the total potential risk posed by all site-related contaminants. However, the potential risks posed by the other (non-indicator) chemicals would be expected to be negligible when compared to that posed by the indicator chemicals.

Table 5-26

**Exposure Pathways in Which the Estimated Daily Intake Exceeded
the Acceptable Chronic Intake
Scenario A**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Inhalation of Fugitive Dust	Dermal Contact	Soil Ingestion	Total of All Path- ways
<u>Organics</u>							
bis(2-ethyl- hexyl)phthalate							
Carbon tetra- chloride	AA, AC MA, MC	AA, AC MA, MC					AA, AC MA, MC
1,2-Dichloro- ethane	AA, AC MA, MC	AA, AC MA, MC					AA, AC MA, MC
1,1-Dichloro- ethene	AA, AC MA, MC	AA, AC MA, MC					AA, AC MA, MC
t-1,2-Dichloro- ethene	MA, MC	MA, MC					AC, MA, MC
Tetrachloro- ethene	AA, AC MA, MC	AA, AC MA, MC					AA, AC MA, MC
Trichloro- ethene	AA, AC MA, MC	AA, AC MA, MC					AA, AC MA, MC
<u>Inorganics</u>							
Nickel	MA, MC						MA, MC
Selenium	AA, AC MA, MC		MA, MC				AA, AC MA, MC
Strontium	AA, AC MA, MC		AA, MA AC, MC				AA, AC MA, MC
<u>Radionuclides</u>							
Uranium (total)	AC, MA, MC						AC, MA, MC

AA = Average exposed adult.
AC = Average exposed child.
MA = Maximum exposed adult.
MC = Maximum exposed child.

Table 5-27

**Exposure Pathways in Which the Estimated Daily Intake
Exceeded the Acceptable Chronic Intake
Scenario B**

Indicator Chemical	Drinking Water	Showering/ Bathing	Vegetable Ingestion	Total of All Pathways
<u>Organics</u>				
bis(2-ethylhexyl) phthalate				
Carbon tetra- chloride	AC MA, MC	AC MA, MC		AA, AC MA, MC
1,2-Dichloro- ethane	MA, MC	MA, MC		MA, MC
1,1-Dichloro- ethene	MA, MC	MA, MC		AC, MA, MC
t-1,2-Dichloro- ethene				MC
Tetrachloro- ethene	MC	MC		MC
Trichloro- ethene	MA, MC	MA, MC		AC, MA, MC
<u>Inorganics</u>				
Nickel				
Selenium	MC			MC
Strontium			AA, AC MA, MC	AA, AC MA, MC
<u>Radionuclides</u>				
Uranium (total)				

AA = Average exposed adult.

AC = Average exposed child.

MA = Maximum exposed adult.

MC = Maximum exposed child.

The major part of the noncarcinogenic and carcinogenic risks potentially posed by the indicator chemicals were found to be associated with groundwater usage (i.e., drinking water ingestion, showering/bathing, and the ingestion of vegetables irrigated with groundwater). It was assumed in this evaluation that the alluvial water bearing zone is the groundwater source. It is unlikely, however, that this water-bearing zone would yield sufficient water to make it a practical water source. Even if it is assumed that the alluvial groundwater may be used as a source of domestic water in the future, estimates of potential risk are conservative, particularly for Scenario B. Scenario B, in which individuals are assumed to be living at the Plant boundary is considered to be a "more-likely" case scenario than Scenario A, in which individuals are assumed to be residing at the 881 Hillside location in the future. Risk in Scenario B was based on groundwater usages. The concentrations of contaminants in the groundwater at the Plant boundary were estimated by conservatively assuming that no contaminant attenuation other than dilution occurs as the contaminants flow from the site towards the boundary. Processes such as volatilization, which is likely to decrease the concentrations of volatile organics, and sorption processes were not taken into account. It is likely that contaminant concentrations at the boundary, and therefore potential risks for Scenario B, are lower than those predicted.

To add further perspective to the estimates of carcinogenic risk, it should be noted that the carcinogen potency factors are derived from high dosage animal studies using a linearized multistage model. This model, which is consistent with some theories for the mechanism of carcinogenesis, gives a reasonable upper limit to carcinogenic risk. The actual risk is unknown, but may be as low as zero (EPA, 1986d). It should also

be noted that in the evaluation of noncarcinogenic risk, that if the estimated daily intake exceeds the acceptable chronic intake, it does not necessarily mean that adverse effects will occur. AICs are usually based on lowest-observed-adverse effect levels or no observed-adverse-effect levels from animal studies and incorporate an uncertainty/safety factor usually in the range of 2 to 3 orders of magnitude.

5.5 COMPARISON TO OTHER RISKS

All human activities are associated with some degree of risk. For the sake of perspective, the risk of death associated with various occupations, personal habits, lifestyles, and accidents are presented in Figure 5-1.

**FIGURE 5-1
PUTTING RISK IN PERSPECTIVE**

RISK OF DEATH	OCCUPATION	LIFESTYLE	ACCIDENTS	ENVIRONMENTAL RISKS
1 IN 100 10^{-2}	STUNTMAN			
1 IN 1000 10^{-3}	RACE CAR DRIVER	SMOKING (one pack a day)	ROCK CLIMBING	
1 IN 10,000 10^{-4}	FARMER		DRIVING MOTOR VEHICLE ALL HOME ACCIDENTS FREQUENT AIR TRAVEL	
1 IN 100,000 10^{-5}	TRUCK DRIVING ENGINEER	USING CONTRACEPTIVE PILLS	SKIING HOME FIRE	LIVING DOWNSTREAM OF A DAM NATURAL BACKGROUND RADIATION
1 IN 1,000,000 10^{-6}		DIAGNOSTIC X-RAY	FISHING OCCASIONAL AIR TRAVEL (one flight a year)	
1 IN 10,000,000 10^{-7}		EATING CHARCOAL-BROILED STEAK		
				ANIMAL BITE OR INSECT STING

SOURCE: ADAPTED FROM EPRI (1985).

SUPPLEMENT A

INFORMATION USED IN THE SELECTION OF INDICATOR CHEMICALS

2539B

Table A-1

Scoring for Indicator Chemical Selection Based on Noncarcinogenic Effects

Chemical	Groundwater CXT		Surface Water CXT		Soil CXT		Indicator Score		Rank	
	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
Inorganics										
Antimony	6.45E+00	9.89E+00	—	—	1.30E-03	4.21E-03	6.45E+00	9.89E+00	2	4
Barium	4.93E-01	3.78E+00	—	—	2.45E-02	1.65E-01	5.18E-01	3.95E+00	5	7
Cadmium	8.90E-03	2.58E-02	—	—	4.46E-04	2.01E-03	9.35E-03	2.78E-02	11	13
Copper	8.57E-03	2.60E-02	—	—	4.64E-05	1.06E-03	8.61E-03	2.70E-02	13	14
Mercury	1.84E-02	1.10E-01	—	—	1.65E-04	1.91E-03	1.86E-02	1.11E-01	9	11
Nickel	3.41E-01	1.86E+00	—	—	2.77E-03	1.51E-02	3.44E-01	1.88E+00	6	5
Selenium	2.89E+01	2.21E+02	—	—	2.61E-03	2.61E-03	2.89E+01	2.21E+02	1	1
Vanadium	2.00E-03	5.26E-03	—	—	2.00E-04	3.68E-04	2.20E-03	5.63E-03	16	18
Zinc	—	—	3.21E-02	6.30E-02	2.88E-04	9.86E-04	3.24E-02	6.30E-02	8	12
Organics										
2-Butanone	6.98E-05	1.71E-04	—	—	1.66E-08	1.51E-07	6.98E-05	1.71E-04	19	20
Carbon tetrachloride	2.63E-01	8.87E+00	—	—	—	—	2.63E-01	8.87E+00	7	6
1,1-Dichloroethane	5.93E-04	8.82E-03	—	—	—	—	5.93E-04	8.82E-03	18	16
1,2-Dichloroethane	8.91E-03	2.82E-01	—	—	7.04E-09	8.80E-09	8.91E-03	2.82E-01	12	8
1,1-Dichloroethene	1.40E+00	1.78E+01	—	—	1.48E-07	1.48E-07	1.40E+00	1.78E+01	4	3
t-1,2-Dichloroethene	6.61E-03	2.68E-01	—	—	2.12E-08	4.77E-08	6.61E-03	2.68E-01	14	9
Di-n-butyl phthalate	—	—	—	—	7.22E-07	6.92E-06	7.22E-07	6.92E-06	22	22
Methylene chloride	9.20E-06	4.42E-05	—	—	1.89E-09	2.71E-08	9.20E-06	4.42E-05	21	21
PAH (total) (as B(a)P)	—	—	—	—	2.54E-03	2.58E-03	2.54E-03	2.58E-03	15	18
Tetrachloroethene	1.05E-02	1.27E-01	—	—	6.25E-09	9.14E-08	1.05E-02	1.27E-01	10	10
Toluene	5.68E-05	3.48E-04	—	—	2.08E-09	6.50E-09	5.68E-05	3.48E-04	20	19
1,1,1-Trichloroethane	2.14E-03	2.22E-02	—	—	4.04E-10	4.04E-09	2.14E-03	2.22E-02	17	15
Trichloroethene	4.35E+00	7.56E+01	—	—	5.79E-07	7.89E-06	4.35E+00	7.56E+01	3	2

1. Concentration (C) times toxicity constant (T).
 2. Benzo(a)pyrene (B(a)P) and benzo(a)anthracene were the only PAH detected on-site for which toxicity constants were available. It was conservatively assumed in the scoring process that all PAH were present as B(a)P, which had the highest toxicity constants.

- Agarwal, D.K., et al., 1985. "Correlation of dose-dependent functional pathophysiological changes induced by di-(2-ethylhexyl)-phthalate (DEHP)." (Abstract 467). Toxicologist 5:117. (Cited in NAS, 1986.)
- Carpenter, C.P., et al., 1953. "Chronic oral toxicity of di(2-ethylhexyl)phthalate for rats, guinea pigs, and dogs." AMA Arch. Ind. Health 8:219. (Cited in U.S. EPA, 1980.)
- Carter, B.R., et al., 1977. "Studies on dibutyl phthalate-induced testicular atrophy in the rat: Effect on zinc metabolism." Toxicol. Appl. Pharmacol. 41:609. (Cited in U.S. EPA, 1980.)
- Clayton, G.D. and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, 3rd ed. New York: John Wiley and Sons.
- Daniel, J.W., and H. Bratt, 1974. "The absorption, metabolism and tissue distribution of di(2-ethylhexyl)phthalate in rats." Toxicology 2:51. (Cited in U.S. EPA, 1980.)
- Gray, T.J.B., and K.R. Butterworth, 1980. "Testicular atrophy produced by phthalate esters." Arch. Toxicol. (Suppl. 4) :452. (Cited in NAS, 1986.)
- Gray, T.J.B., et al., 1977. "Short-term toxicity study of di(2-ethylhexyl)phthalate in rats." Food Cosmet. Toxicol. 15:389. (Cited in NAS, 1986.)
- Harris, R.S., et al., 1956. "Chronic oral toxicity of 2-ethyl-hexyl phthalate in rats and dogs." AMA Arch. Ind. Health 13:259. (Cited in U.S. EPA, 1980.)
- Lake, B.G., et al., 1977. "The in vitro hydrolysis of some phthalate diesters by hepatic and intestinal preparations from various species." Toxicol. Appl. Pharmacol. 39:239. (Cited in U.S. EPA, 1980.)
- NAS (National Academy of Sciences), 1986. Drinking Water and Health, Volume 6. National Research Council. Washington, D.C.: National Academy Press.
- NTP (National Toxicology Program), 1983. "Carcinogenesis Bioassay of Di(2-ethylhexyl)phthalate (CAS No. 117-81-7) in F344 Rats and B6C3F Mice (Feed Study)." NIH Publication No. 82-1773. U.S. Department of Health and Human Services, Washington, D.C. (Cited in NAS, 1986.)
- Nikonorow, M., et al., 1973. "Effect of orally administered plasticizers and polyvinyl chloride stabilizers in the rat." Toxicol. Appl. Pharmacol. 26:253. (Cited in NAS, 1986, and U.S. EPA, 1980.)
- Reel, J.R., et al., 1985. "Reproductive toxicity of dietary diethylhexyl phthalate (DEHP) in mouse breeding pairs. (Abstract 466.) Toxicologist 5:117. (Cited in NAS, 1986.)
- Shaffer, C.B., et al., 1945. "Acute and subacute toxicity of di(2-ethylhexyl)phthalate with note upon its metabolism." J. Ind. Hyg. Toxicol. 27:130. (Cited in U.S. EPA, 1980.)

Shiota, K., et al., 1980. "Embryotoxic effects of di-2-ethylhexyl phthalate (DEHP) and di-n-butyl phthalate (DBP) in mice." Environ. Res. 22:245. (Cited in NAS, 1986.)

U.S. EPA, 1980. Ambient Water Quality Criteria for Phthalate Esters. Office of Water Regulations and Standards, Washington, D.C. PB 81-11780.

U.S. EPA, 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response, Washington, D.C.

Ward, J.M., et al., 1986. "Tumor-initiating and promoting activities of di(2-ethylhexyl)phthalate in vivo and in vitro." Environ. Health Perspect. 65:279.

Yagi, Y., et al., 1980. "Teratogenic potential of di- and mono-(2-ethylhexyl)phthalate (DEHP) and di-n-butyl phthalate (DBP) in mice." Environ. Res. 22:245. (Cited in NAS, 1986.)

CARBON TETRACHLORIDE (CCl₄)

1.0 PHYSICO/CHEMICAL PROPERTIES (U.S. EPA, 1987a)

Molecular Weight	153.8
Boiling Point	76.5°C
Melting Point	-23°C
Vapor Pressure	115.2 mm Hg (25°C)
Water Solubility	800 mg/l

2.0 TOXICOLOGICAL EFFECTS

Liver and kidney toxicity are the main adverse effects of CCl₄ toxicity. Liver damage is characterized by fatty acid infiltration and necrosis. Kidney lesions are primarily in the proximal tubules. CCl₄ has also been shown to produce liver tumors in laboratory animals.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

Ingestion of as little as 1.5 ml (34 mg/kg) CCl₄ by adults may cause adverse effects on the liver and kidneys and in some cases may result in death (U.S. EPA, 1987a). In most instances, however, the ingestion of 2.5 to 15 ml (57 to 343 mg/kg) is without effect. Ingested doses of 0.18 to 0.92 ml (29 to 150 mg/kg) may be fatal in children (U.S. EPA, 1987a).

Acute inhalation exposure can lead to central nervous system (CNS) depression, as well as kidney and liver damage. Liver effects have been seen after exposure to 2,309 mg/m³ for 70 minutes. Acute exposure to 1,500 mg/m³ may result in death (U.S. EPA, 1987a). Exposure to high concentrations may lead to rapid loss of consciousness. Less severe CNS symptoms include dizziness, headache, depression, and incoordination. Gastrointestinal symptoms may also occur (e.g., nausea, pain, diarrhea).

Animal

The liver is the organ most sensitive to acute CCl_4 exposure. Liver damage has been seen in rats dosed with 10 to 2,000 mg CCl_4 /kg by gavage in a variety of vehicles (corn oil, aqueous emulsion, undiluted, water) (Bruckner, et al., 1986; Kim, et al., 1986). Single oral doses of 4,000 mg/kg have been reported to cause kidney and lung damage (U.S. EPA, 1987a).

Oral LD_{50} s of 1,000 to 12,800 mg/kg have been observed in a variety of animals (Clayton and Clayton, 1981; U.S. EPA, 1987a). The maximum inhalation time-concentrations survived by rats have been reported to be 12,000 ppm (15 min.), 7,300 ppm (1.5 hr.), and 3,000 ppm (8 hr.) (Adams, et al., 1952).

2.1.2 Subchronic

Animal

Rats administered CCl_4 in corn oil by gavage at 20 mg/kg or higher for 9 out of 11 days or at 20 or 33 mg/kg for 12 weeks (5 days/week) showed liver damage (Bruckner, et al., 1986). Hepatotoxicity has been observed in mice exposed to CCl_4 in corn oil by gavage at doses of 625 to 2,500 mg/kg for 14 consecutive days or at 12 to 1,200 mg/kg for 90 consecutive days (Hayes, et al., 1986). Subchronic hepatotoxicity was also seen in mice dosed with 12 mg/kg CCl_4 in corn oil by gavage or with 12 or 120 mg CCl_4 /kg in corn oil or Tween-60 by gavage for 90 days (5 days/week) (Condie, et al., 1985).

Severe liver damage and increased mortality were found by Prendergast, et al. (1967) in guinea pigs and monkeys exposed via inhalation to 80 ppm for 8 hrs/day, 5 days/week, for 6 weeks. In the same study, guinea pigs exposed to 10 ppm continuously for 90 days exhibited degenerative changes in the liver and decreased survival; similar liver changes and depressed growth rates were observed in monkeys and rabbits. A depressed growth rate was seen in rats at concentrations as low as 1 ppm.

2.1.3 Chronic

Human

Visual effects, including restricted visual field, reduced corneal sensitivity, subnormal dark adaptation, and decreased color perception, have been reported in studies on humans exposed to CCl_4 in the workplace. Evidence of liver and kidney damage has also been reported (U.S. EPA, 1984).

No studies were located in the surveyed literature relating to the hepatotoxic or nephrotoxic effects of CCl_4 in humans.

Animal

In chronic (30 to 40 week) toxicity studies, Adams, et al., (1952) exposed guinea pigs and rats to carbon tetrachloride via inhalation for 7 hrs/day, 5 days/week. Guinea pigs showed enlargement and degeneration of the liver at concentrations of 5 ppm or greater, and cirrhosis at concentrations of over 50 ppm. In the same study, at 25 ppm, rabbits also had liver damage and at 50 and 100 ppm showed increased kidney weights and a decreased growth rate. Exposures of 50 ppm in monkeys resulted in weight loss and some cellular changes in the liver were seen at 100 ppm. Mortality was high in guinea pigs at 200 and 400 ppm and in rats at 100 ppm.

Smyth and co-workers (Smyth and Smyth, 1935; Smyth, et al., 1936) also conducted long-term inhalation studies on rats, guinea pigs, and monkeys (8 hrs/day, 4 to 6 days/week, for up to 321 days). Mortality in guinea pigs was high, even at 25 ppm. At concentrations of 25 ppm or greater, pathological changes were observed in the liver. Optic nerve degeneration and degeneration of the ocular muscles were seen in a few animals in each treatment group. Rats also showed liver degeneration at concentrations of 50 ppm or greater; degeneration of ocular muscles and of the myelin sheath of the sciatic nerve, and some indications of kidney damage were occasionally observed. At 50 ppm, mild changes were noted in the kidney and liver of monkeys.

2.1.4 Teratogenicity

Schwetz, et al. (1974), exposed rat dams to CCl_4 at 300 and 1,000 ppm for 7 hrs/day on days 6 to 15 of gestation. Pups in both groups showed a decrease in body weight and length, and delayed ossification of the sternbrae. Hepatotoxicity was observed in the dams but was not believed to be a causal factor in the fetal effects.

2.2 Mutagenicity and Carcinogenicity

CCl_4 has been classified by the U.S. EPA as a Group B2 carcinogen (i.e., sufficient evidence of carcinogenicity in animals and inadequate evidence in humans). There are a number of studies which provide evidence for the production of liver tumors in rodents as a result of the oral intake of CCl_4 (reviewed in U.S. EPA, 1984). Information regarding the production of tumors via the inhalation route is limited, however. Liver nodules, interpreted as being incipient hepatocellular carcinomas, were observed in rats exposed to an unspecified level of atmospheric CCl_4 for up to 7 months (Costa, et al., 1963).

Information regarding the potential carcinogenicity of CCl_4 in humans is limited. Although an increase in cancers have been reported in an epidemiological study on workers exposed to carbon tetrachloride, no conclusions could be reached because of complicating factors (e.g., simultaneous exposure to other chemicals, small number of cases) (Blair, et al., 1979; Wilkosky, et al., 1984).

CCl₄ has been reported to produce cell transformation in Syrian hamster embryo cells (Amacher and Zelljadt, 1983). CCl₄ has been tested for mutagenicity in a few bacterial systems (E. coli, Salmonella typhimurium). The results of these studies have been negative (U.S. EPA, 1984).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

Carcinogenic Potency Factor	1.30×10^{-1} (mg/kg/day) ⁻¹	(U.S. EPA, 1986)
RfD	7.0×10^{-4} mg/kg/day	(U.S. EPA, 1987a)
MCL	5 ug/l	(U.S. EPA, 1987b)
1-Day HA-Child	4,000 ug/l	(U.S. EPA, 1987a)
10-Day HA-Child	160 ug/l	(U.S. EPA, 1987a)
Longer Term (7-year) HA - Child	71 ug/l	(U.S. EPA, 1987a)
Longer Term (7-year) HA - Adult	250 ug/l	(U.S. EPA, 1987a)
1-Day SNARL	14,000 ug/l	(NAS, 1980)
7-Day SNARL	2,000 ug/l	(NAS, 1980)

4.0 REFERENCES

ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988. Cincinnati: ACGIH.

Adams, E.M., et al., 1952. "Vapor toxicity of carbon tetrachloride determined by experiments on laboratory animals." Arch. Ind. Hyg. Occup. Med. 6:50. (Cited in Clayton and Clayton, 1981; U.S. EPA, 1984.)

Amacher, D.E., and I. Zelljadt, 1983. "The morphological transformation of Syrian hamster embryo cells by chemicals reportedly nonmutagenic to Salmonella typhimurium." Carcinogenesis 4:291. (Cited in U.S. EPA, 1987a.)

Blair, A., et al., 1979. "Causes of death among laundry and dry cleaning workers." Am. J. Public Health 69:508. (Cited in U.S. EPA, 1984.)

- Bruckner, J.V., et al., 1986. "Oral toxicity of carbon tetrachloride: acute, subacute, and subchronic studies in rats." Fund. Appl. Toxicol. 6:16.
- Clayton, G.D. and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, 3rd ed. New York: John Wiley and Sons.
- Condie, L.W., et al., 1985. "Effect of corn oil gavage on hepatotoxicity of carbon tetrachloride in CD-1 mice." Fund. Appl. Toxicol. (Cited in U.S. EPA, 1987a.)
- Hayes, J.R., et al., 1986. "Acute 14-day repeated dosing, and 90-day subchronic toxicity studies of carbon tetrachloride in CD-1 mice." Fund. Appl. Toxicol. In Press. 7:454. (Cited in U.S. EPA, 1987a.)
- Kim, H.J., et al., 1986. "Effect of oral dosing vehicles on acute hepatotoxicity of carbon tetrachloride (CCl₄) in rats." Abstract, Society of Toxicology 1987 Annual Meeting. (Cited in U.S. EPA, 1987a.)
- NAS (National Academy of Sciences), 1980. Drinking Water and Health, Volume 3. National Research Council, Washington, D.C.: National Academy Press.
- Prendergast, J.A., et al., 1967. "Effects on experimental animals of long-term inhalation of trichloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, dichlorodifluoromethane, and 1,1-dichloroethylene." Toxicol. Appl. Pharmacol. 10:270. (Cited in U.S. EPA, 1984, 1987a.)
- Schwetz, B.A., et al., 1974. "Embryo and fetotoxicity of inhaled carbon tetrachloride, 1,1-dichloroethane and methyl ethyl ketone in rats." Toxicol. Appl. Pharmacol. 28:452. (Cited in Clayton and Clayton, 1981; U.S. EPA, 1984.)
- Smyth, H.F., and H.F. Smyth, Jr., 1935. Investigation of the Chronic Toxicity of Carbon Tetrachloride - Final Report to the Producers Committee. (Cited in U.S. EPA, 1984.)
- Smyth, H.F., et al., 1936. "The chronic toxicity of carbon tetrachloride - animal exposures and field studies." J. Ind. Hyg. Toxicol. 18:277. (Cited in U.S. EPA, 1984.)
- U.S. EPA, 1984. Health Effects Assessment for Carbon Tetrachloride. Final Draft. Environmental Criteria and Assessment Office. ECAO-CIN-H039.
- U.S. EPA, 1987a. Health Advisories for 25 Organics. Office of Drinking Water. Washington, D.C. PB 87-235578.
- U.S. EPA, 1987b. "National Primary Drinking Water Regulations--Synthetic Organic Chemicals; Monitoring for Unregulated Contaminants; Final Rule." Federal Register 52(130):25690, July 8, 1987.
- Wilkosky, C., et al., 1984. "Cancer mortality and solvent exposures in the rubber industry." Am. Indust. Hyg. J. 45:809. (Cited in U.S. EPA, 1987a.)

1,2-DICHLOROETHANE (1,2-DCA)

1.0 PHYSICO/CHEMICAL PROPERTIES (U.S. EPA, 1987)

Molecular Weight	98.96
Vapor Pressure	64 mm Hg (20°C)
Water Solubility	8,820 mg/l
Log octanol/water partition coefficient	1.48

2.0 TOXICOLOGICAL EFFECTS

Chronic exposure to 1,2-DCA results in damage to the liver and kidneys. The main effect of acute exposure is central nervous system depression; liver and kidney damage may also occur. Exposure to 1,2-DCA has produced tumors in laboratory animals.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

The ingestion of 1,2-DCA in humans leads to central nervous system and gastrointestinal symptoms (U.S. EPA, 1987). These include headache, dizziness, nausea, diarrhea, hematemesis, cerebellar and mental disorders, and loss of consciousness. Heart pains, pulmonary edema, and cyanosis have also been reported. Liver necrosis, kidney damage, and adrenal degeneration have been observed. Death is usually the result of circulatory and respiratory collapse and has been reported to occur after the ingestion of as little as 15 ml (340 mg/kg) in a 14 year old boy (Yodarken and Babcock, 1973).

Animal

The main acute effect of 1,2-DCA in mammals is central nervous system depression leading, in extreme cases, to coma and death. If an acutely exposed animal recovers and death occurs within a few hours after recovery, it is usually due to shock or cardiovascular collapse; if death occurs after several days it is usually due to kidney damage. Lung irritation, liver damage, and injury to the adrenals may also result from acute exposure. Oral LD₅₀s of 680 mg/kg and 860 mg/kg have been seen

in the rat and rabbit, respectively (NIOSH, 1977). LC₅₀s of 1,000 ppm (7.2 hr), 3,000 ppm (2.75 hr), and 12,000 ppm (0.53 hr) have been observed in rats. A dermal LD₅₀ of 3.89 ml/kg was determined for rabbits (NAS, 1977).

2.1.2 Subchronic

Animal

Subchronic oral exposure to 1,2-DCA has been shown to produce adverse effects on the immune system in mice. Mice exposed to 3 to 189 mg 1,2-DCA/kg/day in their drinking water for 90 days exhibited a dose-dependent decrease in growth rate and water consumption (Munson, et al., 1982). In the same study, exposure to 49 mg/kg/day for 14 days by gavage resulted in a decreased leukocyte count. Effects on both cell-mediated and humoral immunity, evidenced by a delayed hypersensitivity reaction and a decrease in the number of antibody producing cells were seen in mice administered 4.9 or 49 mg/kg/day by gavage for 14 days. No immunosuppression was seen in mice administered 1,2-DCA in their drinking water for 90 days.

Several subchronic inhalation studies showed increased mortality in exposed animals. High mortality rates (7 to 100 percent) were reported in monkeys, guinea pigs, rats, and rabbits after 2 to 97 exposures to 400 ppm for 7 hours/day, 5 days/week (Heppel, 1946; Spencer, 1951). Mortality rates of 35 to 90 percent were observed in rats, guinea pigs, and mice after 7 to 88 exposures to 200 ppm for 7 hrs/day, 5 days/week (Heppel, 1946). Exposure to 500 ppm for 6 weeks (6 hours/day, 5 days/week) led to over 90 percent mortality in rats, guinea pigs, and rabbits; cats subjected to the same regimen showed heart enlargement and increased blood urea nitrogen (Hofman, et al., 1971). Decreased growth rate, and liver enlargement and degeneration were reported in guinea pigs exposed to 200 ppm for 180 exposures (7 hours/day, 5 days/week) (Spencer, 1951).

2.1.3 Chronic

Human

Studies on workers exposed to 1,2-DCA have been published in the foreign literature. Some of the symptoms that have been reported to result from chronic inhalation exposure to 1,2-DCA include irritation of the eyes and upper respiratory tract, gastrointestinal disorders (diarrhea, epigastric pain/discomfort, vomiting), effects on the heart (bradycardia, murmur), enlarged liver, weakness, fatigue, and nervous system dysfunction (decreased reflex response, nervousness, nystagmus, tongue tremors). Gastrointestinal disorders, including liver disease, and effects on the nervous systems (decreased reaction time) may possibly have occurred at levels as low as 10-15 ppm (time-weighted average) (Clayton and Clayton, 1981; Kozik, 1957; U.S. EPA, 1984).

Animal

Changes in kidney and liver function were seen in rats exposed to 150 ppm 1,2-DCA via inhalation (7 hrs/day, 5 days/week) for 12 months (Spreafico, et al., 1980). Chronic oral studies have shown up to 100 percent mortality in rats exposed by gavage (5 days/week) to concentrations (time-weighted average) of 47 and 95 mg/kg/day. Death was attributed to noncarcinogenic effects (NCI, 1978).

2.1.4 Teratogenicity

There is insufficient evidence to indicate that 1,2-DCA causes teratogenic or fetotoxic effects at levels which are not maternally toxic (U.S. EPA, 1984; 1987).

2.2 Mutagenicity and Carcinogenicity

1,2-DCA is classified by the U.S. EPA in Group B₂, probable human carcinogen (i.e., sufficient evidence of carcinogenicity in animals and insufficient evidence in humans). This is based on long-term (78-week) gavage studies which revealed increased tumor incidences in rats and mice (NCI, 1978). Stomach and circulatory system (hemangiosarcomas) tumors were observed in male rats; mammary tumors were observed in female rats. An increase in lung tumors was seen in both male and female mice. Female mice also showed an increase in endometrial and mammary cancers.

1,2-DCA has been shown to be weakly mutagenic in bacteria, including Salmonella and E. coli. The response is increased by rat S-9 hepatic microsomal activation. Germ and somatic cell mutations have been observed in Drosophila that were exposed to 1,2-DCA through their diet. Mutations in in vitro cultures of Chinese hamster ovary cells have also been reported. This response was enhanced by hepatic S-9 microsomal activation (U.S. EPA, 1984; 1987).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

Carcinogenic Potency Factor	$9.10 \times 10^{-2} \text{ (mg/kg/day)}^{-1}$	(U.S. EPA, 1986)
MCL (proposed)	5 ug/l	(U.S. EPA, 1985)
MCLG	Zero	(U.S. EPA, 1985)

3.2 Inhalation

Carcinogenic Potency Factor	3.50×10^{-2} (mg/kg/day) ⁻¹	(U.S. EPA, 1986)
TLV-TWA	10 ppm (40 mg/m ³)	(ACGIH, 1987)

4.0 REFERENCES

- ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988. Cincinnati: ACGIH.
- Heppel, L.A., et al., 1946. "Toxicology of 1,2-dichloroethane. V. Effects of daily inhalation." J. Ind. Hyg. Toxicol. 28:113. (Cited in U.S. EPA, 1984.)
- Hofmann, H.T., et al., 1971. "On the inhalation toxicity of 1,1- and 1,2-dichloroethane." Arch. Toxicol. 27:248. (Cited in U.S. EPA, 1984.)
- Kozik, I., 1957. "Problems of occupational hygiene in the use of dichloroethane in the aviation industry." Gig. Fr. Prof. Zabol. 1:31. (Cited in U.S. EPA, 1984.)
- Munson, A.E., et al., 1982. "In vivo assessment of immunotoxicity." Environ. Health Perspect. 43:41. (Cited in U.S. EPA, 1984.)
- NCI (National Cancer Institute), 1978. "Bioassay of 1,2-dichloroethane for possible carcinogenicity." NCI Carcinogenesis Technical Report Series No. 55. DHEW Publ. No. (NIH) 78-1361. Washington, D.C.: Government Printing Office. (Cited in U.S. EPA, 1984.)
- NIOSH (National Institute for Occupational Safety and Health), 1977. Registry of Toxic Effects of Chemical Substances. U.S. Dept. of HEW, Washington, D.C.
- NAS (National Academy of Sciences), 1977. Drinking Water and Health, Volume I. National Research Council, Washington, D.C.: National Academy Press.
- Spencer, H.C., et al., 1951. "Vapor toxicity of ethylene dichloride determined by experiments on laboratory animals." Ind. Hyg. Occup. Med. 4:482. (Cited in U.S. EPA, 1984.)
- Spreafico, F., et al., 1978. "Metabolism of 1,2-dichloroethane in experimental animals." Report Nos. 1 and 2 to Chemical Manufacturers Association. New York. (Cited in U.S. EPA, 1984.)
- U.S. EPA, 1985. "National Primary Drinking Water Regulations; Volatile Synthetic Organic Chemicals. Final Rule and Proposed Rule." Federal Register 50(219):46880, November 13.

U.S. EPA, 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response, Washington, D.C.

U.S. EPA 1987. Health Advisories for 25 Organics. Office of Drinking Water. PB87-235578.

Yodarken, R.E., and J.R. Babcock, 1973. "1,2-Dichloroethane poisoning." Arch. Environ. Health. 26:281. (Cited in U.S. EPA, 1987.)

1,1-DICHLOROETHENE (1,1-DCE)

1.0 PHYSICO/CHEMICAL PROPERTIES

Molecular Weight	96.9
Vapor Pressure	600 mm Hg (25°C)
Water Solubility	2,250 mg/l
Log octanol/water partition coefficient	1.8

2.0 TOXICOLOGICAL EFFECTS

Chronic exposure to low concentrations of 1,1-DCE results primarily in liver and kidney damage. Acute exposure leads to central nervous system depression.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

There were no acute human studies located in the surveyed literature. Exposure to high concentrations would be expected to result in central nervous system depression.

Animal

The acute oral LD₅₀ for the rat has been reported to be in the range of 200-1500 mg/kg. An oral LD₅₀ of 5,750 mg/kg was noted in the dog. LC₅₀s of 98 ppm (22 hour) and 6,350 ppm (4 hour) have been observed in the mouse and rat, respectively, although an LC₅₀ as high as 10,000 ppm (24 hour) has been seen in the rat. In general, mice are more sensitive than rats to the toxic effects of 1,1-DCE than rats, probably due to their high rate of metabolism of the compound (Clayton and Clayton, 1981; Sax, 1984).

2.1.2 Subchronic

Animal

An increase in cytoplasmic vacuolization was observed in hepatocytes of rats exposed to 200 mg/l 1,1-DCE in their drinking water for 90 days (Rampy, et al., 1977). Renal lesions were reported in rats continuously exposed to approximately 50 ppm via inhalation for 90 days (Prendergast, et al., 1967). In the same study, hepatic lesions were seen in the rat, dog, and monkey at 50 ppm. Damage to the adrenals and lungs were also observed in some animals. Dose-related mortality occurred in monkeys and guinea pigs at concentrations of up to 50 ppm. Decreased weight gain and mortality were observed in some species at all dose levels (5 to 100 ppm). Weight loss also occurred in rabbits and monkeys exposed to 100 ppm, 8 hours/day, 5 hours/week, for 6 weeks. In another study (Norris, 1977) rats exposed to 25 or 75 ppm, 6 hours/day, 5 days/week, for 90 days were observed to have reversible liver damage.

2.1.3 Chronic

Human

A study of 138 workers who were exposed to 5 to 20 ppm revealed no effects of 1,1-DCE exposure on mortality or on the health parameters evaluated (Ott, et al., 1975).

Animal

A number of pathological changes in the liver, including fat accumulation and periportal hypertrophy, were described in rats exposed to 1,1-DCE in their drinking water at concentrations ranging from 50 to 200 mg/l (U.S. EPA, 1984). In a National Toxicology Program study (NTP, 1982), increased incidences of renal inflammation were reported in rats and liver necrosis was found in mice that were dosed by gavage, 5 days/week, for 2 years at doses of 5 mg/kg/day and 10 mg/kg/day, respectively.

Fatty changes in the liver were also reported in an inhalation study in rats conducted by the Dow Chemical Company (Rampy, et al., 1977; McKenna, et al., 1982). Animals were exposed to 10 or 40 ppm for 6 hours/day, 5 days/week, for 5 weeks, after which exposures were increased to 25 or 75 ppm, respectively, for 73 weeks. The effect was reversible after cessation of treatment. Other studies have also shown comparable liver changes in rats exposed to 55 ppm, 6 hours/day, 5 days/week, for 6 to 12 months (Lee, et al., 1977; Hong, et al., 1981).

2.1.4 Teratogenicity

No effects on embryonic or fetal development have been observed in rats or rabbits at ambient air concentrations of 1,1-PCE which were not toxic to dams (Huffman and Desai-Greenway, 1976). In a three-generation reproductive study in which 1,1-DCE was administered through the drinking water at concentrations of 100 and 200 mg/l, increased hepatocellular fatty degeneration occurred in F₁ males and females and in F₂ females (Nitschke, et al., 1983).

2.2 Mutagenicity and Carcinogenicity

1,1-DCE has been classified by EPA as a Group C carcinogen (i.e., possible human carcinogen-limited evidence of carcinogenicity in animals in the absence of human data). The only studies in which 1,1-DCE has given positive results for carcinogenicity are those of Maltoni, et al. (1977, 1980, 1985). Exposure via inhalation was demonstrated to cause an increase in mammary tumors in rats and mice, and in kidney tumors in mice. At least 5 oral carcinogenicity assays have been conducted by Maltoni and others; no significant increases in tumors were found, however. There is no evidence for the carcinogenicity of 1,1-DCE in humans.

1,1-DCE has given positive results in a number of mutagenicity tests. It has been shown to be mutagenic to E. coli, Salmonella typhimurium, Bacillus subtilis, and Saccharomyces cerevisiae when a mammalian activating system is present (U.S. EPA, 1984). It has also given positive responses for DNA alkylation, repair, and synthesis (U.S. EPA, 1985).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

AIC	9.00×10^{-3} mg/kg/day	(U.S. EPA, 1986)
Carcinogenic Potency Factor	5.80×10^{-1} (mg/kg/day) ⁻¹	(U.S. EPA, 1986)
MCL	7 ug/l	(U.S. EPA, 1987)

3.2 Inhalation

Carcinogenic Potency Factor	1.16×10^0 (mg/kg/day) ⁻¹	(U.S. EPA, 1986)
TLV-TWA	5 ppm (20 mg/m ³)	(ACGIH, 1987)
TLV-STEL	20 ppm (80 mg/m ³)	(ACGIH, 1987)

4.0 REFERENCES

- ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988. Cincinnati: ACGIH.
- Clayton, G.D. and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, 3rd ed. New York: John Wiley and Sons.
- Hong, C.B., et al., 1981. "Follow-up study on the carcinogenicity of vinyl chloride and vinylidene chloride in rats and mice. Tumor incidence and mortality subsequent to exposure." J. Toxicol. Environ. Health 7:909. (Cited in U.S. EPA, 1984).
- Huffman, R.D., and P. Desai-Greenway, 1976. Health and Environmental Impacts. U.S. NTIS ISS 258855. (Cited in Clayton and Clayton, 1981.)
- Lee, C.C., et al., 1977. "Inhalation toxicity of vinyl chloride and vinylidene chloride." Health Perspect. 21:25. (Cited in U.S. EPA, 1984.)
- Maltoni, C., et al., 1977. "Carcinogenicity bioassays of vinylidene chloride. Research plan and early results." Med. Lav. 68:241. (Cited in U.S. EPA, 1984.)
- Maltoni, C., et al., 1980. Toxicity and Carcinogenicity Bioassay of Vinylidene Chloride. II. Chronic Toxicity and Carcinogenicity Report of Institute of Oncology and Tumor Center. Bologna, Italy. (Cited in U.S. EPA, 1984.)
- Maltoni, C., 1985. (Cited in U.S.EPA, 1985.)
- McKenna, M.J., et al., 1982. Vinylidene Chloride: A Chronic Inhalation and Oncogenicity Study in Rats. Dow Chemical, Midland, MI. (Cited in U.S. EPA, 1984.)
- Nitschke, K.D., et al., 1983. "A three-generation rat reproductive toxicity study of vinylidene chloride in the drinking water." Fundam. Appl. Toxicol. 3:75. (Cited in U.S. EPA, 1984.)
- Norris, J.M., 1977. Paper Synthetic Conference, Technical Association of the Pulp and Paper Industry. Chicago, Ill.: September 26-28, 1977, p. 45.
- NTP (National Toxicology Program), 1982. NTP Technical Report on the Carcinogenesis Bioassay of Vinylidene Chloride in F344/N Rats and B6C3F1/Mice (Gavage Study). NTP No. 80-82. NIH Public. No. 82-1784. (Cited in U.S. EPA, 1984.)
- Ott, M.G., et al., 1975. Arch. Environ. Health 30:333. (Cited in Clayton and Clayton, 1981.)

- Prendergast, J.A., et al., 1967. "Effects on experimental animals of long-term inhalation of trichloroethylene, carbon tetrachloride, 1,1,1-trichloroethane, dichlorodifluoromethane and 1,1-dichloroethylene." Toxicol. Appl. Pharmacol. 10:270. (Cited in U.S. EPA, 1984.)
- Rampy, L.W., et al., 1977. "Interim results of two-year toxicological studies in rats of vinylidene chloride incorporated in the drinking water or administered by repeated inhalation." Environ. Health Perspect. 21:33. (Cited in U.S. EPA, 1984.)
- Sax, N.I., 1984. Dangerous Properties of Industrial Materials, 6th ed. New York: Van Nostrand Reinhold Company.
- U.S. EPA, 1984. Health Effects Assessment for 1,1-Dichloroethylene. Final Draft. Environmental Criteria and Assessment Office. ECAO-CIN-H051.
- U.S. EPA, 1985. "National Primary Drinking Water Regulations: Volatile Synthetic Organic Chemicals". Federal Register 50(219):46880, November 13.
- U.S. EPA, 1987. "National Primary Drinking Water Regulations--Synthetic Organic Chemicals; Monitoring for Unregulated Contaminants; Final Rule." Federal Register 52(130):25690. July 8.

SELENIUM (Se)

1.0 PHYSICO/CHEMICAL PROPERTIES (Clayton and Clayton, 1981)

Atomic Weight	78.96
Specific Gravity	4.3-4.8 (20°C)
Melting Point	217°C
Boiling Point	688°C

2.0 TOXICOLOGICAL EFFECTS

Selenium has been shown to be an essential element in animals. Among the effects of selenium deficiency in animals are liver necrosis, muscle disease, cardiomyopathy, and hair loss. In humans, there is also epidemiological evidence that selenium deficiency may lead to cardiac and vascular disorders. Selenium interacts with other toxic metals and has been shown to protect against the toxic effects of arsenic, cadmium, mercury, silver, copper, and thallium. There is also evidence that it may have anticarcinogenic properties. The toxic potential of exposure to excessive amounts of selenium and its compounds is dependent upon the chemical form. (Klaasen, et al., 1986; U.S. EPA, 1984)

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

Acute inhalation exposure to selenium-containing dusts or fumes can cause a respiratory distress syndrome. Symptoms include irritation to the eyes and mucous membranes, difficulty in breathing, sneezing, coughing, pulmonary edema, nausea, headache, dermatitis, and garlic odor on the breath. Prolonged exposure may be fatal. (Clayton and Clayton, 1981)

Animal

Acute poisonings resulting from excessive selenium ingestion have been reported in domestic animals (Clayton and Clayton, 1981). The oral administration of 10 mg of sodium selenite to lambs led to the death of seven animals within 10 to 16 hours; eight developed diarrhea, and five were asymptomatic. Three mg of selenium fed to young pigs has proven fatal within 2.5 to 14 hours.

An oral LD₅₀ of 12.5 mg/kg has been reported for selenium in rats (Morss and Olcott, 1967). Rats exposed for eight hours to selenium dust at a concentration of 33 mg/m³ resulted in the death of 10 percent of the animals (Hall, et al., 1951). Interstitial pneumonia was the main toxicological effect.

2.1.2 Subchronic

Animal

A decreased growth rate was seen in young rats fed 5 ppm selenium as selenite in their diets for two weeks (Hopkins, et al., 1966). A decreased growth rate was also observed in young rats who were administered 4.8 ppm or greater selenium (as selenite) in their diet for 6 weeks (Halverson, et al., 1966). At concentrations of 8 ppm or greater, death occurred after 4 weeks. Signs of toxicity occurring at levels of 6.4 ppm or greater included pancreatic enlargement, decreased liver weight, decreased hemoglobin, and increased serum bilirubin. In another study, changes in the ovaries, pituitary, and adrenals were seen in guinea pigs orally exposed to 5 to 12.5 mg sodium selenide for two periods of 20 days each (Vesce, 1974).

2.1.3 Chronic

Human

Chronic selenium poisoning in humans has occurred as a result of the ingestion of elevated levels of selenium in drinking water and of vegetables grown in seleniferous soil. Chronic inhalation poisoning has resulted from workplace exposure. Skin discoloration, hair loss, and loss of fingernails have been reported in individuals whose drinking water contained 9 mg selenium/l (Beath, 1962). Individuals living in an area where the soil had a high selenium content and whose daily selenium intake was estimated at 0.1 to 0.2 mg/kg/day were reported to show signs of selenium toxicity including gastrointestinal disorders, dermatitis, arthritis, fatigue, jaundice, and bad teeth (Smith, et al., 1939). Similar symptoms as well as nervous system disorders including peripheral paresthesias, limb pain, convulsions, and motor dysfunctions have been observed in an area of China where selenium had contaminated the soil and surface/groundwaters (Yang, et al., 1983). The average daily intake of selenium was estimated at 5 mg/day. Other studies have indicated an association between high selenium intake and dental cavities (U.S. EPA, 1984). Chronic inhalation of selenium has been reported to lead to upper respiratory and gastrointestinal distress, garlic odor on the breath, dermatitis, irritability, and fatigue (Clayton and Clayton, 1981; U.S. EPA, 1984).

Animal

Selenium toxicity to farm animals resulting from the chronic ingestion of high-selenium forage or feed is well documented. Livestock feeding on plants containing

approximately 25 ppm selenium develop alkali disease which is characterized by hair loss, anemia, hoof atrophy, lameness, and lassitude. At concentrations of 100 to 1000 ppm blind stagger, characterized by impaired vision, limb weakness, and respiratory failure, can result (Klaasen, et al., 1986). Other symptoms and pathologies noted in chronically exposed farm animals include loss of appetite, liver damage, nephritis, and upper gastrointestinal ulceration (Clayton and Clayton, 1981).

An increase in dental caries has been produced in monkeys fed selenium at 1 ppm in their drinking water and an increase in caries has been correlated with selenium intake in rats (U.S. EPA, 1984). Decreased growth rate and increased mortality were observed in rats fed 22.3 or 33.5 selenium (as selenite) in their diets (Franke and Potter, 1935). Liver necrosis was observed in survivors. Excessive mortality and liver necrosis have also been reported by investigators who fed rats 10 ppm or greater selenium (as ammonium potassium selenide) in their diets (U.S. EPA, 1984). Anemia has also been seen in rats chronically exposed to selenium (NAS, 1977).

2.1.4 Teratogenicity

There is limited evidence for the teratogenicity of selenium in humans. Of the four definite and one possible pregnancy in female workers exposed to selenite, only one went to term. This infant had a clubfoot (Robertson, 1980).

Embryonic chicks are highly sensitive to selenium. Hatchability is decreased and embryos exhibit morphological abnormalities including absence of eyes and beaks, and deformed wings and feet (U.S. EPA, 1984). In a three-generation reproductive study in which mice were fed 3 ppm selenium (as selenate) in their drinking water, adverse effects were seen by the third generation (Schroeder and Mitchener, 1971). Decreased fertility and decreased pup survival was also seen in female rats fed 7.5 ppm selenium (as selenate) in drinking water (Rosenfeld and Beath, 1964).

2.2 Mutagenicity and Carcinogenicity

Selenium is currently classified by the U.S. EPA in Group D (i.e., not classified chemical) with regard to carcinogenicity. There is no evidence for the carcinogenicity of selenium in humans and there is limited epidemiological evidence that it may have anticarcinogenic effects. Negative correlations have been made between higher blood levels of selenium and cancer, and between cancer rates and the concentration of selenium in forage crops (Shamberger and Frost, 1969). The significance of the epidemiological findings, however, is questionable (U.S. EPA, 1984).

There are some data from an unpublished NCI (National Cancer Institute) animal study that suggest that selenium dioxide may be carcinogenic in female mice (U.S. EPA, 1984). There are insufficient data, however, to indicate that selenite or selenate may be carcinogenic. Increased dietary selenium has been associated with a decrease in induced skin and mammary tumors in mice and induced liver tumors in rats (Klaasen, et al., 1986; U.S. EPA, 1984).

Recent data concerning the mutagenicity of selenium are lacking. There is some evidence that selenium may adversely affect mitosis (U.S. EPA, 1984).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

AIC	3.0×10^{-3} mg/kg/day	(U.S. EPA, 1986)
AIS	3.2×10^{-3} mg/kg/day	(U.S. EPA, 1986)
MCL	10 ug/l	

3.2 Inhalation

AIC	1.00×10^{-3} mg/kg/day	(U.S. EPA, 1986)
TLV-TWA (Selenium compounds as selenium)	0.2 mg/m ³	(ACGIH, 1987)

4.0 REFERENCES

- ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988. Cincinnati: ACGIH.
- Beath, O.A., 1962. The Story of Selenium in Wyoming. University of Wyoming, Laramie. (Cited in U.S. EPA, 1984.)
- Clayton, G.D. and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, 3rd ed. New York: John Wiley and Sons.
- Franke, K.W. and V.R. Potter, 1935. "New toxicant occurring naturally in certain samples of plant foodstuffs; toxic effects of orally ingested selenium." J. Nutr. 10:213. (Cited in U.S. EPA, 1984.)
- Hall, R.H., et al., 1951. Arch. Ind. Hyg. Occup. Med. 4:458. (Cited in Clayton and Clayton, 1981.)
- Halverson, A.W., et al., 1966. "Toxicity of selenium to postweanling rats." Toxicol. Appl. Pharmacol. 9:477. (Cited in NRC, 1977 and U.S. EPA, 1984.)
- Hopkins, L.L., et al., 1966. "Distribution of microgram quantities of selenium in the tissues of the rat and effects of previous selenium uptake." J. Nutr. 88:61. (Cited in NRC, 1977.)

- Klaasen, C.D., et al. (eds.), 1986. Casarett and Doull's Toxicology, 3rd ed. New York: Macmillan Publishing Company.
- Morss, S.G. and H.S. Olcott, 1967. "Absence of effect of tocopherol on acute oral toxicity of sodium selenite in the rat." Proc. Soc. Exp. Biol. Med. 124:483. (Cited in NRC, 1977.)
- NRC (National Research Council), 1977. Drinking Water and Health, Vol. I. Washington, D.C.: National Academy Press.
- Robertson, D.S.F., 1970. "Selenium, a possible teratogen?" Lancet 1:518. (Cited in U.S. EPA, 1984.)
- Rosenfeld, I. and O.A. Beath, 1964. Selenium: Geobotany, Biochemistry, Toxicity, and Nutrition. New York: Academic Press.
- Schroeder, H.A., and M. Mitchener, 1971. "Toxic effects of trace elements on the reproduction of rats and mice." Arch. Environ. Health 23:102. (Cited in U.S. EPA, 1984.)
- Smith, M.I., 1939. Public Health Report 54, 1441. (Cited in U.S. EPA, 1984.)
- U.S. EPA, 1984. Health Effects Assessment for Selenium and Compounds. Final Draft. Office of Emergency and Remedial Response. Washington, D.C. ECAO-CIN-H058.
- U.S. EPA, 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response, Washington, D.C.
- Vesce, C.A., 1974. "Intorsicazione spermentale da selenio." Folia Med. 33:209. (Cited in U.S. EPA, 1984.)
- Yang, G., 1983. "Endemic selenium intoxication of humans in China." Amer. J. Clin. Nutr. 37:872. (Cited in U.S. EPA, 1984.)

**STRONTIUM (Sr)
(STABLE)**

1.0 PHYSICO/CHEMICAL PROPERTIES

Atomic Weight	87.62
Specific Gravity	2.6 (20°C)

2.0 TOXICOLOGICAL EFFECTS

Strontium and its salts are of low toxicity and strontium poisoning is rare. There is some evidence that strontium may be necessary in animals for the calcification of bones and teeth.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

There was no available information concerning acute oral or inhalation effects of strontium in humans. The daily intravenous injection of 47 mg of strontium lactate over a period of five days reportedly led to no signs of toxicity (McCance and Widdowson, 1939).

Animal

Oral LD₅₀s ranging from 250 mg/kg in rats to over 5,000 mg/kg in guinea pigs have been reported for strontium salts. LC₅₀s of 55 to 580 ppm have been observed after inhalation exposure in rats. Signs of acute poisoning include excessive salivation and gastrointestinal distress (vomiting, colic, diarrhea). Death in rats has resulted from respiratory failure, in cats from cardiac arrest (Clayton and Clayton, 1981; NRC, 1982).

2.1.2 Subchronic

Animal

Minor hematological and blood chemistry changes were observed in Wistar rats fed strontium as strontium chloride at 4,800 mg/kg diet for 90 days (Droes, et al., 1977). Female rats showed decreased liver glycogen at 12 weeks when fed 4,800 mg/kg diet. Male rats had increased thyroid weights when fed 1,200 or 4,800 mg/kg diet. Weanling rats fed 0.2 percent strontium in their diets for eight weeks exhibited severe skeletal aberrations, including deformed and shortened bones (Johnson, 1973).

Rats exposed to 50 mg/m³ strontium nitrate via inhalation for one month (4 hours/day) exhibited both functional and histological changes in a number of organs (Zyuzukin, 1974). Physiological changes included decreased urinary chloride excretion, increased blood nitrogen, increased hippuric acid biosynthesis, and changes in mineral metabolism as evidenced by increased urinary excretion of calcium and increased serum alkaline phosphatase. Morphological effects included interstitial pneumonia accompanied by hemorrhage in the lungs, dystrophy of heart muscle fibers and renal convoluted tubules, and hyperemia in the lungs, heart, liver, and kidney.

2.1.3 Chronic

Human

There is little evidence for chronic toxicity in humans resulting from strontium exposure (Schroeder, et al., 1972). Strontium has been used for medicinal purposes.

Animal

The major symptoms of chronic strontium toxicity involve the skeletal system and have been referred to as "strontium rickets". Mice fed 16,000 ppm strontium lactate in their drinking water for 402 days exhibited stunting of growth due to inhibited bone calcification (Alexander, et al., 1951; Alexander, et al., 1956). Rickets have also been produced in rats by feeding them two percent strontium carbonate in the diet (Follis, 1955).

2.1.4 Teratogenicity

There was no data available concerning the teratogenicity of strontium.

TETRACHLOROETHENE (PCE)

1.0 PHYSICO/CHEMICAL PROPERTIES

Molecular Weight	165.83
Vapor Pressure	17.8 mm Hg (25°C)
Water Solubility	150 mg/l (25°C)
Log octanol/water partition coefficient	2.6

2.0 TOXICOLOGICAL EFFECTS

The main effects of acute exposure to PCE are on the central nervous system, with CNS depression occurring at high concentrations. Subchronic and chronic exposure primarily causes liver and kidney damage, as well as CNS effects. PCE has been shown to be carcinogenic in some animal species.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

When exposure to PCE occurs via inhalation, minimal effects (eye irritation, lightheadedness, impaired coordination) begin to be experienced at 200 ppm. Salivation, nasal irritation, and a metallic taste have been reported at 500 ppm. Central nervous system depression (narcosis) has been observed at 1,000 to 2,000 ppm. Unconsciousness can occur after a thirty-minute exposure to 1,500 ppm. In extreme cases, death may result.

Little data are available concerning acute oral toxicity. An oral dose of 500 mg/kg has been reported not to be lethal in humans.

Animal

In laboratory animals, oral LD₅₀s have been reported to range from 2,600 mg/kg (rats) to 8,850 mg/kg (mice). Via inhalation, an LC₅₀ (eight-hour) of 5,000 ppm has been demonstrated.

The major effect of acute exposure is central nervous system depression. At ambient air concentrations of 6,000 and 3,000 ppm, unconsciousness occurred in rats

within a few minutes and after several hours, respectively. Slight liver damage has been observed by several investigators in animals exposed to 200 to 2,000 ppm for four hours, and in animals that died from single-dose exposure to higher levels. Other signs and symptoms of acute exposure in animals include cardiac depression, decreased respiration, decreased blood pressure, and congestion/inflammation of the lungs.

2.1.2 Subchronic

Animal

Guinea pigs exposed to PCE vapors showed adverse effects at levels of 100 to 400 ppm (seven hours/day, five days/week, six months) (Rome, et al, 1952). Increased liver weight was seen at 200 ppm (females only). Histological signs of liver damage was seen at 200 to 400 ppm. No adverse effects were seen in rats, rabbits, or monkeys at the same exposure levels.

EEG changes and alterations of the cytology of cerebral cortical cells were seen in rats exposed to 15 ppm (four hours/day, five months) (Dmitrieva, 1966). Mice exposed to 15 to 74 ppm (five hours/day, three months) exhibited a decrease in muscle electroconductance and a decrease in muscle contraction amplitude (Cmitrieva, 1968).

2.1.3 Chronic

Human

Chronic inhalation exposure has been reported to cause a number of health effects including liver and kidney pathologies, respiratory tract irritation, nausea, headache, sleeplessness, abdominal pains, and constipation.

Animal

Kidney and liver damage are the main effects of chronic exposure in animals. In a chronic oral study by the National Cancer Institute (NCI) (1977) on mice and rats in which PCE was administered in corn oil by gavage (five days/week, seventy-eight weeks), nephropathy was noted at all dose levels. Doses ranged upwards from 300 mg/kg/day in mice and 471 mg/kg/day in rats.

Rats dosed with air concentrations of 230 or 470 ppm (eight hours/day, five days/week, seven months) showed congestion/swelling of the liver, kidneys, and spleen (Carpenter, 1937). Pathological changes in the liver and kidneys were reported in rabbits exposed to 15 ppm (three to four hours/day, seven to eleven months) (Navrotskii, et al., 1971). Liver damage has also been reported in rats exposed to 600 ppm (five hours/day, five days/week, twelve months) (Pegg, et al., 1978).

2.1.4 Teratogenicity

Teratogenic effects were described in mice and rats that were exposed to 300 ppm (seven hours/day) via inhalation on days six to fifteen of pregnancy (Schwetz, et al., 1975). Depression of fetal weight, defects in bone development, and subcutaneous edema were observed in mice. Increased fetal resorption occurred in rats.

A reduction in the proportion of pups born alive were seen in rats exposed to 20 ppm on days seven to thirteen or fourteen to twenty of gestation (Nelson, 1979). Offspring showed a temporary decrease in performance in behavioral tests. A decrease in brain neurotransmitters was measured in offspring of dams exposed during the second week of gestation.

2.2 Mutagenicity and Carcinogenicity

PCE has been classified by EPA as a Group B₂ carcinogen (i.e., sufficient evidence of carcinogenicity in animals and inadequate data in humans). The classification is based upon several studies. In an inhalation study completed by the National Toxicology Program (NTP) in 1985, PCE caused increases in leukemias in male and female rats, rare renal cell cancers in male rats, and liver tumors in male and female mice.

In an earlier (1977) study performed by the National Cancer Institute in which PCE was administered to mice in corn oil by gavage, a significant increase in liver tumors was observed. Based on the NCI study, EPA's Carcinogen Assessment Group has calculated that lifetime exposure to 1 ug/l of PCE in drinking water poses a 10⁻⁶ (one in a million) cancer risk, assuming the ingestion of two liters of water per day (Federal Register, 1984).

Mutagenicity testing has given mixed results. Positive test results have been reported in the Salmonella typhimurium reverse mutation assay, in a host-mediated assay in mice using Salmonella typhimurium, and in a transformation assay using rat embryo cells (Cerna and Kypenova, 1977; Price, et al., 1978). It has tested negative, however, in other assays using Salmonella, E. coli, and rat lymphocytes (Clayton and Clayton, 1981; U.S. EPA, 1980).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

AIC	2.00 x 10 ⁻² mg/kg/day	(U.S. EPA, 1986)
Carcinogenic Potency Factor	5.10 x 10 ⁻² (mg/kg/day) ⁻¹	(U.S. EPA, 1986)

3.2 Inhalation

Carcinogenic Potency Factor	1.7×10^{-3} (mg/kg/day) ⁻¹	(U.S. EPA, 1986)
TLV-TWA	50 ppm (335 mg/m ³)	(ACGIH, 1987)
TLV-STEL	200 ppm (1,340 mg/m ³)	(ACGIH, 1987)
PEL (eight-hour)(OSHA)	100 ppm	(U.S. EPA, 1984)

4.0 REFERENCES

ACGIH (American Conference of Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988. Cincinnati: ACGIH.

Carpenter, C.P., 1937. "The chronic toxicity of tetrachloroethylene." J Ind. Hyg. Toxicol. 9:323. (Cited in U.S. EPA, 1984.)

Cerna, M. and H. Kypenova, 1977. "Mutagenic activity of chloroethylenes analyzed by screening system tests." Mutat. Res., 46:214. (Cited in U.S. EPA, 1984.)

Clayton, G.D. and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, 3rd edition. New York: John Wiley and Sons.

Dmitrieva, N.V., 1966. "Maximal permissible concentration of tetrachloroethylene in factory air." Hyg. Sanit., 31:387. (Cited in U.S. EPA, 1984.)

Dmitrieva, N.V., 1968. "Bioelectric activity and electric conducting properties of muscles exposed to chlorinated hydrocarbons." Farmakol. Toksikol., 31:228. (Cited in U.S. EPA, 1984.)

Federal Register, June 12, 1984. "National Primary Drinking Water Regulations; Volatile Synthetic Organic Chemicals." 49(114): 24330.

Navrotskii, V.K., et al., 1971. "Comparative evaluation of the toxicity of a series of industrial poisons during their long-term inhalation action in low concentrations." Fr. Sezda. Gig. Ukr., 8:224. (Cited in U.S. EPA, 1984.)

Nelson, B.K., 1979. "Behavioral teratology of perchloroethylene." Teratology, 19:41A. (Cited in U.S. EPA, 1980.)

Pegg, D.G., et al., 1978. "Disposition of (¹⁴C) tetrachloroethylene following oral and inhalation exposure in rats." Toxicol. Appl. Pharmacol., 45:276. (Cited in U.S. EPA, 1984.)

Price, P.J., et al., 1978. "Transforming activities of trichloroethylene and proposed industrial alternatives." In Vitro, 14: 290. (Cited in U.S. EPA, 1980.)

Rowe, V.K., et al., 1952. "Vapor toxicity of tetrachloroethylene for laboratory animals and human subjects." Arch. Ind. Hyg. Occup. Med., 5:566. (Cited in U.S. EPA, 1984.)

Schwetz, B.A., et al., 1975. "The effect of maternally inhaled trichloroethylene, perchloroethylene, methyl chloroform, and methylene chloride on embryonal and fetal development in mice and rats. Toxicol. Appl. Pharmacol., 32:84. (Cited in U.S. EPA, 1984.)

U.S. EPA, 1980. An Exposure and Risk Assessment for Tetrachloroethylene. Final Draft Report. Office of Water Regulations and Standards.

U.S. EPA, 1984. Health Effects Assessment for Tetrachloroethylene. Final Draft. Environmental Criteria and Assessment Office. ECAO-CIN-H009.

U.S. EPA, 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response, Washington, D.C.. EPA 540/1-86-060.

TRICHLOROETHENE (TCE)

1.0 PHYSICO/CHEMICAL PROPERTIES

Molecular Weight	131.3
Vapor Pressure	77 mm Hg (25°C)
Water Solubility	1,000 mg/l
Log octanol/water partition coefficient	2.3

2.0 TOXICOLOGICAL EFFECTS

The main effects in humans and animals of exposure to high doses of TCE are central nervous system effects, and kidney and liver pathologies. TCE also has evidence of carcinogenicity in mice.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

When individuals are exposed to TCE in the ambient air, mild eye irritation is experienced at 200 ppm. Light-headedness may occur at 400 ppm after a three-hour exposure. Nasal irritation and dizziness after six minutes occurs at exposure concentrations of 1,000 to 2,000 ppm. Nausea and drowsiness occur after five minutes at 2,000 ppm. Visual disturbances, mental confusion, and fatigue are other symptoms that may accompany acute exposure.

In cases of extreme inhalation exposure, death may result from cardiac failure or respiratory arrest. The ingestion of TCE has also reportedly resulted in death, with severe injury occurring to the liver and kidneys.

Animal

TCE has a moderate to low acute oral toxicity in laboratory animals. LD₅₀s have been reported to range from 300 mg/kg to 7,000 mg/kg.

Full anesthesia occurs in rats via the inhalation route at concentrations of 4,800 ppm or greater. Hepatotoxicity has been observed at anesthetic doses. At highly

anesthetic levels (5,000 to 12,000 ppm) sensitization of the heart to adrenalin has been seen in dogs. Death occurs in rats after single inhalation exposures of 3,000 ppm after three hours, 6,400 ppm after one and one-half hours, and 20,000 ppm after eighteen minutes.

2.1.2 Subchronic

Animal

Tucker, et al. (1982) exposed mice to TCE in their drinking water for six months. Increased liver weights were observed in males at 216 mg/kg/day. In addition, at 393 mg/kg/day, an elevation of urinary ketones and protein occurred, and at 660 mg/kg/day a decrease in body weight and increased kidney weights resulted. All three changes were seen in female mice at 793 mg/kg/day.

Similar changes were described in animals exposed via inhalation. At 400 ppm, rats exposed for seven hours/day, five days/week for six months had increased liver and kidney weights and increased liver weights were seen in guinea pigs and rabbits (Adams, et al., 1951). In the same study, body weights were decreased in guinea pigs at a dose level of 200 ppm and in male rats at 400 ppm. Increased liver weights were also reported in rats intermittently exposed to 55 ppm for fourteen weeks (Kimmerle and Eben, 1973).

Slight growth depression was observed in a number of animal species that were continuously exposed to 35 ppm for ninety days (Prendergast, et al., 1967). Histological changes were noted in a number of areas of the brain, particularly the cerebellum, in dogs that were exposed to TCE vapor at concentrations ranging from 500 to 3,000 ppm (two to eight hours/day, up to five days/week for up to 162 hours) (Baker, 1958).

2.1.3 Chronic

Human

A number of symptoms have been reported by individuals that were occupationally exposed to air concentrations ranging from 50 to 6,300 ppm for periods ranging from six months to twenty-five years. These include headaches, dizziness, anxiety, cardiac abnormalities, flushing of the face, and fatigue.

Animal

Other than carcinogenicity bioassays, no studies could be located in the surveyed literature that addressed the chronic toxicity of TCE in animals.

2.1.4 Teratogenicity

Teratogenic effects have also been seen. Pups born to mice treated via inhalation with 300 ppm for seven hours/day on days six to fifteen of gestation exhibited decreased body weights, and delays in skeletal development and testicular descent (Schwetz, et al., 1975). Decreased fetal size and delayed ossification have also been reported by other investigators (U.S. EPA, 1984).

2.2 Mutagenicity and Carcinogenicity

Of six animal studies investigating the carcinogenic potential of TCE, two have given positive results for liver tumors in male and female mice. The other studies were considered by EPA to be technically flawed or gave negative results (Federal Register, 1985). On the basis of this evidence, as well as additional evidence of TCE causing lymphomas and lung tumors in mice, EPA has conservatively classified TCE in Group B₂ (i.e., sufficient evidence of carcinogenicity in animals and inadequate data in humans). Based on a study conducted by the National Cancer Institute in which TCE was administered to mice orally by gavage, EPA's Carcinogen Assessment Group calculated that lifetime exposure to 1.8 ug/l of TCE in drinking water poses a 10⁻⁶ (one in a million) cancer risk, assuming the ingestion of two liters of water per day (Federal Register, 1984).

TCE has given positive responses in a number of mutagenicity tests. These include increased mutagenicity in strains of Salmonella typhimurium, Saccharomyces cerevisiae, and E. coli, and a positive reaction in the mouse spot test (Clayton and Clayton, 1981; U.S. EPA, 1984).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

Carcinogenic Potency Factor	1.10×10^{-2} (mg/kg/day) ⁻¹	(U.S. EPA, 1986)
RfD	7.35×10^{-3} mg/kg/day	(U.S. EPA, 1987a)
MCL	5 ug/l	(U.S. EPA, 1987b)

3.2 Inhalation

Carcinogenic Potency Factor	4.60×10^{-3} (mg/kg/day) ⁻¹	(U.S. EPA, 1986)
TLV-TWA	50 ppm (270 mg/m ³)	(ACGIH, 1987)
TLV-STEL	200 ppm (1,080 mg/m ³)	(ACGIH, 1987)

4.0 REFERENCES

- ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988. Cincinnati: ACGIH.
- Adams, E.M., et al., 1951. "Vapor toxicity of trichloroethylene determined by experiments on laboratory animals." Am. Med. Assoc. Arch. Ind. Hyg. Occup. Med., 4:469. (Cited in U.S. EPA, 1984.)
- Baker, A.B., 1958. J. Neuropathol. Exp. Neurol. 17:649. (Cited in Clayton and Clayton.)
- Clayton, G.D. and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, 3rd ed. New York: John Wiley and Sons.
- Federal Register, June 12, 1984. "National Primary Drinking Water Regulations; Volatile Synthetic Organic Chemicals," 49(114):24330.
- Federal Register, November 13, 1985. "National Primary Drinking Water Regulations; Volatile Synthetic Organic Chemicals," 50(219):46880.
- Kimmerle, G. and A. Eben, 1973. "Metabolism, excretion, and toxicology of trichloroethylene after inhalation. 1. Experimental exposure on rats." Arch. Toxicol., 30:115. (Cited in U.S. EPA, 1984.)
- Prendergast, J.A., et al., 1967. Toxicol. Appl. Pharmacol., 10:270. (Cited in Clayton and Clayton, 1981.)
- Sax, N.I., 1984. Dangerous Properties of Industrial Materials, 6th ed. New York: Van Nostrand Reinhold Company.
- Schwetz, B.A., B.K.J. Leong, and P.J. Gehrig, 1975. "The effect of maternally inhaled trichloroethylene, perchloroethylene, methyl chloroform, and methylene chloride on embryonal and fetal development in mice and rats." Toxicol. Appl. Pharmacol., 32:84. (Cited in U.S. EPA, 1984.)
- Tucker, A.N., et al., 1982. "Toxicology of trichloroethylene in the mouse." Toxicol. Appl. Pharmacol., 62:351. (Cited in U.S. EPA, 1984.)
- U.S. EPA, 1984. Health Effects Assessment for Trichloroethylene. Final Draft. Environmental Criteria and Assessment Office. ECAO-CIN-H046.
- U.S. EPA, 1986. Superfund Public Health Evaluation Manual. Office of Emergency and Remedial Response, Washington, D.C.
- U.S. EPA 1987a. Health Advisories for 25 Organics. Office of Drinking Water. PB87-235578.

U.S. EPA, 1987b. "National Primary Drinking Water Regulations--Synthetic Organic Chemicals; Monitoring for Unregulated Contaminants; Final Rule." Federal Register 52(130):25690, July 8.

URANIUM (U)

1.0 PHYSICO/CHEMICAL PROPERTIES (Natural Uranium) (Clayton and Clayton, 1981; U.S. EPA, 1985)

Atomic Weight	238.03 U-238: 99.27% U-235: 0.72% U-234: 0.006%
Specific Gravity	19.05 (25°C)
Melting Point	1132.3°C
Boiling Point	3818°C
Half-Life	2.47 x 10 ⁵ years (U-234) 7.1 x 10 ⁸ years (U-235) 4.51 x 10 ⁹ years (U-238)

2.0 TOXICOLOGICAL EFFECTS

The following discussion primarily addresses the toxic effects of natural uranium. Since the three isotopes comprising natural uranium occur in consistent proportions and since their half-lives vary, it is possible that the toxicity of other mixtures containing the same isotopes may differ from that of natural uranium. The main target of the toxic chemical effects of uranium is the kidney. There is insufficient evidence for the radiometric effects of natural uranium.

2.1 Noncarcinogenic Effects

2.1.1 Acute

Human

Individuals who were administered oral doses of 30 to 60 mg of uranyl nitrate two to three times per day exhibited glucosuria, reduced urine output, and thirst. These symptoms were reversible after treatment ceased. An individual who voluntarily ingested 1 g of uranyl nitrate was reported to show diarrhea, vomiting, and slight albuminuria (Hodge, et al., 1973).

Accidental exposure to uranium hexafluoride in the workplace has been associated with injury to the eye (corneal and conjunctival damage), the respiratory tract, and the urinary tract. Nervous symptoms (mental derangement, tension,

restlessness) were also described. These manifestations were reversible (Clayton and Clayton, 1981).

Animal

Acute exposure to uranium in animals results in kidney damage. Few oral studies have been carried out, and no acute inhalation studies were located in the surveyed literature. A lethal oral dose of 1,400 mg of uranyl nitrate has been reported in the dog (U.S. EPA, 1985).

2.1.2 Subchronic

Animal

Studies in which a variety of laboratory animals (mice, rats, dogs, rabbits) were fed diets containing 0.02 to 10 percent soluble uranium compounds (e.g., uranyl oxide, uranyl nitrate, uranyl acetate) for 30 days indicated kidney damage at all exposure levels (Hodge, et al., 1973). Diets containing 2 to 10 percent led to 100 percent mortality in all species tested. A diet of 0.5 percent resulted in 100 percent mortality in rabbits. Diets containing 0.1 to 1 percent led to growth depression.

Subchronic oral exposure to uranium can also lead to damage in other tissues and organs, although they are less sensitive than the kidney. Liver damage has been reported in rats that were fed 100 mg/kg uranyl nitrate every other day for approximately one month (Goel, et al., 1979). Testicular and thyroid damage were reported in rats that were administered 0.1 percent uranyl nitrate in their drinking water for four months (Malenchenko, et al., 1978).

Dusts and mists of uranium hexafluoride, uranyl nitrate, uranium tetrafluoride, and uranyl fluoride were fatal to most laboratory species exposed daily to 20 mg/m³ for one month; a concentration of 2.5 mg/m³ was fatal to some species and 0.2 mg/m³ was fatal to a few animals. Uranium tetrafluoride and uranium dioxide were fatal to a few animals at 20 mg/m³ (Clayton and Clayton, 1981).

2.1.3 Chronic

Animal

Growth depression was observed in dogs fed uranyl nitrate in their diet at 0.2 g/kg/day for one year (Hodge, et al., 1973). Some kidney damage was seen in dogs fed 10 g/kg/day. Borderline growth depression was seen in male and female rats fed 0.1 and 0.5 percent uranyl nitrate in their diet, respectively, for two years (Clayton and Clayton, 1981).

Increased serum alkaline phosphatase, thought to be due to kidney damage, was measured in the blood of rats that were administered 60 mg/l uranyl nitrate orally

for 11 months. Morphological changes were observed in the kidneys of rats and guinea pigs at this dosing level (Novikor, 1970, 1972). Changes in urinary resorptive capacity were reported in rats that were given uranyl nitrate by gavage at 16 mg/kg/day for two years (Gus'kova, et al., 1966).

In a chronic toxicity study conducted by the Canadian Radiation Protection Bureau (CRPB, 1980), increased serum alkaline phosphatase was seen in rats fed uranyl nitrate at 0.9 mg/kg/day in their drinking water for 11 months. At 2.11 mg/kg/day, acid phosphatase activity was inhibited in the spleen and nucleic acid metabolism was decreased in the kidneys and liver. Dogs that were administered 2.11 mg/kg/day of uranyl nitrate for 21 months were found to have changes in blood morphology, alterations in thyroid and liver function, increased basal metabolism, and hematopoietic deficiency.

Fibrotic changes, suggestive of radiation damage, were occasionally seen in the tracheobronchial lymph nodes of dogs and monkeys that were administered uranium dioxide via inhalation at 5 mg uranium/m³ (6 hrs/day, 5 days/week) for periods of greater than three years (Clayton and Clayton, 1981). Alpha radiation doses were estimated at greater than 500 rads to the lung and 7000 rads to the tracheobronchial lymph nodes.

2.1.4 Teratogenicity

There was no information in the surveyed literature regarding the teratogenicity or reproductive effects of uranium exposure.

2.2 Mutagenicity and Carcinogenicity

There is insufficient evidence in laboratory animals or humans for the carcinogenicity of natural uranium through the oral or inhalation routes. Cancer has been experimentally produced, however, with other uranium isotopes and through other routes of entry. It has been observed that when a suspension of powdered uranium (50 mg U/0.05 cm³ lanolin) was injected into the femur or pleural cavity of rats, that tumors were produced at the injection site. The tumors formed at the femur metastasized to other sites (Heuper, et al., 1952). Bone cancers have been produced in rats injected intravenously with U-232 or U-233 (Finkel, 1953).

Although the evidence for the carcinogenicity of natural uranium is insufficient, because it accumulates in bones similar to radium, the U.S. EPA has stated that it expects that the radiotoxicity of uranium via the oral route would also be similar to that of radium (U.S. EPA, 1985). The ingestion of radium produces bone cancer. Based on this assumption, the specific activities of U-234 and U-238 (the contribution of U-235 is considered negligible), the ingestion of 2 liters of water per day, and an uncertainty factor of 4 to 5, the U.S. EPA (1985) has estimated that a drinking water activity level of 0.7 pCi of natural uranium per liter will pose a lifetime cancer risk of 10⁻⁶ (one in one million).

3.0 HUMAN HEALTH CRITERIA AND STANDARDS

3.1 Oral

AADI	6 to 60 ug/l (4 to 40 pCi/l)	(U.S. EPA, 1985)
10 ⁻⁶ Cancer Risk-- Drinking Water	0.7 pCi/l	(U.S. EPA, 1985)
24-Hour SNARL	3,500 ug/l	(NAS, 1980)
7-Day SNARL	210 ug/l	(NAS, 1980)
Chronic SNARL	35 ug/l	(NAS, 1983)

3.2 Inhalation

TLV-TWA	0.2 mg/m ³	(ACGIH, 1987)
TLV-STEL	0.6 mg/m ³	(ACGIH, 1987)

4.0 REFERENCES

- ACGIH (American Conference of Governmental Industrial Hygienists), 1987. Threshold Limit Values and Biological Exposure Indices for 1987-1988. Cincinnati: ACGIH.
- Clayton, G.D. and F.E. Clayton (eds.), 1981. Patty's Industrial Hygiene and Toxicology, 3rd ed. New York: John Wiley and Sons.
- CRPB (Canadian Radiation Protection Bureau), 1980. Guidelines for Canadian Drinking Water Quality, 1978. Health and Welfare, Ottawa, Canada. (Cited in U.S. EPA, 1985.)
- Finkel, M.P., 1953. "Relative biological effectiveness of radium and other alpha emitters in CR No. 1 female mice." Proc. Soc. Exp. Biol. Med. 83:494. (Cited in U.S. EPA, 1985.)
- Goel, K.A., et al., 1979. "Histopathological alterations induced by uranyl nitrate in the liver of albino rat." Bull. Environ. Contam. Toxicol. 22:785. (Cited in U.S. EPA, 1985.)
- Gus'kova, V.N., et al., 1966. "A contribution to the substantiation of maximum permissible concentration of natural uranium in the water of open basins." Akademiva Meditsinskikh Nauk SSR, Vestnik, No. 8. (Cited in U.S. EPA, 1985.)

- Heuper, W.C., et al., 1952. "Experimental studies in metal carcinogenesis. II. Experimental uranium cancers in rats." J. Natl. Cancer Inst. 13:291. (Cited in NAS, 1980.)
- Hodge, H.C., et al., (eds.), 1973. uranium, Plutonium, Transplutonic Elements: Handbook of Experimental Pharmacology XXXVI. New York: Springer-Verlag. (Cited in U.S. EPA, 1985.)
- Malenchenko, A.F., et al., 1978. "Effect of uranium on the induction and course of experimental autoimmune orchitis and thyroiditis." J. Hyg. Epidem. Microbiol. Immunol. 22:268. (Cited in U.S. EPA, 1985.)
- NAS (National Academy of Sciences), 1980. Drinking Water and Health, Volume 3. National Research Council. Washington, D.C.: National Academy Press.
- NAS (National Academy of Sciences), 1983. Drinking Water and Health, Volume 5. National Research Council. Washington, D.C.: National Academy Press.
- Novikor, Y.V., 1970. "On the hygienic standards for natural uranium in drinking water." Hyg. Sanit. 37:13. (Cited in U.S. EPA, 1985.)
- Novikor, Y.V., 1972. "Hygienic standardization of the permissible amount of uranium in drinking water." Gig. Sanit. 37:12. (Cited in U.S. EPA, 1985.)
- U.S. EPA, 1985. Criteria Document for Uranium in Drinking Water. Criteria and Standards Division, Washington, D.C. PB 86-241049.

SUPPLEMENT C

**APPOACHES USED TO ESTIMATE EXPOSURE CONCENTRATIONS
AND CONTAMINANT MIGRATION TIMES FOR SCENARIO B**



SUPPLEMENT C

Approaches Used to Estimate Exposure Concentrations and Contaminant Migration Times for Scenario B

Source controlled flow in the alluvium complicates the prediction of contaminant concentrations downstream of the SWMUs. Given the lack of continuous saturation (both temporal and spatial), transport occurs as discrete slugs. Much of the slug is released to the surface system as stream flow (flooding), the turbulence of which is very likely to volatilize the organic contaminants of concern. As the recharge source (event) declines, the water level in the alluvium also declines until flow ceases in the absence of the driving recharge source and is consumed by evapotranspiration. If one assumes that phreatophytes cover about 20 percent of the alluvium and that evapotranspiration is equal to the pan evaporation rate (Meinzer, 1927), then 40 inches of evapotranspiration is slightly more than enough to consume the water in the alluvium (20,000 feet long, 150 feet wide, 6 feet deep and 0.1 porosity). Evapotranspiration can also be expected to volatilize the volatile organics of concern.

In spite of these considerations it is possible to estimate the contaminant concentrations at the plant property boundary if it is assumed that flow occurs under full-alluvium conditions for a certain portion of the year (the following analyses assume half of the year). Contaminants enter the alluvial flow system from the colluvium, are diluted by flow already in the alluvium, and then are transported (advected and dispersed) to the boundary. The concentrations are predicted as follows. It is assumed that no attenuation processes other than dilution (e.g., volatilization, sorption) act upon the contaminants as they are transported to the boundary.

- 1) The contaminants concentrations in the alluvial system beneath the solid waste management units (SWMVs) at the 881 Hillside location are diluted by through-flow from upstream in the alluvium. Flow in the alluvium is produced equally by flow from the sides, which can be expressed as q gallons per minute per foot of side. The through-flow can be estimated based on the length of the sides of the alluvium upstream of the SWMU (approximately 10,000 feet on each side). Flow from the SWMU can be estimated as a proportion of the through-flow based on the length of side occupied by the SWMU (500 feet). The influent from the SWMU is 500/20,000 of the total flow downstream of the SWMU. Therefore, the initial contaminant concentrations are diluted by a factor of 38 (19,500/500) by the time they reach the property boundary.

- 2) Based on an average ground surface gradient of 0.024, hydraulic conductivity of 0.002 feet per minute, and effective porosity of 0.1 (), the contaminants are estimated to move toward the property boundary at a velocity of 250 feet per year. Thus, if the alluvium were saturated for the entire year, travel time to the boundary (approximately 10,000 feet from the 881 Hillside location) would be approximately 40 years. Because the alluvium is saturated only part of the year (assumed to be half of the year), the actual travel time is on the order of 80 years.

- 3) While traveling toward the boundary, the contaminants are dispersed, resulting in lower concentrations but faster arrival times. Using Ogata (1970) to estimate longitudinal dispersion effects results in the plot shown in Figure E-1 (Dispersion is calculated at the actual velocity because it is dependent on velocity). Rates must be reduced for saturation during part of the year). It can be seen that

the 50-percent concentration (i.e., $0.5 \times 1/38 \times$ on-site concentration) reaches the boundary at the calculated travel time and that the effects of dispersion are sooner arrivals of low concentrations and later arrivals of high concentrations. For the highest dispersivity considered reasonable (500 feet), (approximately 20 percent) (0.2) would arrive at the boundary in about 30 years if saturation were continuous and in about 60 years if the alluvium is saturated about half the time.

- 4) The effects of dispersion are transitory, and ultimately, the full concentration (i.e., $1/38$ of the on-site concentration) will arrive at the boundary. Based on the above calculations, the maximum concentration will be detected at the boundary somewhere between 80 and 200 years after the release begins, if the release continues unabated. It should be noted that the maximum concentration will not be reached at the boundary if the source is removed before the 0.5 concentration reaches the boundary.

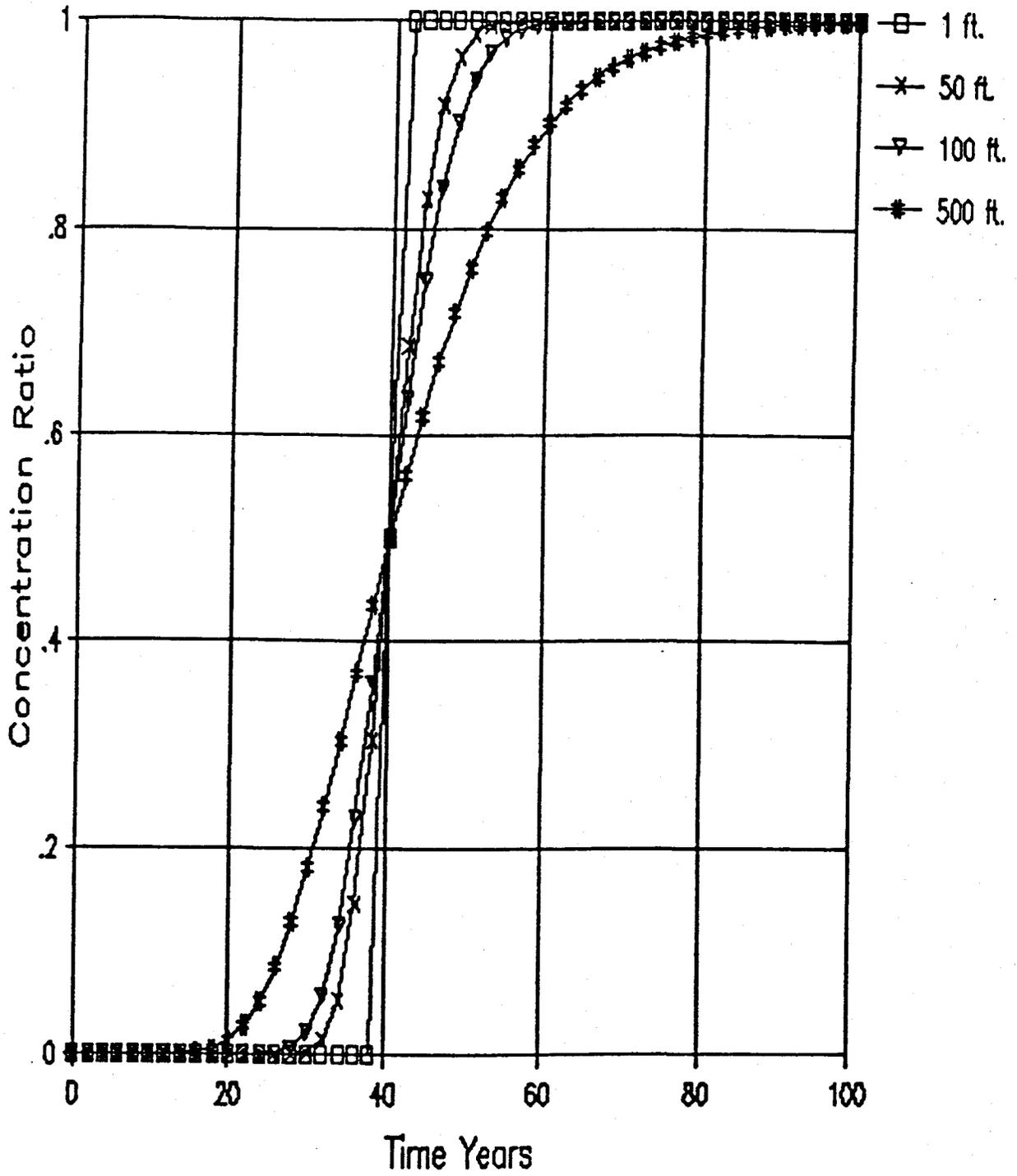


FIGURE C -1 CONCENTRATION RATIOS FOR VARIOUS DISPERSIVITIES

References:

Meinzer, O.E., Plants as Indicators of Ground Water, U.S. Geological Survey Water-Supply Paper 557, 1927.

Ogata, A., Theory of Dispersion in a Granular Medium, Fluid Movement in Earth Materials, U.S. Geological Survey Professional Paper 411-I, 1970.

SUPPLEMENT D

Determination of Contaminant Concentrations in
Home Grown Vegetables Through Irrigation
and Uptake from the Soil

The estimated contaminant concentration in plants is a result of two factors as represented by the equation below. The first term represents contamination from irrigation water, and the second term represents contamination directly from the soil. It was assumed that there is no buildup or loss of pollutants in the soil through irrigation. In addition, it was assumed that the total amount of water that a plant needs is being taken up through irrigation.

Carrots

$$\begin{array}{l} \text{Contaminant} \\ \text{Concentration} \\ \text{in Plant} \\ \text{(mg/kg)} \end{array} = \begin{array}{l} (\text{RCF} \times C_{\text{water}}) \\ (1/\text{kg}) \quad (\text{mg/l}) \end{array} + \begin{array}{l} (C_{\text{soil}} \times B_r) \\ (\text{mg/kg}) \end{array}$$

where,

$$\text{RCF} = \text{root concentration factor} = K_d \times B_r$$

$$K_d = \frac{C_{\text{soil}} \text{ (mg/kg)}}{C_{\text{water}} \text{ (mg/l)}} = \begin{array}{l} \text{soil to water} \\ \text{concentration factor} \end{array}$$

$$B_r = \frac{C_{\text{plant}} \text{ (mg/kg)}}{C_{\text{soil}} \text{ (mg/kg)}} = \text{soil to plant concentration factor for nonvegetative (reproductive) portions of food crops (unitless)}$$

C_{water} = concentration in water (mg/l)

C_{soil} = concentration in soil (mg/kg)

Lettuce

The estimated contaminant concentrations in lettuce were calculated similarly to carrots; however, B_v was substituted for B_r . B_v is a soil to plant concentration factor for vegetative portions of food crops, and is used for leafy vegetables.

Values of K_d , B_v , and B_r chosen for the contaminants of concern represent the average case and were taken from Baes et al. (1984). These values are presented in Table D-1.

Table D-1
Values of Concentration Factors

Chemical	K _d	B _v	B _r
Nickel	150	6.0E-02	6.0E-02
Selenium	300	2.5E-02	2.5E-02
Strontium	35	2.5E+00	2.5E-01
Uranium	450	8.5-03	4.0E-03

Tables D-2 and D-3 present the maximum and average plant contaminant concentrations (mg/kg) calculated for carrots and lettuce, respectively.

Table D-2
Predicted Contaminant Concentrations
in Vegetables (mg/kg)
Scenario A

Indicator Chemical	Carrots		Lettuce	
	Average	Maximum	Average	Maximum
Nickel	1.50E+00	8.20E+00	1.50E+00	8.20E+00
Selenium	2.08E+00	1.58E+01	2.08E+00	1.58E+01
Strontium	2.53E+01	7.34E+01	2.53E+02	7.34E+02
Uranium	7.74E-02	2.30E-01	1.64E-01	4.89E-01

Table D-3
Predicted Contaminant Concentrations
in Vegetables (mg/kg)
Scenario B

Indicator Chemical	Carrots		Lettuce	
	Average	Maximum	Average	Maximum
Nickel	7.99E-01	4.36E+00	7.99E-01	4.36E+00
Selenium	6.67E-02	4.27E-01	6.67E-02	4.27E-01
Strontium	1.67E+01	5.28E+01	1.67E+02	5.28E+02
Uranium	1.43E-02	3.23E-02	3.03E-02	6.86E-02

Reference:

Baes, C.F., et al. A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides through Agriculture. Prepared by Oak Ridge National Laboratory for the U.S. Department of Energy. ORNL-5786; DE85-000287, 1984.

SUPPLEMENT E

Determination of Radioactivity in Home Grown Vegetables Through Irrigation and Uptake From the Soil

The concentration of radioactive material in vegetation results from deposition on the plant foliage and from uptake from the soil of activity deposited on the ground. The equation for the model used is presented below. The first term relates to the concentration derived from foliage deposition during the growing season. The second term relates to uptake from soil and reflects long-term deposition. For a uniform release rate, the concentration C_v in the edible portion of crop species V, in units of pCi/kg, is given by:

$$C_v = d' \left[\frac{r [1 - \exp(-\lambda_E t_c)]}{Y_v \lambda_E} + \frac{B_v [1 - \exp(-\lambda_i t_b)]}{P \lambda_i} \right] \exp(-\lambda_i t_h)$$

where,

C_v = Concentration in the edible portion of the plant (pCi/kg).

d' = $C_w I$ (water deposition).
 C_w = Concentration in water (pCi/l).
 I = Irrigation rate ($l/m^2/hr$).

B_v = Concentration factor for uptake from soil by edible plants (pCi/kg(wet)/pCi/kg(dry)).

P = Effective "surface density" for soil.

T = Fraction of deposited activity retained on crops.

- Y_v = Agricultural productivity in kg (wet weight/m²).
 t_b = Midpoint of soil exposure time (hours).
 t_c = Time period crops are exposed to contamination during the growing season (hours).
 t_h = Holdup time (i.e., time between harvest and consumption) (hours).
 λ_E = Effective removal rate constant from crops (hr⁻¹), provided that $\lambda_E = \lambda_i + \lambda_w$.

where,

λ_i = Radioactive decay constraint (hr⁻¹) and
 λ_w = removal rate constant for physical loss by weathering.

Tables E-1 and E-2 list the values used for the variables, and the estimated radionuclide concentrations in vegetables.

The annual dose equivalent is calculated using the following equation:

$$R = U_v C_v D$$

Where:

- U_v = The intake rate of vegetables for an individual (kg/yr).
 C_v = Radionuclide concentration in vegetables (pCi/kg).
 D = Dose factor (mrem/pCi).

Table E-1

Variable	Value	Comments
B _v	2.5x10 ⁻³	<u>Reference:</u> USNRC Reg. Guide 1.10 USNRC-NUREG/ CR-2011
P	240 kg/m ²	<u>Reference:</u> Reg. Guide 1.109
r	0.25	<u>Reference:</u> Reg. Guide 1.109
Y _v	2 kg/m ²	<u>Reference:</u> Reg. Guide 1.109
t _b	1.31x10 ⁻⁵ hr	<u>Reference:</u> Reg. Guide 1.109
T _c	1.44x10 ³ hr	<u>Reference:</u> Reg. Guide 1.109 Assumes 60 day growing cycle.
t _h	24 hr	
Z _E	2.1x10 ⁰³ hr ⁻¹	<u>Reference:</u> Reg. Guide 1.109 As- sumes 14 day half-time for removal.
Z _i	U-234 5.2x10 ⁻¹⁰ hr ⁻¹ U-235 1.11x10 ⁻¹³ hr ⁻¹ U-238 1.75x10 ⁻¹⁴ hr ⁻¹	
I	0.133 1/m ² /hr	3.18 1/m ² in one day

Table E-2

Predicted Radionuclide Concentrations in Vegetables
(pCi/kg)
Scenario A

	Average	Maximum
U-234	100	225
U-235	3.6	10
U-238	76.9	254

The annual dose equivalent rate was multiplied by an organ weighting factor of 0.12 to obtain the annual dose equivalent rate.

The annual dose equivalent is calculated using the following equation:

$$R = U_V C_V D$$

Where:

U_V = The intake rate of vegetables for an individual (kg/yr).

C_V = Radionuclide concentration in vegetables (pCi/kg).

D = Dose factor (mrem/pCi).

The average adult vegetable ingestion rate was estimated to be 105 kg/yr (USNRC, 1981). Only 50 percent of the annual consumption was estimated to be from the home garden. In the calculation $U = 52$ Kg/yr. Listed below are the dose factors for bone for the 3 uranium isotopes of interest.

Radionuclide	Dose Factor (mrem/pCi)	Reference
U-234	8.37×10^{-4}	Reg. Guide 1.109
U-235	8.02×10^{-4}	Reg. Guide 1.109
U-238	7.67×10^{-4}	Reg. Guide 1.109

References:

USNRC (United States) Nuclear Regulatory Commission)
"Calculation of Annual Doses to Man from Routine Releases of
Reactor Effluents for the Purpose of Evaluating Compliance with
10 CFR Part 50, Appendix I," Regulatory Guide 1.109, 1982.

-----"MILDOS - A Computer Program for Calculating
Environmental Radiation Doses from Uranium Recovery Operations,
1981.

SUPPLEMENT F

Estimates of Annual Dose Equivalents Resulting from the Inhalation of Fugitive Dusts and Soil Ingestion

The daily contaminant intake of uranium from the inhalation of fugitive dusts was calculated using the equation in Section 4.3.4. It was assumed that the dust particles were 1 μm (AMAD) and that retention in the pulmonary compartment of the lung is 25 percent (ICRP,79). These results are presented in Table F-1. An estimate of the annual dose equivalent received from the inhalation of dusts is presented in Table F-2.

Annual dose equivalents for the ingestion of soil were calculated using dose conversion factors from MILDOS and making the same assumptions regarding intake as for the chemicals (Section 4.3.6). These results are presented in Table F-3.

Table F-1

Daily Contaminant Intakes through Fugitive Dust Inhalation -
(pCi/day)

Scenario A

Radio-nuclide	Adult		Child	
	Average	Maximum	Average	Maximum
U-233, 234	7.63×10^{-5}	1.87×10^{-4}	1.91×10^{-5}	4.68×10^{-5}
U-238	8.10×10^{-5}	1.62×10^{-4}	2.03×10^{-5}	4.04×10^{-5}

Table F-2

Annual Dose Equivalents from the Inhalation of Fugitive Dusts
(mrem/yr)

Scenario A

Radionuclide	Whole Body	Bone
Maximum Exposed Adult		
U-234	4.2×10^{-4}	6.7×10^{-3}
U-238	3.2×10^{-4}	5.4×10^{-3}
Average Exposed Adult		
U-234	1.8×10^{-4}	2.9×10^{-3}
U-238	1.6×10^{-4}	2.7×10^{-3}

Table F-3

Annual Dose Equivalent from the Ingestion of Soil -
(mrem/year)

Scenario A

	Average		Maximum	
	U-234	U-238	U-234	U-238
<u>Child</u>				
Whole body	7.62×10^{-2}	4.52×10^{-3}	8.09×10^{-2}	9.59×10^{-3}
Bone	4.16×10^{-2}	4.06×10^{-2}	1.02×10^{-1}	2.09×10^{-2}
<u>Adult</u>				
Whole body	4.82×10^{-4}	4.50×10^{-4}	1.19×10^{-3}	8.98×10^{-4}
Bone	7.79×10^{-3}	7.61×10^{-3}	1.91×10^{-2}	1.52×10^{-2}

APPENDIX 2

**SCREENING OF APPLICABLE, OR RELEVANT
AND APPROPRIATE REQUIREMENTS**

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentration Limit (MCL) (ug/l)	SDWA Maximum Contaminant Level (MCL) (ug/l)	CWA Ambient Water Quality Criteria for Protection of Aquatic Life		CDH Proposed Water Quality Standard (ug/l)	For Use in Special Circumstances SDWA/MCLG (ug/l)	Geometric Mean*** 881 Hillside Wells ug/l	ARAR	Remedial Action	Comment
			Freshwater Acute/Chronic (ug/l)	Ground-Water standards ^a (30 day mean) (ug/l)						
Organic Compounds										
Acetone							13.55 (<10)	Background concentration for groundwater remediation	No standards given; Background will be used as the GWPS for ground water remediation	
Carbon Disulfide							3.10 (<5)	Background concentration for groundwater remediation	No standards given; Background will be used as the GWPS for ground water remediation	
Carbon Tetrachloride	5	3500		0.0004	5.0	0	8.40 (<5)	SDWA MCL is RFA CDH standards are proposed and are not yet ARAR but should be considered.	SDWA MCL is exceeded. Background will be used as the GWPS for ground water remediation.	
Chloroform	100*	2800/1200**		0.19	0.19		2.9 (<5)	SDWA MCL and CDH standards are proposed and are not yet ARAR but should be considered.	Potential ARAR (proposed standards) are exceeded. Background will be used as the GWPS for ground water remediation.	
1,1 Dichloroethane							5.6 (<5)	None	No standards given	

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	ACRA Maximum Concentra- tion Limit (MCL) (ug/l)	SDWA Maximum Contaminant Level (MCL) (ug/l)	CWA Ambient Water Quality Criteria for Protection of Aquatic Life		CDH Proposed Water Quality Standard (ug/l)	For Use in Special Circumstances SDWA/MCLG (ug/l)	Geometric Mean 881 Hillside Wells ug/l	ARAR	Remedial Action Comment
			Freshwater Acute/Chronic (ug/l)	(ug/l)					
Organic Compounds (continued)					Surface Water Ground-Water standards ^a standards ^b (30 day mean) (ug/l)				
1,2 Dichloroethane	-	5	110,000/20,000**	0.94	5.0	0	4.2 (<5)	ARAR is not exceeded. Background will be used as the GMS for ground water remediation.	
1,1 Dichloroethene	-	7	11,000**/	0.033	7.0	7	9.9 (<5)	ARARS are exceeded. Background will be used as GMS for ground water remediation.	
t-1,2 Dichloroethene	-	-	11,000**/	0.033	0.03	-	5.1 (<5)	Potential ARAR (CDH proposed ground water standard) is exceeded. Background will be used as the GMS for ground water remediation.	
Methyl Ethyl Ketone	-	-	-	-	-	-	6.8	EPA's drinking water health advisory for MEK is 860 ug/l lifetime intake for a 70 kg adult. Average concen- trations in alluvial wells do not exceed this advisory level.	

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentra- tion Limit (MCL) (ug/l)	SDWA Maximum Contaminant Level (MCL) (ug/l)	CWA Ambient Water Quality Criteria for Protection of Aquatic Life		CDH Proposed Water Quality Standard (ug/l)	Surface Water standards ^a (30 day mean) (ug/l)	Ground-Water standards ^b (ug/l)	For Use in Special Circumstances SDWA/MCLG (ug/l)	Geometric Mean 881 Hillside Wells ug/l	Reedial Action	Comment
			Freshwater Acute/Chronic (ug/l)	Freshwater Quality Standard (ug/l)							
Organic Compounds (continued)									Alluvial	ARAR	
Methylene Chloride	-	-	-	-	-	-	-	-	5.1 (<5)	EPA drinking water health advisory is 100 ^c (see comments)	EPA reference concentration for this potential carcinogen is 5 ug/l. This concentration corresponds to the 10 ⁻⁶ risk level. Wells exceed.
Tetrachloroethene	-	-	5200**/840**	0.8	0.8	0.8	0*	0*	9.5 (<5)	MCLG and CDH standards are proposed and are not yet ARAR but should be con- sidered.	Potential ARARS are exceeded. Back- ground will be used as the GMS for ground water remediation.
Toluene	-	-	17,000**/	14,300	14,300	14,300	2,000	2,000	5.4 (<5)	MCLG is RfA;	Potential ARARS are not exceeded. Background will be used as the GMS for ground water remediation.
1,1,1 Trichloroethane	-	200	-	-	200	200	200	200	8.6 (<5)	SDWA MCL, MCLG and CDH proposed stds. are equivalent and are RfA	Potential ARARS are not exceeded. Background will be used as the GMS for ground water remediation.
1,1,2 Trichloroethane	-	-	-	0.6	0.6	0.6	-	-	3.4 (<5)	CDH proposed standards are to be consid- ered.	Potential ARAR is exceeded. Back- ground will be used as GMS for ground water remediation.

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentration Limit (MCL) (ug/l)	SDWA Maximum Contaminant Level (MCL) (ug/l)	CMA Ambient Water Quality Criteria for Protection of Aquatic Life		CDM Proposed Water Quality Standard (ug/l)	For Use in Special Circumstances SDWA/MCLG (ug/l)	Geometric Mean 881 Hillside Wells ug/l	Reedial Action
			Freshwater Acute/Chronic (ug/l)	Ground-Water standards ^a (30 day mean) (ug/l)				
Organic Compounds (continued)								
Trichloroethene	-	5	45,000**/21,000**	2.7	5.0	0	22.0 (± 5)	SDWA MCL is R&A; CDM proposed ground water standard and MCLG are TBC
								SDWA MCL, MCLG and CDM standard are exceeded. Background will be used as the GWPS for ground water re- mediation.

* proposed value as of October 1986

** Lowest Observed Effect Level

*** Geometric mean concentration of analyte in those 881 wells presumed to be impacted. Note that means are calculated by including analyses that were found to be below detection limits for these same wells. The value of 0.5 times the detection was used to calculate the mean well concentrations for analyses below detection limits.

[] - Limit of detection for analyte

- Analytes that exceed ARARS

^a 5 CFR 1002-8, Section 3.11.11, Basic Standards Applicable to Surface Waters of the State, Proposed Amendments to the Basic Standards and Methodologies, Nov. 1987

^b 5 CFR 1002-8, Section 3.11.5 (C), Basic Standards Applicable to Ground Waters of the State, Proposed Amendments to the Basic Standards and Methodologies, Nov. 1987

^c TBC - To be considered; The most recent EPA guidance on the identification of ARARS states that existing criteria, advisories, guidance, or proposed standards should be considered for a chemical in the absence of a promulgated standard.

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentration Limit (MCL) (ug/l)	SDWA Maximum Contaminant Level (MCL) (ug/l)	CDH		For Use in Special Circumstances SDWA/MCLG (ug/l)	Geometric Mean 881 Hillside Wells ug/l	ARAR	Remedial Action Comment
			Ground Water Standard Human Health/ Agriculture ^a (ug/l)	Water Quality Limited Standard (ug/l)				
Metals								
Aluminum	-	-	/5.0	0.95/0.15 ^c	-	0.048 [0.039]	CDH ground water standard is applic- licable	ARAR is not exceeded. Background will be used as the GWPS for groundwater remediation.
Antimony	-	-	-	(b)	-	0.020 [0.060]	None	No ground water or surface water standard. Background will be used as the GWPS for groundwater remediation.
Arsenic and Compounds	0.05	0.05	0.05/0.1	0.05 ^f	-	0.0030 [0.0010]	CDH human health ground water std. is applicable	ARAR is not exceeded. RCRA MCL will be used as the GWPS for ground water remediation.
Barium	1.0	1.0	1.0 /	1.0 ^c	1.5 ^e	0.097 [0.190]	CDH human health ground water std. is applicable	ARAR is not exceeded. RCRA MCL will be used as the GWPS for ground water remediation.
Beryllium	-	-	/0.1	0.1 ^c	-	0.0068 [0.0070]	CDH agricultural standard is applic- licable	CDH standard is not exceeded. Background will will be used as the GWPS for ground water rene- diation.
Cadmium and Compounds	0.01	0.01	0.01/0.01	0.0004 ^f	0.005	0.0006 [0.0070]	CDH human health ground water std. is applicable	ARAR is not exceeded. RCRA MCL will be used as the GWPS for ground water remediation.

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentra- tion Limit (MCL) (ug/l)	SDMA Maximum Contaminant Level (MCL) (ug/l)	CDH		CDH Water Quality Limited Standard (ug/l)	For Use in Special Circumstances SDMA/MCLG (ug/l)	Geometric Mean 881 Hillside Wells ug/l	ARAR	Remedial Action	Comment
			Ground Water Standard Human Health/ Agriculture ^a (ug/l)	Standard Agriculture ^a (ug/l)						
Metals (continued)										
Chromium III (compounds)	-	-	0.05/0.1	-	0.05 ^f	-	0.0014 [0.0460]	CDH human health ground water std. is applicable	Analytical result is total chromium. ARAR is not exceeded. Background will be used as GWPS for ground water remediation.	
Chromium VI (compounds)	0.05	0.05	0.05/0.1	-	0.025 ^f	0.0012	0.0014 [0.0460]	CDH human health ground water std. is applicable	Analytical result is total chromium. ARAR is not exceeded. Background will be used as GWPS for ground water remediation.	
Copper	-	-	1.0/0.2	-	0.005 ^f	1.3 ^g	0.010 [0.046]	CDH agricultural ground water std. is applicable	ARAR is not exceeded. Background will be used as the GWPS for ground water remediation.	
Iron	-	-	0.3/5.0	-	1.0 ^d /0.3 ^e	-	0.027 [0.022]	CDH human health ground water std. is applicable	ARAR is not exceeded. Background will be used as the GWPS for ground water remediation.	
Lead	0.05	0.05	0.05/0.1	-	0.004 ^f	0.002 ^g	0.0045 [0.05]	CDH human health ground water std. is applicable	ARAR is not exceeded. RCRA MCL will be used as the GWPS for ground water remediation.	
Manganese	-	-	0.05/0.2	-	1.0 ^d /0.05 ^e	-	0.068 [0.547]	CDH human health ground water std. is applicable	ARAR is exceeded on the average for the 881 hill- side alluvial wells. The upper limit of the background concentrations exceeds ARAR.	

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentra- tion Limit (MCL) (ug/l)	SDWA Maximum Contaminant Level (MCL) (ug/l)	CDH Ground Water Standard Human Health/ Agriculture ^a (ug/l)	CDH Water Quality Limited Standard (ug/l)	For Use in Special Circumstances SDWA/MCLG (ug/l)	Geometric Mean 881 Hillside Wells ug/l	ARAR	Remedial Action	Comment
Metals (continued)									
Mercury	0.002	0.002	0.002/0.01	0.00005 ^f	0.003	0.0002 [0.0002]	CDH human health ground water std. is applicable	ARAR is not exceeded. RCRA MCL will be used as the GWPS for ground water remediation.	
Molybdenum	-	-	/0.1	-	-	0.018 [0.10]	CDH agricultural ground water std. is applicable	ARAR is not exceeded. Background will be used as the GWPS for ground water remediation.	
Nickel (and Compounds)	-	-	/0.20	0.05 ^f	-	0.040 [0.070]	CDH agricultural ground water std. is applicable	ARAR is not exceeded. Background will be used as the GWPS for ground water remediation.	
Selenium	0.01	0.01	0.01/0.02	0.01 ^f	0.045 ^g	0.029 [0.005]	CDH human health ground water std. is applicable	ARAR is exceeded. RCRA MCL will be used as the GWPS for ground water remediation.	
Silver	0.05	0.05	0.05/	0.0001 ^f	-	0.005 [0.010]	CDH human health ground water stds. are applicable	ARAR is not exceeded. RCRA MCL will be used as the GWPS for ground water remediation.	
Thallium	-	-	-	0.015 ^c	-	0.006 [0.010]	CDH water quality limited standard is T8C	Potential ARAR is not exceeded. Background will be used as the GWPS for ground water remediation.	

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS						
Chemical	RCRA Maximum Concentration Limit (MCL) (ug/l)	SDMA Maximum Contaminant Level (MCL) (ug/l)	CDH Ground Water Standard Human Health/ Agriculture ^a ug/l	CDH Water Quality Limited Standard (ug/l)	For Use in Special Circumstances SDMA/MCLG (ug/l)	Remedial Action
					Geometric Mean *** 881 Hillside Wells ug/l	ARAR
Zinc	-	-	5.0/2.0	0.05 ^f	0.027 {0.090}	CDH agricultural ground water std. is applicable ARAR is not exceeded.

Metals (continued)

* Proposed value as of October 1986

*** Geometric mean concentration of analyte in those 881 wells presumed to be impacted. Note that means are calculated by including analyses that were found to be below detection limits for these same wells. The value of 0.5 times the detection was used to calculate the mean well concentrations for analyses below detection limits.

[] Upper limit of background concentration range in alluvial wells west of the plant

^a - Analytes that exceed ARARS

IBC - To be considered

^b 1) 5 CCR 1002-8 Section 3.11.5, dissolved concentration

(e) 5 CCR 1002-8, Section 3.8.6, Region 3, Segment 2, soluble

(b) No Colorado standard; defer to Federal Ambient Water Quality Criteria

(f) 5 CCR 1002-8, Section 3.8.6, Region 3, Segment 2

(c) 5 CCR 1002-8, Section 3.1.7, Table 3

(d) 5 CCR 1002-8, Section 3.8.6, Region 3, Segment 2, total recoverable

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentration (MCL) (mg/l)	SDWA Maximum Contaminant Level (MCL) (mg/l)	CDH Ground Water Standards (mg/l)	CDH Water Quality Limited Standard (mg/l)	Geometric Mean *** (mg/l) 881 Hillside Wells Alluvial	ARAR	Remedial Action	Comment
Conventional Pollutants								
pH	-	-	6.5 - 8.5 units	6.5 - 9.0 ^a units	7.28 units	CDH g.w. std. is applicable	ARAR is not exceeded.	
Fecal Coliform	-	-	1/100ml (total coliform)	200/100ml ^a	N.M.	CDH g.w. std. is applicable	Fecal coliforms were not measured in well samples	
Dissolved Oxygen	-	-	-	5.0 ^a	N.M.	CDH s.w. std. is R&A	Dissolved Oxygen was not measured in well samples.	
Temperature	-	-	-	20°/max 3° increase ^c	13.8° C	CDH s.w. std. is R&A	Average temperature meets CDH standard	
Ammonia(total)	-	-	-	0.5 ^a	N.M.	CDH s.w. std. is R&A	Total ammonia nitrogen not measured in well samples	
Ammonia(unionized)	-	-	-	0.06 ^a	N.M.	CDH s.w. std. is R&A	Ammonia nitrogen not measured in well samples	
Nitrite	-	-	1.0 as N	0.5 ^a	1.24 (1.68)	CDH g.w. std. is applicable	Analytical results are total nitrite plus nitrate nitrogen. Reanalysis required to determine if nitrite standard is exceeded	
Nitrate	-	-	10.0 as N	10.0 ^a	1.24 (1.68)	CDH g.w. std. is applicable	Analytical results are total nitrite plus nitrate nitrogen. Results indicate that nitrate standard is not exceeded.	

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	ACRA Maximum Concentra- tion Limit (MCL) (ug/l)	SDWA Maximum Contaminant Level (MCL) (ug/l)	CDH Ground Water Standards (ug/l)	CDH Water Quality Limited Standard (ug/l)	Remedial Action	
					Geometric Mean *** (ug/l) 881 Hillside Wells Alluvial	Comment
Conventional Pollutants						
Chloride	-	-	250.0 ^b	250.0 ^a	163 (9)	CDH standard is applicable CDH standard is not exceeded.
Sulfate	-	-	250.0 ^b	250.0 ^b	171 (17.7)	CDH standard is applicable CDH standard is not exceeded.
Sulfide(as H ₂ S) unds.	-	-	-	0.002 ^a	N.M.	CDH standard is applicable Sulfide was not measured in wells.
Cyanide(free)	-	-	-	0.005 ^a	N.M.	CDH standard is applicable Free cyanide was not measured in wells.
T.D.S. ^b	-	-	400 mg/l or 1.25 times background, whichever is least re- strictive		1053 (161)	CDH standard is applicable 1.25 times background TDS is 201 ug/l. CDH standard is exceeded for alluvial wells

*** Geometric mean concentration of analyte in those 881 wells presumed to be impacted. Note that means are calculated by including analyses that were found to be below detection limits for these same wells. The value of 0.5 times the detection limit was used to calculate the mean well concentrations for analyses below detection limits.

[] Geometric mean concentration of analyte in background wells. Note that means are calculated by including analyses that were found to be below detection limits for these same wells. The value of 0.5 times the detection limit was used to calculate the mean well concentrations for analyses below detection limits.

N.M. - Not Measured

(a) 5 CCR 1002-B, Section 3.8.6, Region 3, Segment 2

(c) 5 CCR 1002-B, Section 3.1.7

(b) 5 CCR 1002-B, Section 3.11.5

Analytes that exceed ARARS

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentration Limit (MCL)	SDMA Maximum Contaminant Level (MCL)	CMA Ambient Water Quality Criteria for Protection of Aquatic Life		CDH Water Quality Standard	For Use in Special Circumstances SDMA/MCLG	Geometric Mean (pci/l) 881 Hillside Wells Alluvial	ARAR	Remedial Action Comment
			Freshwater Acute/Chronic						
Surface Water Ground-Water standards ^a standards ^b									
Radionuclides									
Gross Alpha	-	15 pci/l	-	-	15 pci/l	-	52.3 [21.8]	CDH standard is applicable	Mean gross alpha exceeds ARAR; note that error associated with individual analyses exceeds the reported values in some cases. Value includes Uranium and Radon. Back- ground will be used as the GWS for ground water remediation.
Gross Beta	-	50 pci/l	-	-	-	-	70.8 [26.3]	SDMA MCL is RAA	Mean gross beta exceeds ARAR; note that error associated with individual analyses exceeds the reported values in some cases. Background will be used as the GWS for ground water remediation.
Pu ^{238,239,240}	-	40 pci/l***	-	-	15 pci/l ^a	-	0.44 [0.07]	CDH standard is applicable	Mean value reported is the mean of analytical results for plutonium 239,240. ARAR is not exceeded. Background will be used as the GWS for ground water remediation.
Am ²⁴¹	-	4 pci/l***	-	-	-	-	0.46 [0.02]	SDMA MCL is RAA	ARAR is not exceeded; note that the error associated with individual analyses exceeds the reported value in some cases. Background will be used as the GWS for ground water re- mediation.
H ³	-	20,000 pci/l	-	-	20,000 pci/l ^a	-	122 [56.5]	CDH standard is applicable.	ARAR is not exceeded. Background will be used as the GWS for ground water reedi- ation.
Sr ⁹⁰	-	8 pci/l	-	-	8 pci/l ^a	-	1.63 [0.87]	CDH standard is applicable	ARAR is not exceeded. Background will be used as the GWS for ground water reedi- ation.

SCREENING OF CHEMICAL SPECIFIC ARARS
PERTINENT TO 881 HILLSIDE REMEDIAL ACTIONS

POTENTIAL ARAR REQUIREMENTS

Chemical	RCRA Maximum Concentration Limit (MCL)	SDWA Maximum Contaminant Level (MCL)	CWA Ambient Water Quality Criteria for Protection of Aquatic Life Freshwater Acute/Chronic	CDH Water Quality Standard	For Use in Special Circumstances SDWA/MCLG	Geometric Mean (pCi/l) 881 Hillside Wells Alluvial	Remedial Action	Comment
Radionuclides								
Cs-134	-	100,000 pCi/l****	-	80 pCi/l ^a	-	N.M.	CDH standard is applicable	Cesium-134 was not measured.
Cs-137	-	100 pCi/l	-	-	-	1.76 {no data}	SDWA MCL is RAA	ARAR is not exceeded.
Radium-226	-	5 pCi/l	-	5 pCi/l ^a	-	N.M.	CDH standard is applicable	Radium isotopes were not measured.
Radium-228	-	5 pCi/l	-	5 pCi/l ^a	-	N.M.	CDH standard is applicable	Radium isotopes were not measured.
Thorium-230	-	-	-	60 pCi/l ^a	-	N.M.	CDH standard is applicable	Thorium isotopes were not measured.
Thorium-232	-	-	-	60 pCi/l ^a	-	N.M.	CDH standard is applicable	Thorium isotopes were not measured.
Uranium total	-	-	-	40 pCi/l ^c	-	1.50 (0.32)	CDH surface water standard is RAA	ARAR is not exceeded. Background will be used as the GWPS for ground water remediation.

*** Proposed value in drinking water yielding a risk equal to that from a dose rate of 4 area/year
September 30, 1986 (51 FR 34859)

**** Geometric mean concentration of analyte in those 881 wells presumed to be impacted. Note that the means are calculated by including analyses that were found to be below detection limits for these same wells. The value of 0.5 times the detection limit was used to calculate the mean well concentrations for analyses below detection limits.

[] Geometric mean of background wells N.M. - Not Measured

- (a) 5 CCR 1002-8, Section 3.1.11, Basic Standards Applicable to Surface Waters of the State
- (b) 5 CCR 1002-8, Section 3.11.5 (B), Basic Standards Applicable to Ground Waters of the State
- (c) 5 CCR 1002-8, Section 3.8.5 (3)

SCREENING OF PROBABLE ACTION SPECIFIC ARANS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Treatment	<p>80AF standards for spent solvent wastes and dioxin-containing wastes are based on one of four technologies or combinations; for waste waters, (1) steam stripping, (2) biological treatment, or (3) carbon absorption (alone or in combination with (1) or (2)); and for all other wastes, incineration. Any technology may be used, however, if it will achieve the concentration levels specified.</p>	<p>Effective November 8, 1988, disposal of contaminated soil or debris resulting from CERCLA response actions or RCRA corrective actions is subject to land disposal prohibitions and/or treatment standards established for spent solvent wastes, dioxin-containing wastes, and "California List" wastes.</p>	<p>RCRA Sections 3004 (d)(3), (e)(3) 42 U.S.C. 6924(d)(3),(e)(3)</p>	Applicable	<p>Reinjection of treated groundwater or movement of excavated soil onsite or transportation of soil offsite for disposal must be treated to attain levels achievable by best demonstrated available treatment technologies before being land-disposed.</p>
Direct discharge of treatment system effluent	<p>Use of best available technology (BAT) economically achievable is required to control toxic and nonconventional pollutants. Use of best conventional pollutant control technology (BCT) is required to control conventional pollutants. Technology-based limitations may be determined on a case-by-case basis.</p>	<p>Effective November 8, 1988 disposal of spent solvent and dioxin-containing wastes resulting from CERCLA response actions or RCRA corrective actions is subject to land disposal prohibitions and/or treatment standards.</p>	40 CFR 122.44(a)	RAA	<p>Treatment technologies and unit processes for treatment of contaminated alluvial groundwater are selected to control toxic, non-conventional and conventional pollutants.</p>
	<p>Applicable Federally approved State water quality standards must be complied with. These standards may be in addition to or more stringent than other Federal standards under the CWA.</p>		40 CFR 122.44 and State regulations approved under 40 CFR 131	Applicable/To be considered.	<p>Chemical specific State standards have been identified as ARAR. Basic standards for surface water and groundwater (narrative) requires water to be free of toxic pollutants. Numeric criteria for conventional pollutants and metals are applicable. Proposed numeric criteria for those toxic organics found at the 881 hillside are to be considered.</p>
	<p>Applicable Federal water quality criteria for the protection of aquatic life must be complied with when environmental factors are being considered.</p>		50 FR 30784 (July 29, 1985)	Not ARAR for ground water discharge	<p>CDH numeric standards for Region 3, Segment 2 (Standley Lake) protect four use classifications: Class 1 Recreation, Aquatic Life Class I warm, water supply, and agriculture.</p>

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Direct discharge of treatment system effluent (continued)	<p>The discharge must conform to applicable water quality requirements when the discharge affects a state other than the certifying state.</p> <p>The discharge must be consistent with the requirements of a Water Quality Management plan approved by EPA</p> <p>Discharge limitations must be established for all toxic pollutants that are or may be discharged at levels greater than that which can be achieved by technology-based standards.</p> <p>Develop and implement a BMP program and incorporate in the NPDES permit to prevent the release of toxic constituents to surface waters</p>		40 CFR 122.44(d)	REA	
			40 CFR 122.44(e)	REA	Certain contaminants may not be controlled to levels required by in-stream standards due to limitations of Best Available Technology (BAT)
			40 CFR 125.100	REA	
	<p>The BMP program must:</p> <ul style="list-style-type: none"> o Establish specific procedures for the control of toxic and hazardous pollutant spills. o Include a prediction of direction, rate of flow, and total quantity of toxic pollutants where experience indicates a reasonable potential for equipment failure. 		40 CFR 125.104	Applicable	BMP applicable to onsite treatment facilities

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Direct discharge of treatment system effluent (continued)	<ul style="list-style-type: none"> o Assure proper management of solid and hazardous waste in accordance with regulations promulgated under RCRA. 	<p>Discharge must be monitored to assure compliance. Discharger will monitor:</p> <ul style="list-style-type: none"> o The mass of each pollutant o The volume of effluent o Frequency of discharge and other measurements as appropriate. 	40 CFR 122.44(i)	RAA	
	<p>Approved test methods for waste constituents to be monitored must be followed. Detailed requirements for analytical procedures and quality controls are provided.</p>			RAA	
	<p>Sample preservation procedures, container materials, and maximum allowable holding times are prescribed.</p>		40 CFR 136.1-136.4	RAA	
	<p>Permit application information must be submitted including a description of activities, listing of environmental permits, etc.</p>	<p>On-site discharges to surface waters are exempt from procedural NPDES permit requirements. Off-site dischargers would be required to apply for and obtain an NPDES permit</p>	40 CFR 122.21	RAA	
	<p>Monitor and report results as required by permit (minimum of at least annually)</p>		40 CFR 122.44(i)	RAA	
	<p>Comply with additional permit conditions such as:</p> <ul style="list-style-type: none"> o Duty to mitigate any adverse effects of any discharge; and o Proper operation and maintenance of treatment systems. 		40 CFR 122.41(i)	RAA	

SCREENING OF PROBABLE ACTION SPECIFIC ARMS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Capping	<p>Placement of a cap over waste (e.g., closing a landfill, or closing a surface impoundment or waste pile as a landfill, or similar action) requires a cover designed and constructed to:</p> <ul style="list-style-type: none"> o Provide long-term minimization migration of liquids through the capped area; o Function with minimum maintenance; o Promote drainage and minimize erosion or abrasion of the cover; o Accommodate settling and subsidence so that the cover's integrity is maintained; and o Have a permeability less than or equal to the permeability of any bottom liner system or natural sub-soils present. <p>Eliminate free liquids, stabilize wastes before capping (surface impoundments).</p> <p>Restrict post-closure use of property as necessary to prevent damage to the cover.</p> <p>Prevent run-on and run-off from damaging cover.</p> <p>Protect and maintain surveyed benchmarks used to locate waste cells (landfills, waste piles).</p>	<p>RCRA hazardous waste placed at site after November 19, 1980, or movement of hazardous waste from one unit, area of contamination, or location into another unit or area of contamination will make requirements applicable. Capping without such movement will not make requirements applicable, but technical requirements are likely to be relevant and appropriate.</p>	<p>40 CFR 264.228(b) 40 CFR 264.310(a)</p>	<p>RAA</p>	<p>Capping of waste in place using RCRA technical requirements RAA</p>

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Closure with Waste in Place (Capping)	Eliminate free liquids by removal or solidification.	Disposal of RCRA hazardous waste (listed or characteristic) at site after November 19, 1980, or movement of hazardous waste from one unit, area of contamination, or location into another unit or area of contamination. Not applicable to material undisturbed since November 19, 1980.	40 CFR 264.228 (a)(2)	See capping	See capping
	Stabilization of remaining waste and waste residues to support cover.	40 CFR 264.228 (a)(2) and 40 CFR 264.258(b)			
	Installation of final cover to provide long-term minimization of infiltration.	40 CFR 264.310			
	Post-closure care and ground-water monitoring.	40 CFR 264.310			
Clean Closure (Removal)	General performance standard requires minimization of need for further maintenance and control; minimization or elimination of post-closure escape of hazardous waste, hazardous constituents, leachate, contaminated runoff, or hazardous waste decomposition products. Disposal of decontamination of equipment, structures, and soils.	RCRA hazardous waste (listed or characteristic) placed at site after November 19, 1980, or movement of hazardous waste from one unit, area of contamination, or location into another unit or area of contamination. Not applicable to material undisturbed since November 19, 1980	40 CFR 264.111	REA	Applicable to soil excavated for offsite disposal.
	Removal or decontamination of all waste residues, contaminated containment system components (e.g. liners, dikes), contaminated subsoils, and structures and equipment contaminated with waste and leachate, and management of them as hazardous waste.	May apply to surface impoundment; contaminated soil, including soil from dredging or soil disturbed in the course of drilling or excavation, and returned to land.	40 CFR 264.111		
	Meet health-based levels at unit.	40 CFR 264.228(a)(1) and 40 CFR 264.258			
					40 CFR 244.111

SCREENING OF PROBABLE ACTION SPECIFIC ARANS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Excavation/ Consolidation	<p>Area from which materials are excavated may require cleanup to levels established by closure requirements</p> <p>Consolidation in storage piles/storage tanks will trigger storage requirements.</p>	<p>Movement of hazardous waste (listed or characteristic) from one unit or area of contamination into another. Consolidation within a unit or area of contamination does not trigger applicability.</p>	<p>See Clean Closure</p>	<p>RAA</p>	<p>RCRA requirements for clean closure are RAA to remedial action involving soil excavation.</p> <p>RCRA requirements for storage in waste piles or tanks are relevant and appropriate for interim storage of excavated soil destined for consolidation or offsite disposal. RAA because soil may not be RCRA hazardous waste.</p>
	<p>Placement on or in land outside unit boundary or area of contamination will trigger land disposal requirements and restrictions.</p>		<p>40 CFR 268 (Subpart D)</p>	<p>RAA</p>	<p>Soil excavated during installation of french drains is subject to land disposal restrictions for solvent containing waste. Requirements are applicable for RCRA hazardous waste; RAA if not RCRA hazardous waste.</p>

SCREENING OF PROBABLE ACTION SPECIFIC ARMS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARRR	Comments
Ground-Water Diversion	Excavation of soil for construction of slurry wall may trigger cleanup or land disposal restrictions.	RCRA hazardous waste placed at site after November 19, 1980, or movement hazardous waste from one unit, area of contamination, or location into another unit or area of contamination	See Excavation/ Consolidation	RAA	See Excavation/Consolidation
Underground injection of Wastes and Treated Ground Water	<p>UIC program prohibits:</p> <ul style="list-style-type: none"> o Injection activities that allow movement of contaminants into underground sources of drinking water and results in violations of MCLs or adversely affects health. o Construction of new Class IV wells, and operation and maintenance of existing wells. <p>Wells used to inject contaminated ground water that has been treated and is being reinjected into the same formation from which it was drawn are not prohibited if activity is part of CERCLA or RCRA actions.</p> <p>All hazardous waste injection wells must also comply with the RCRA requirements.</p>		40 CFR 144.12	Applicable/RAA	<p>Requirements pertaining to the operation of Class IV wells are applicable to remedial actions for the 881 hillside because ground water will be treated before reinjection. More stringent requirements for Class I wells (direct injection of untreated hazardous waste) are not applicable to the 881 hillside; however, some requirements for Class I wells may be relevant and appropriate.</p>
			40 CFR 144.13		
			40 CFR 144.14	Applicable	Applicable for injection of treated ground water by french drain or drilled well.
			40 CFR 144.16	Not applicable	

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Underground injection of Wastes and Treated Ground Water (continued)	<p>The Director of the UIC program in a State may lessen the stringency of 40 CFR 144.23 construction, operation, and manifesting requirements for a well if injection does not occur into, through, or above a USPW or if the radius of endangering influence (see 40 CFR 146.06(c)) is less than or equal to the radius of the well.</p> <p>Owners and operators must:</p> <ul style="list-style-type: none"> o Submit inventory information to the Director of the UIC program for the State; including hydrogeologic data for wells, construction record, nature or composition of injected fluids, injection rate and pressure, and ground-water monitoring data. o Report non-compliance orally within 24 hours. o Prepare, maintain, and comply with plugging and abandonment plan. <p>Monitor class 1 wells by:</p> <ul style="list-style-type: none"> o frequent analysis of injection fluid. o continuous monitoring of injection pressure. o flow rate, and volume and, o installation and monitoring of ground-water monitoring wells. <p>Applications for Class 1 permits must:</p> <ul style="list-style-type: none"> o Identify all injection wells within the area of review. 		40 CFR 144.21		
			40 CFR 144.26 40 CFR 144.27		
			40 CFR 144.28		
			40 CFR 144.55		

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Underground Injection of Wastes and Treated Ground Water (continued)	<ul style="list-style-type: none"> o Take action as necessary to ensure that such wells are properly sealed, completed, or abandoned to prevent contamination of USDW. 		40 CFR 146.4		
	<p>Criteria for determining whether an aquifer may be determined to be an exempted aquifer include current and future use, yield, and water quality characteristics.</p> <p>Case and cement all Class I wells to prevent movement of fluids into USDW, taking into consideration, well depth, injection pressure, hole size, composition of injected waste and other factors.</p> <p>Conduct appropriate logs and other tests during construction and a descriptive report prepared and submitted to the UIC program director.</p> <p>Injection pressure may not exceed a maximum level designed to ensure that injection does not initiate new fractures or propagate existing ones and cause the movement of fluids into a USDW.</p> <p>Continuous monitoring of injection pressure, flow rate, and volume, and annual pressure, if required.</p> <p>Demonstration of mechanical integrity is required every 5 years.</p> <p>Ground-water monitoring may also be required.</p>		40 CFR 146.13		

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Treatment or Storage in Tanks	Tanks must have sufficient shell strength (thickness), and, for closed tanks, pressure controls, to assure that they do not collapse or rupture.	RCRA hazardous waste (listed or characteristic), held for temporary period before treatment, disposal, or storage elsewhere, (40 CFR 264.10) in a tank.	40 CFR 264.190	REA	Relevant and appropriate for treatment and storage tanks used in treating contaminated groundwater
	Waste must not be incompatible with the tank material unless the tank is protected by a liner or by other means.		40 CFR 264.191		
	Tanks must be provided with controls to prevent overfilling, and sufficient freeboard maintained in open tanks to prevent overtopping by wave action or precipitation.		40 CFR 264.194		
	Inspect the following: overfilling control, control equipment, monitoring data, waste level (for uncovered tanks), tank condition, above-ground portions of tanks, (to assess their structural integrity) and the area surrounding the tank (to identify signs of leakage).		40 CFR 264.195		
	Repair any corrosion, crack, or leak.		40 CFR 264.196		
	At closure, remove all hazardous waste and hazardous waste residues from tanks, discharge control equipment, and discharge confinement structures.		40 CFR 264.197		
	Store ignitable and reactive waste so as to prevent the waste from igniting or reacting. Ignitable or reactive wastes in covered tanks must comply with buffer zone requirements in "Flammable and Combustible Liquids Code," Tables 2-1 through 2-6 (National Fire Protection Association, 1976 or 1981).		40 CFR 264.198		

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Container Storage (On-Site)	<p>Containers of hazardous waste must be:</p> <ul style="list-style-type: none"> o Maintained in good condition; o Compatible with hazardous waste to be stored; and o Closed during storage (except to add or remove waste). <p>Inspect container storage areas weekly for deterioration.</p> <p>Place containers on a sloped, crack-free base, and protect from contact with accumulated liquid. Provide containment system with a capacity of 10% of the volume of containers of free liquids. Remove spilled or leaked waste in a timely manner to prevent overflow of the containment system.</p> <p>Keep containers of ignitable or reactive waste at least 50 feet from the facility's property line.</p> <p>Keep incompatible materials separate. Separate incompatible materials stored near each other by a dike or other barrier.</p> <p>At closure, remove all hazardous waste and residues from the containment system, and decontaminate or remove all containers, liners.</p>	<p>RCRA hazardous waste (listed or characteristic) held for a temporary period before treatment, disposal, or storage elsewhere, (40 CFR 264.10) in a container (i.e., any portable device in which a material is stored, transported, disposed of, or handled) (40 CFR 264.10)</p>	<p>40 CFR 264.171</p> <p>40 CFR 264.172</p> <p>40 CFR 264.173</p> <p>40 CFR 264.174</p> <p>40 CFR 264.175</p> <p>40 CFR 264.176</p> <p>40 CFR 264.177</p> <p>40 CFR 264.178</p>	<p>ARAR</p> <p>R&A</p>	<p>RCRA container storage requirements are R&A</p>

SCREENING OF PROBABLE ACTION SPECIFIC ARARs
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Off-Site Treatment Storage or Disposal	<p>In the case of any removal or remedial action involving the transfer of any hazardous substance or pollutant or contaminant offsite, such hazardous substance or pollutant or contaminant shall only be transferred to a facility which is operating in compliance with section 3004 and 3005 of the Solid Waste Disposal Act (or where applicable, in compliance with the Toxic Substances Control Act or other applicable Federal law) and all applicable State requirements. Such substance or pollutant or contaminant may be transferred to a land disposal facility only if the President determines that both of the following requirements are met:</p> <ul style="list-style-type: none"> o The unit to which the hazardous substance or pollutant or contaminant is transferred is not releasing any hazardous waste, or constituent thereof, into the groundwater or surface water or soil. o All such releases from other units at the facility are being controlled by a corrective action program approved by the Administrator under subtitle C of the Solid Waste Disposal Act. 		SARA section 121 (d)(2)(c)	Applicable	Applicable to the offsite treatment, storage, or disposal of wastes generated during onsite remedial actions.

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Hazardous Waste Operations	<p>As mandated by SARA, OSHA has promulgated regulations that require employers to develop and implement a written safety/health program designed to regulate employee safety and health during hazardous waste operations. The safety and health program must include:</p> <ul style="list-style-type: none"> o <u>Organizational structure-</u> Establish and implement chain of command and specify the responsibilities of key personnel. o <u>Comprehensive Work Plan-</u> Identify anticipated activities, define work tasks, establish personnel requirements, and provide for the implementation of medical surveillance and training programs as required by these regulations. o <u>Site-Specific Health and Safety Plans</u> A site health and safety plan must be prepared for each phase of operation that addresses key personnel; hazard recognition; training assignments; personnel protective equipment to be used; medical surveillance; frequency and type of monitoring, including air and personal monitoring; site control measures; decontamination procedures; emergency contingency plans. <p>General Requirements of these regulations:</p> <ul style="list-style-type: none"> o <u>Site characterization and analysis-</u> Identify site hazards to determine levels of personnel protection 	<p>Regulations apply to hazardous substance response operations under CERCLA; Corrective cleanup under RCRA; hazardous waste operations that have been designated for cleanup by state or local authorities; most operations involving the treatment, storage or disposal of hazardous wastes regulated under RCRA; and emergency response operations for releases or threats of releases of hazardous substances.</p>	29 CFR Part 1910.120		
			29 CFR 1910.120(c)	Applicable	Site hazards have been characterized through the RI/FS process

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Hazardous Waste Operations (continued)	<ul style="list-style-type: none"> o <u>Site Control-</u> Implement site control zones to minimize employee exposure to hazardous substances. 		29 CFR 1910.120(d)	Applicable	Site control zones will be defined in site-specific health and safety plans.
	<ul style="list-style-type: none"> o <u>Training-</u> Initial training and refresher training required before employee is permitted to engage in site activities. 		29 CFR 1910.120(e)	Applicable	Personnel engaged in remedial actions at the 881 hillside are required to meet minimum training requirements as specified in the OSHA standards
	<ul style="list-style-type: none"> o <u>Medical Surveillance</u> Employers must implement medical surveillance for employees potentially exposed to hazardous substances. 		29 CFR 1910.120(f)	Applicable	
	<ul style="list-style-type: none"> o <u>Engineering Controls, Work Practices and Personnel Protective Equipment</u> One or all of these shall be used to minimize exposure of employees to hazardous substances and health hazards 		29 CFR 1910.120(g)	Applicable	
	<ul style="list-style-type: none"> o <u>Monitoring-</u> Monitoring of exposures of employees to hazardous substances is required to determine the efficacy of protective equipment and engineering controls. 		29 CFR 1910.120(h)	Applicable	
	<ul style="list-style-type: none"> o <u>Informational Programs</u> Employees, contractors, and subcontractors shall be informed of the degree and nature of hazards associated with site activities. 		29 CFR 1910.120(i)	Applicable	All personnel involved in site activities will be required to read and comply with the site safety plan. The safety plan will outline the anticipated physical and chemical hazards.

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
Hazardous Waste Operations (continued)	o <u>Material Handling</u> Hazardous substances, contaminated soils, liquids or other residues shall be handled, transported, and labeled according to subsection (j) of the OSHA standard		29 CFR 1910.120(j)	Applicable	D.O.T. specification containers will be used to handle, store, or transport
	o <u>Decontamination-</u> Decontamination procedures outlined in subsection (k) of the standard must be complied with during onsite remedial action.		29 CFR 1910.120(k)	Applicable	Decontamination procedures will be presented in the site health and safety plan.
	o <u>Emergency Response</u> Contingency plans must be developed as part of site health and safety planning		29 CFR 1910.120(l)	Applicable	Contingency plans will developed for the site health and safety plan
	o <u>Illumination/Sanitation</u> Minimum illumination and sanitation facilities must be provided for employees involved in hazardous waste operations		29 CFR 1910.120(m)(n)	Applicable	
	o <u>Site Excavation</u> Site excavations must be shored or sloped to prevent collapse.		29 CFR 1910.120/1926	Applicable	
	o <u>Contractors and Subcontractors</u> Employers must inform contractors or subcontractors of potential hazards associated with site activities		29 CFR 1910.120	Applicable	

SCREENING OF PROBABLE ACTION SPECIFIC ARARS
FOR REMEDIAL ACTIONS AT THE 881 HILLSIDE

Action	Requirement	Prerequisite	Citation	ARAR	Comments
General Releases from SHUs	The owner or operator of a facility seeking a permit for the treatment, storage or disposal of hazardous waste must institute corrective action as necessary to protect human health and the environment for all releases of hazardous waste or constituents from any solid waste management unit at the facility, regardless of the time at which waste was placed in such unit.	Owners or operators of facilities that treat, store or dispose of hazardous waste. The owners or operators must satisfy the requirements for all wastes contained in solid waste management units at the facility, regardless of the time at which waste was placed in such units.	40 CFR 264 (Subpart F)		
	Owners or operators are required to conduct a monitoring and response program as follows:				
	o Compliance monitoring program required whenever hazardous constituents from a regulated unit are detected at a compliance point	Following detection, contaminants in the ground water must be identified and a program established to ensure that ground-water contaminant concentrations do not exceed Ground Water Protection Standards (GWPS) established for the facility	40 CFR 264.99	REA	Requirements would be applicable for current disposal of RCRA wastes. They are relevant and appropriate for past disposal that has resulted in contamination of the ground water.
	o Corrective action program must be instituted when ground water protection standards are exceeded.		40 CFR 264.100	REA	Corrective action monitoring is applicable for current disposal activities that have caused exceedance of the facility GWPS beyond the point of compliance. They are relevant and appropriate for monitoring the effectiveness of remedial cleanup activities under CERCLA.
	o Detection monitoring program must be instituted in all other cases.		40 CFR 264.98	Not ARAR	Detection monitoring is not ARAR because contamination has already been detected in at the 881 Hillside site.

SCREENING OF LOCATION SPECIFIC ARARS
 REMEDIAL ACTIONS 881 HILLSIDE

LOCATION	RESTRICTIONS/ LIMITATIONS	PREREQUISITE	CITATION	ARAR CLASSIFICATION	COMMENTS
Siting within 61 meters of a fault displaced in Holocene time ^a	New RCRA TSD facilities prohibited	RCRA hazardous waste treatment, storage or disposal	40 CFR 264.18(a)	Not ARAR	No faults displaced during Holocene times exist within 61 meters of the site.
Siting within 100-year floodplain ^a	Site located within 100 year floodplain must be designed, constructed, and operated to prevent wash-out	RCRA hazardous waste treatment, storage, or disposal	40 CFR 264.18(b)	Not ARAR	The site is not located within a 100 year floodplain.
Siting of Hazardous Waste Disposal Sites	Outlines siting criteria for storage or disposal sites	RCRA hazardous waste TSD facilities	Colorado Hazardous Waste Act, Sections 25-15-101, 203, 208, 302	REA	Relevant and appropriate if wastes are classified hazardous and onsite disposal is proposed.
Siting of Wastewater Treatment facilities	Site conditions must assure prevention of waste exposure for 1000 years and assure short and long-term protection of human health and environment.	RCRA hazardous waste disposal sites	6 OCR 1007-2	REA	Relevant and Appropriate for onsite disposal sites.
Siting of Wastewater Treatment facilities	Colorado Department of Health Water Quality Control Division must approve of locations of wastewater treatment facilities prior to construction	Domestic wastewater treatment plants	Colorado Water Quality Control Act Sections 25-8-202 and 25-8-702	REA	Applicable to domestic wastewater treatment facilities, relevant and appropriate to proposed groundwater treatment facility.
RCRA TSD siting in salt dome formation, underground mine, or cave. ^a	Placement of non-containerized or bulk liquid hazardous waste prohibited	RCRA hazardous waste	40 CFR 264.18(c)	Not ARAR	No such activities are planned for the 881 hillside remedial actions

SCREENING OF LOCATION SPECIFIC ARARS

REMEDIAL ACTIONS 881 HILLSIDE

LOCATION	RESTRICTIONS/ LIMITATIONS	PREREQUISITE	CITATION	ARAR CLASSIFICATION	COMMENTS
Siting within an area where action may cause irreparable harm, loss, or destruction of significant artifacts ^a	Recover and preserve artifacts	Planned actions will alter terrain threatening significant scientific, prehistorical, historical, or archeological data	36 CFR Part 65	Not ARAR	No significant scientific, prehistorical, historical, or archeological data or artifacts are known to exist on the 881 hillside
Siting on or near historic property owned or controlled by federal agency ^a	Actions are to be planned to preserve historic properties and minimize harm to National Historic Landmarks	Property included in or eligible for the National Register of Historic Places	36 CFR Part 800	Not ARAR	No historic sites are known to be present near the 881 hillside
Siting on critical habitat of endangered or threatened species ^a	Actions must conserve endangered or threatened species	Determine if actions will impact endangered or threatened species	50 CFR Part 200, 402	Not ARAR	No endangered or threatened species are known to inhabit the vicinity of the 881 hillside
Wetlands ^a	Actions to minimize the destruction, loss, or degradation of wetlands	Wetlands as defined by Executive Order 11990, section 7	40 CFR 6, Appendix A	Not ARAR	881 hillside is not located in a wetland area
Area affecting stream or river	Discharge of dredged or fill material into wetland is prohibited	Action to protect fish or wildlife	40 CFR Parts 230, 231	Not ARAR	881 hillside is not located in a wetland area
			40 CFR 6.302	Not ARAR	Planned activities will not include diversion, channeling or modification of streams or rivers

(a) "Draft CERCLA Compliance With Other Laws Manual, Volume I Overview and RCRA Requirements" Office of Emergency and Remedial Response, Policy and Analysis Staff, OSWER DIRECTIVE 9234.1-01, June, 1987

APPENDIX 3
COST ESTIMATES

APPENDIX 3
COST ESTIMATES
881 HILLSIDE AREA FEASIBILITY STUDY

ANALYTICAL METHODS

Cost analyses used in this report included estimation of capital and operations & maintenance costs and present worth analyses. The present worth analyses were performed to demonstrate the life cycle costs of identified alternatives. Costs presented in this feasibility study have been prepared by our estimating department using a site specific estimating system. Costs are based upon vendor estimates, prevailing labor and material rates, and our recent experience with similar operations at this site. All costs are presented in 1988 dollars. Costs were estimated for discrete units (components) which appear in their entirety in one or more alternatives. The estimated costs of each component associated with a particular alternative were added to yield the alternative costs (Tables 4-8 and 4-9). This approach was used because the alternative descriptions were optimized constantly during the preparation of this report. By defining component subsets of each alternative, we were able to avoid numerous redundant calculations of alternative costs. Capital costs were distributed in accordance with the schedule discussed under ASSUMPTIONS, below.

ASSUMPTIONS

To demonstrate the relative costs of each alternative, a consistent set of assumptions was required. For the purpose of this report, we have assumed that all capital improvements would be designed and constructed in accordance with existing policies and standards appropriate to this site, the Davis-Bacon Act applies to the

capital construction required for each alternative, and that all specified activities occur during the schedule presented in Table A3-1.

<u>DATE</u>	<u>EVENT</u>
5/88	Lead agency accepts recommended remedy
1/89	End of design and contractor selection period, 8 months
1/89	Begin construction
4/1/89	Complete construction
4/15/89	Complete S.O. testing & adjustment
4/15/89	Begin operation

This schedule is presented to facilitate consistent cost analyses. The schedule is optimistic but not unreasonable and provides a common base upon which to calculate life cycle costs. It is not necessarily a realistic schedule because of events which may be beyond our control and modifications to the remedy which may occur prior to implementation. A realistic schedule will be provided as part of our Remedial Action Plan (RAP).

COMPONENT COST CALCULATIONS

Line item calculations for all components are presented in Tables A3-2 and A3-3. Table A3-2 includes all components other than the treatment unit. Table A3-3 presents the line item estimate for the proposed UV/Peroxide oxidation treatment unit.

TABLE A3-2

 #81 HILLSIDE *****
 ** ESC REF DATE=02/88 ** *****
 BLDG-SITE JOB-986124/05 ERIC W. MENDE 02/26/88 *

 A=00/00 B=00/00 C=00/00 D=00/00 E=00/00 F=00/00 G=00/00 *****

PAGE 1	02/26/88	QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
310001/00000	MONITOR WELL								
(1)									
MONITOR WELL (REF 986124-A1)									
INCLUDES D&P	11 EA		3,284.00	36,124					36,124
>>>DIRECT COST				36,124		0		0	36,124
CATEGORY SUBTOTAL				36,124					36,124
TOTAL CATEGORY COSTS				36,124					36,124

310001/00000 COLLECTOR MANIFOLD
 (2)

---	REF ITEM NO. 2---								
2" PE PIPE		1.680 LF	.73	1,226	.100	168.000	26.740	4,492	5,718
EXCAVATION		1,260 CY	3.00	3,780	.200	252.000	18.980	4,783	8,563
PIPE BEDDING		840 CY	8.00	6,720	.160	134.400	18.980	2,551	9,271
BACKFILL		420 CY	3.40	1,428	.300	126.000	18.980	2,391	3,819
>>>DIRECT COST				13,154		680		14,217	27,371
CATEGORY SUBTOTAL				13,154		680		14,217	27,371
DVH-PFT-BND (20.0%)				2,631				2,843	5,474
TOTAL CATEGORY COSTS				15,785				17,060	32,845

310001/00000 INTERCEPTOR WELLS (169 EA)
 (3)

QUANT	UNIT	MATERIAL COST/UNIT	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
---REF ITEM NO. 4---							
1,690	LF	3.70	.340	574.600	26.740	15,365	21,618
2,028	LF	3.90	.340	689.520	26.740	18,438	26,347
169	EA	8.00	.400	67.600	26.740	1,808	3,160
4,225	LF	.20	.002	8.450	26.740	226	1,071
4,225	LF	.12	.035	147.875	26.740	3,954	4,461
169	EA	22.00	.300	50.700	26.740	1,356	5,074
169	EA	275.00	8.000	1,352.000	26.740	36,152	82,627
169	EA	3.50	.800	135.200	26.740	3,615	4,207
169	EA	10.00	1.300	219.700	26.740	5,875	7,565
15	CY	62.00	.300	4.500	14.610	66	996
169	EA	110.00	2.000	338.000	25.370	8,575	27,165
169	EA	25.00	.800	135.200	26.740	3,615	7,840
28	CY	8.00	1.000	28.000	14.610	409	633
5	CY	62.00	.700	3.500	14.610	51	361
1,252	CY	3.00	.200	250.400	18.980	4,753	8,509
85	CY	8.00	.160	13.600	18.980	258	938
1,166	CY	3.30	.300	349.800	18.980	6,639	10,487
169	EA	10.00	1.000	169.000	18.980	3,208	4,898
MOBILIZATION FOR DRILL RIG		500.00					500
>>>DIRECT COST				4,538		114,363	218,457
CATEGORY SUBTOTAL		104,094		4,538		114,363	218,457
DVH-PFT-BND (20.02)						22,873	43,692
TOTAL CATEGORY COSTS						137,236	262,149

***** PROJECT TITLE: 881 HILLSIDE
 QUANT UNIT MATERIAL TOTAL MTL LABOR HRS TOTAL LABOR TOTAL MTL & LABOR COSTS

--- REF ITEM NO. 3---

QUANT	UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
6	EA	150.00	900	1.000	6.000	26.740	160	1.060
6	EA	200.00	1,200	1.000	6.000	26.740	160	1,360
6	EA	50.00	300	1.800	10.800	26.740	289	589
6	EA	220.00	1,320	2.000	12.000	26.740	321	1,641
>>>DIRECT COST			3,720		35		930	4,650
CATEGORY SUBTOTAL			3,720		35		930	4,650
OVH-PFT-BND (20.0%)			744				186	930
TOTAL CATEGORY COSTS			4,464				1,116	5,580

310001/17000 FNDTN DRAIN SUMP W/PUMP
 (5)

EXCAVATION	13	CY	3.00	39	.200	2.600	18.980	49	88
CONC MANHOLE BASE	1	LS	100.00	100	8.000	8.000	14.610	117	217
3X5 PRECAST MANHOLE	1	EA	250.00	250	6.000	6.000	14.610	88	338
ALUM LADDER	1	EA	80.00	80	2.000	2.000	14.610	29	109
BACKFILL	1	LS			4.000	4.000	14.610	58	58
CI MANHOLE COVER	1	LS	170.00	170	3.400	3.400	14.610	50	220
4X4X6' WOOD POST	1	EA	10.00	10	1.000	1.000	14.610	15	25
PUMP, SUBN, W/FLOAT 10GPM	2	EA	630.00	1,260	8.000	16.000	26.740	428	1,688
GATE VLV, 11/2"	2	EA	35.00	70	.600	1.200	26.740	32	102
CHECK VLV	1	EA	40.00	40	.600	.600	26.740	16	56
NEMA 12 BDX	1	EA	30.00	30	.700	.700	25.370	18	48
SWITCH W/FUSES	2	EA	35.00	70	.800	1.600	25.370	41	111
>>>DIRECT COST			2,119		47		941	3,060	
CATEGORY SUBTOTAL			2,119		47		941	3,060	

***** PROJECT TITLE: 881 HILLSIDE

TOTAL MTL & LABOR COSTS

OVH-PFT-BND (20.0%) 424

188 612

TOTAL CATEGORY COSTS 2,543

1,129 3,672

310001/00000 WELL 9-74 PUMP AND EQUIP (6)

---REF ITEM NO 6---

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
25 LF	.20	5	.002	.050	26.740	1	6
25 LF	.44	11	.080	2.000	26.740	53	64
1 EA	40.00	40	.400	.400	26.740	11	51
1 EA	275.00	275	8.000	8.000	26.740	214	489
1 EA	6.00	6	1.000	1.000	26.740	27	33
1 EA	10.00	10	1.300	1.300	14.610	19	29
1 LB	5.00	5	.300	.300	14.610	4	9
1 EA	110.00	110	2.000	2.000	25.370	51	161
1 EA	25.00	25	.800	.800	26.740	21	46
8 CY	3.00	24	.200	1.600	18.980	30	54
1 CY	8.00	8	.160	.160	18.980	3	11
7 CY	3.30	23	.300	2.100	18.980	40	63
>>>DIRECT COST		542		20		474	1,016
CATEGORY SUBTOTAL		542		20		474	1,016
OVH-PFT-BND (20.0%)		108				95	203
TOTAL CATEGORY COSTS		650				569	1,219

310001/00000 SINGLE WALL WATER PIPE (7)

---REF ITEM NO. 7---

1,160 LF	.73	847	.100	116.000	26.740	3,102	3,949
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QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR TOTAL RATE COSTS	TOTAL MTL & LABOR COSTS
EXCAVATION	870 CY	3.00	2,610	.300	261,000	7,564
PIPE BEDDING	82 CY	8.00	656	.160	13,120	905
BACKFILL	790 CY	3.40	2,686	.300	237,000	7,184
					26,740	

MISC FITTINGS	1 LB	150.00	150	12.000	12,000	471
>>>DIRECT COST			6,949		13,124	20,073

CATEGORY SUBTOTAL			6,949		13,124	20,073
OVH-PFT-BND (20.0%)			1,390		2,625	4,015
TOTAL CATEGORY COSTS			8,339		15,749	24,088

310001/17000 DOUBLE CONTAINMENT PIPE (8)

EXCAVATION	776 CY	3.00	2,328	.200	155,200	5,274
PIPE BEDDING	78 CY	8.00	624	.160	12,480	861
BACKFILL	690 CY	3.30	2,277	.300	207,000	6,206
DOUBLE CONTAINED PE PIPE, 2"	1,035 LF	8.00	8,280	.100	103,500	11,048
MISC FITTINGS	1 LB	100.00	100	8.000	8,000	314
>>>DIRECT COST			13,609		486	23,703

CATEGORY SUBTOTAL			13,609		486	23,703
OVH-PFT-BND (20.0%)			2,722		2,019	4,741
TOTAL CATEGORY COSTS			16,331		12,113	28,444

310001/00000 TREATMENT PLANT (9)

PAGE 6 02/26/88 ***** PROJECT TITLE: 881 HILLSIDE
 QUANT UNIT MATERIAL TOTAL MTL LABOR HRS TOTAL LABOR TOTAL MTL & LABOR COSTS

--- REF ITEM NO. 9---
 TREATMENT PLANT (REF 986124-04)
 FOR U/V PEROXIDE SYS OPTION) 1 LS 291,000.00 291,000 291,000
 >>>DIRECT COST 0 0 291,000
 CATEGORY SUBTOTAL 291,000
 TOTAL CATEGORY COSTS 291,000

310001/00000 FRENCH DRAIN (10)
 --- REF ITEM NO. 10---
 FRENCH DRAIN (REF 986124-01) 1,680 LF 271.00 455,280 455,280
 (INCLUDES O&P)
 >>>DIRECT COST 0 0 455,280
 CATEGORY SUBTOTAL 455,280
 TOTAL CATEGORY COSTS 455,280

310001/00000 FR. DRAIN SUMP W/PUMP (11)
 ---REF ITEM NO. 11---
 SUMP PIT W/PUMP (REF 986124-01) 1 LS 7,400.00 7,400 7,400
 (INCLUDES O&P)
 >>>DIRECT COST 0 0 7,400
 CATEGORY SUBTOTAL 7,400
 TOTAL CATEGORY COSTS 7,400

310001/17000 SINGLE WALL PE PIPE (12)

QUANT UNIT	MATERIAL COST/UNIT	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
520 LF	.44	.080	41.600	1,112	1,341
EXCAVATION	3.00	.200	78.000	1,480	2,650
PIPE BEDDING	8.00	.160	5.760	109	397
BACKFILL	3.30	.300	109.200	2,073	3,274
1 1/2" CHK VLV	40.00	.400	.800	21	101
1 1/2" GATE VLV	35.00	.600	1.200	32	102
MISC FITTINGS	100.00	8.000	8.000	214	314

>>>DIRECT COST 3,138 245 5,041 8,179

CATEGORY SUBTOTAL 3,138 245 5,041 8,179
 OVH-PFT-BND (20.0%) 628 1,008 1,636
 TOTAL CATEGORY COSTS 3,766 6,049 9,815

310001/00000 INFILTRATION GALLERY (13)

---REF ITEM NO. 14---

BULK EXCAVATION	30.667 CY	.52	15,947	.030	920.010	18,980	17,462	33,409
DRAIN ROCK	2,017 CY	10.00	20,170	.100	201,700	18,980	3,828	23,998
BACKFILL	6,250 CY	.50	3,125	.200	1,250,000	18,980	23,725	26,850
WASTE SOIL	22,400 CY			.030	672,000	18,980	12,755	12,755
DISTRIB. BOX	1 EA	30.00	30	1.000	1,000	26,740	27	57
SLOTTED PVC PIPE, 4"	3,510 LF	.58	3,196	.064	352,640	26,740	9,430	12,626
4" PVC DOUBLE ELL	50 EA	18.00	900	1.400	70,000	26,740	1,872	2,772
4" PVC END CAP	16 EA	3.00	48	.600	9,600	26,740	257	305
4" PVC TEE	2 EA	12.00	24	2.000	4,000	26,740	107	131

***** PROJECT TITLE: 881 HILLSIDE

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
4" PVC EL 90	8.00	32	1.230	4.920	26.740	132	164
4" PVC PIPE	.54	54	.064	6.400	26.740	171	225
TRENCH EXCAV	3.00	225	.200	15.000	18.980	285	510
FILTER FABRIC	1.20	7,200	.010	60.000	14.610	877	8,077
BACKFILL	3.30	248	.300	22.500	18.980	427	675

>>>DIRECT COST

 51,199

 71,355

 122,554

CATEGORY SUBTOTAL

71,355

OVH-PFT-BND (20.0%)

14,271

TOTAL CATEGORY COSTS

85,626

310001/00000 RETURN WATER PIPE (14)

---REF ITEM NO. 15---

1" PE PIPE	.25	231	.050	46.250	26.740	1,237	1,468
TRENCH EXCAVATION	3.00	2,082	.200	138.800	18.980	2,634	4,716
PIPE BEDDING	8.00	520	.160	10.400	18.980	197	717
BACKFILL	3.30	2,138	.300	194.400	18.980	3,690	5,828

>>>DIRECT COST

 4,971

 7,758

 12,729

CATEGORY SUBTOTAL

390

OVH-PFT-BND (20.0%)

1,552

TOTAL CATEGORY COSTS

9,310

310001/00000 RCRA CAP (15)

---REF ITEM NO. 16---

 15,275

***** PROJECT TITLE: 881 HILLSIDE	*****	*****	*****	*****	*****	*****	*****	*****	*****
QUANT UNIT	MATERIAL COST/UNIT	LABOR HRS PER UNIT	TOTAL MTL COSTS	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS		
PAGE 9 02/26/88									
RCRA CAP (REF 986124-01)	58,800 SF	2.44	143,472				143,472		
(INCLUDES O&P)									
>>>DIRECT COST			143,472		0	0	143,472		
CATEGORY SUBTOTAL			143,472				143,472		
TOTAL CATEGORY COSTS			143,472				143,472		
310001/00000 SLURRY WALLS (16)									
---REF ITEM NO. 17---									
BETONITE SLURRY WALL (IN PLACE)	19,800 SF	7.00	138,600				138,600		
>>>DIRECT COST			138,600		0	0	138,600		
CATEGORY SUBTOTAL			138,600				138,600		
TOTAL CATEGORY COSTS			138,600				138,600		
310001/00000 SEMI TRAILER TANK (17)									
---REF ITEM NO. 18---									
7500GAL TRAILER RMTD TANK	1 EA	32,000.00	32,000				32,000		
>>>DIRECT COST			32,000		0	0	32,000		
CATEGORY SUBTOTAL			32,000				32,000		
TOTAL CATEGORY COSTS			32,000				32,000		
310001/00000 CONC PARKING PAD W/BERMS (18)									
---REF ITEM NO. 19---									
6X6 WIRE MESH	2,400 SF	.20	480	14,400	22.490	324	804		

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR TOTAL LABOR RATE COSTS	TOTAL MTL & LABOR COSTS
160 LF	4.35	696	.055	8.800	22.490	198 894
6" CONCRETE PAVING	12.25	1,715	.030	4.200	22.490	94 1,809
SUBGRADE PREP	.24	34	.010	1.400	18.980	27 61
>>>DIRECT COST		2,925		29	643	3,568
CATEGORY SUBTOTAL		2,925		29	643	3,568
OVH-PFT-BND (20.0%)		585		129		714
TOTAL CATEGORY COSTS		3,510		772		4,282

310001/00000 GROUT CONTAMINATED SOILS (19)

---REF ITEM NO. 21---

DRILL GROUT HOLES	653 EA		.900	587.700	18.980	11,155 11,155
GROUTING	88,200 CF	529,200	.700	61,740.000	14.610	902,021 1,431,221
MOBILIZATION	1 LB	1,000.00				1,000
>>>DIRECT COST		530,200		62,328		913,176 1,443,376
CATEGORY SUBTOTAL		530,200		62,328		913,176 1,443,376
OVH-PFT-BND (20.0%)		106,040				182,635 288,675
TOTAL CATEGORY COSTS		636,240				1,095,811 1,732,051

310001/00000 CHK VLVs & HYDRANTS (20)

---REF ITEM NO. 22---

CHK VLV ,2"	4 EA	150.00	1.000	4.000	26.740	107 707
ISOLATION VALVE, 2"	4 EA	200.00	1.000	4.000	26.740	107 907
TEE, 2"x3/4"	4 EA	50.00	1.800	7.200	26.740	193 393
FROST PROOF HYDRANT	4 EA	220.00	2.000	8.000	26.740	214 1,094

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRB PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
>>>DIRECT COST		2,480		23		621	3,101
CATEGORY SUBTOTAL		2,480		23		621	3,101
DVN-PFT-BND (20.0%)		496				124	620
TOTAL CATEGORY COSTS		2,976				745	3,721

310001/00000 EXCAVATE/DISPOSE OFF SITE (21)

---REF ITEM NO. 23---

EXCAVATE CONTAM. SOIL & DISPOS	OFF SITE (REF 986124-82)	(INCLUDES O&P)
3,000 CY	356.00	1,068,000
>>>DIRECT COST		1,068,000
CATEGORY SUBTOTAL		1,068,000
TOTAL CATEGORY COSTS		1,068,000

310001/00000 ELECTRIC SERVICE (ALT #2) (22)

---REF ITEM NO. 24---

YFRMR, 13.8KV-230V,4WIRE	FUSIBLE CUTOUTS, 13.8KV W/LA	DISTRIB. PNL.12P.230V,4W	DEAD END POLE	CONDUIT IN TRENCH	WIRE	TRENCHING	BEDDING
12 EA	12 EA	4 EA	4 EA	1,800 LF	7,200 LF	900 CY	200 CY
5,200.00	250.00	300.00	200.00	6.00	.50	3.00	8.00
62,400	3,000	1,200	800	10,800	3,600	2,700	1,600
35.000	3.000	8.000	6.500	.160	.002	.200	.160
384,000	36,000	32,000	26,000	288,000	14,400	180,000	32,000
25,370	25,370	25,370	25,370	25,370	25,370	18,980	18,980
9,742	913	812	660	7,307	365	3,416	607
72,142	3,913	2,012	1,460	18,107	3,965	6,116	2,207

PAGE 12 02/26/88 ***** PROJECT TITLE: 881 HILLSIDE *****

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
700 CY	3.30	2,310	.300	210,000	18.980	3,986	6,296
>>>DIRECT COST		88,410		1,202		27,808	116,218
CATEGORY SUBTOTAL		88,410		1,202		27,808	116,218
OVH-PFT-BND (20.0%)		17,682				5,562	23,244
TOTAL CATEGORY COSTS		106,092				33,370	139,462

310001/00000 ELECT. SERVICE (ALT. #3,4,8)
(23)

---REF ITEM NO. 25---

XFRMR, 13.8KV-230V	6 EA	5,200.00	32.000	192.000	25.370	4,871	36,071
FUSIBLE CUTOFF W/LIGHT ARREST	6 EA	250.00	3.000	18.000	25.370	457	1,957
DISTRIB. PNL	2 EA	300.00	8.000	16.000	25.370	406	1,006
DEAD END POLE	2 EA	200.00	6.500	13.000	25.370	330	730
LINE POLE	1 EA	200.00	4.000	4.000	25.370	101	301
CONDUIT IN TRENCH	150 LF	6.00	.160	24.000	25.370	609	1,509
WIRE	600 LF	.50	.002	1.200	25.370	30	330
EXCAVATE TRENCH	75 CY	3.00	.200	15.000	18.980	285	510
BEDDING	20 CY	8.00	.160	3.200	18.980	61	221
BACKFILL	55 CY	3.30	.300	16.500	18.980	313	495
>>>DIRECT COST		35,667		303		7,463	43,130
CATEGORY SUBTOTAL		35,667		303		7,463	43,130
OVH-PFT-BND (20.0%)		7,133				1,493	8,626
TOTAL CATEGORY COSTS		42,800				8,956	51,756

***** PROJECT TITLE: 881 HILLSIDE
 QUANT UNIT MATERIAL LABOR HRS TOTAL LABOR TOTAL MTL & LABOR COSTS

310001/00000 DOUBLE CONTAINED PIPE
 (24)

---REF ITEM NO.26---

QUANT	UNIT	MATERIAL COST/UNIT	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS	
740	LF	9.50	.120	88.800	26.740	2,375	9,405	
555	CY	3.00	.200	111.000	18.980	2,107	3,772	
52	CY	8.00	.160	8.320	18.980	158	574	
516	CY	3.30	.300	155.400	18.980	2,949	4,658	
2	EA	40.00	.400	.800	26.740	21	101	
2	EA	35.00	.400	.800	26.740	21	91	
1	LB	100.00	8.000	8.000	26.740	214	314	
2	EA	220.00	2.000	4.000	26.740	107	547	
>>>DIRECT COST							7,952	19,462
CATEGORY SUBTOTAL							7,952	19,462
OVH-PFT-BND (20.0%)							1,590	3,892
TOTAL CATEGORY COSTS							9,542	23,354

310001/00000 ELECT. SERVICE (ALT. #5&7)
 (25)

---REF ITEM NO. 27---

1	LB	21,565.00					21,565	
>>>DIRECT COST							0	21,565
CATEGORY SUBTOTAL								21,565
OVH-PFT-BND (20.0%)								4,313
TOTAL CATEGORY COSTS								25,878

310001/00000 DOUBLE CONTAINED PIPE
 (26)

***** PROJECT TITLE: 881 HILLSIDE
 QUANT UNIT MATERIAL TOTAL MTL LABOR HRS TOTAL LABOR TOTAL MTL & LABOR COSTS

---REF ITEM NO. 28---

QUANT	UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
1	LS	13,623.00	13,623					13,623
>>>DIRECT COST								
CATEGORY SUBTOTAL								
			13,623					13,623
			2,725					2,725
			16,348					16,348

310001/00000 CHK VLVS AND HYDRANTS
 (27)

---REF ITEM NO. 29---

QUANT	UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
1	LS	3,876.00	3,876					3,876
>>>DIRECT COST								
CATEGORY SUBTOTAL								
			3,876					3,876
			775					775
			4,651					4,651

PROJECT: 881 HILLSIDE
 JOB: 986124/05

>>> CONSTRUCTION MARKUP SUMMARY <<<

	MATERIAL COSTS	LABOR COSTS	TOTAL COSTS
	\$	\$	\$
TOTAL MISC LABOR & MATERIAL COSTS	0	0	0
TOTAL BLDG FACTOR COSTS	0	0	0
TOTAL RESPIRATOR COSTS	0	0	0
TOTAL FULL FACE COSTS	0	0	0
TOTAL SUPPLIED AIR COSTS	0	0	0
TOTAL SUBCONTRACT COSTS	0	0	0
TOTAL ESCALATION COSTS	0	0	0
TOTAL CPFF LABOR FRINGE COSTS	0	0	0
SUM TOTAL OF MARKUPS	0	0	0
TOTAL DIRECT COSTS	3,085,627	1,195,960	4,281,587
SUBTOTAL	3,085,627	1,195,960	4,281,587
TOTAL OVH-PFT-BND COSTS	182,751	239,193	421,944
TOTAL CPFF OVERHEAD COSTS	0	0	0
TOTAL CPFF FEE COSTS	0	0	0
TOTAL CONTRACT COSTS	3,268,378	1,435,153	4,703,531

ADDITIONAL CONST. INSP. & APPROX	3.0% OF ITEMS C, D, & E.	141,106	4,844,637
CONTINGENCY & APPROX	20 %	970,363	5,815,000
OF ALL OTHER COSTS.			*****

JOB: 986124/05
DATE: 02/26/88

*** ESTIMATED COST SUMMARY ***

PROJECT: 881 HILLSIDE

A. ENGR. DESIGN AND INSP.-----\$ 141,106

ED&I @ 3% OF ITEMS C, D, & E.

ENGR. TITLE I-----\$ 0

ENGR. TITLE II-----\$ 0

ENGR. TITLE III-----\$ 0

CONSTRUCTION INSPECTION-----\$ 141,106

B. LAND AND LAND RIGHTS-----\$ 0

C. CONSTRUCTION COSTS-----\$ 4,703,531

(1) IMPROVEMENTS TO LAND-----\$ 4,703,531

(2) BUILDINGS-----\$ 0

(A) NEW-----\$ 0

(B) MODIFICATIONS-----\$ 0

(3) OTHER STRUCTURES-----\$ 0

(4) SPECIAL FACILITIES-----\$ 0

(5) UTILITIES-----\$ 0

(6) PROJECT & CONSTRUCTION MGMT-----\$ 0

D. STANDARD EQUIPMENT-----\$ 0

E. REMOVAL COST LESS SALVAGE-----\$ 0

F. CONTINGENCY @ APPROX 20%-----\$ 970,363
OF ALL OTHER COSTS.

G. TOTAL ESTIMATED COST (TEC)-----\$ 5,815,000

TABLE A3-3

 #881 HILLSIDE UV Peroxide *****
 BLDG-SITE JOB-986124/04 ERIC W. MENDE *
 ** ESC REF DATE=12/87 ***** A=05/88 B=11/88 C=08/88 D=00/00 E=11/88 F=01/89 G=04/89 *****

PAGE 1	02/26/88	QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	LABOR TOTAL COSTS	TOTAL MTL & LABOR COSTS
100000/00000 TITLE I ENGINEERING									
(1)									
TITLE I DESIGN-BOA		1 LB			1,067.000	1,067.000	62.000	66,134	66,134
TITLE I BOA SUPPORT		1 LB			107.000	107.000	62.000	6,634	6,634
TITLE I ROCKWELL SUPPORT		1 LB			118.000	118.000	94.000	11,092	11,092
TITLE I COST ESTIMATING		1 LB			18.000	18.000	94.000	1,692	1,692
>>>DIRECT COST				0		1,310		85,572	85,572
MATL ESC (RE)	8 MONTHS								85,572
LABR ESC (RE)	8 MONTHS		1,942					87,514	87,514
CATEGORY SUBTOTAL									
TOTAL CATEGORY COSTS									
						1,310		87,514	87,514
								87,514	87,514
100001/00000 TITLE II ENGINEERING									
(2)									
TITLE II DESIGN- BOA		1 LB			2,314.000	2,314.000	62.000	143,468	143,468
TITLE II BOA SUPPORT		1 LB			231.000	231.000	62.000	14,322	14,322
TITLE II ROCKWELL SUPPORT		1 LB			255.000	255.000	94.000	23,970	23,970
TITLE II COST ESTIMATING		1 LB			25.000	25.000	94.000	2,350	2,350
>>>DIRECT COST				0		2,825		184,110	184,110
MATL ESC (RE)	8 MONTHS								184,110
LABR ESC (RE)	8 MONTHS		4,179					188,289	188,289
CATEGORY SUBTOTAL									
TOTAL CATEGORY COSTS									
						2,825		188,289	188,289
								188,289	188,289

***** PROJECT TITLE: 881 HILLSIDE CARBON ABSORPTION OPT *****
 QUANT UNIT MATERIAL COST/UNIT LABOR HRS PER UNIT TOTAL LABOR HOURS LABOR TOTAL LABOR COSTS TOTAL MTL & LABOR COSTS

100002/17000 TITLE III ENGINEERING
 (3)

TITLE III DESIGN	1 LB	714.000	714.000	94.000	67.116	67,116
TITLE III COST ESTIMATING	1 LB	8.000	8.000	94.000	752	752
>>>DIRECT COST		0	722		67,868	67,868
MATL ESC (RE) 17 MONTHS						67,868
LABR ESC (RE) 17 MONTHS		3.590			71,458	71,458
CATEGORY SUBTOTAL			722		71,458	71,458
TOTAL CATEGORY COSTS					71,458	71,458

390001/17000 ALARMS/COMMUNICATION UTIL
 (4)

JB MENA 01.24X24X08, HINGED	2 EA	79.00*	158	2.670	5.340	25.370	135	293
3" UNDERGROUND CONDUIT	200 LF	4.25	850	.100	20.000	25.370	507	1,357
EXC, SM BCKHDE, CLASSC 3.9CF	52 CY	2.94*	153	.196	10.192	18.980	193	346
FILL, SAND, MACH PLACED	15 CY	8.00*	120	.159	2.385	18.980	45	165
BACKFIL W/LOADR & COMPCT CLC	37 CY	3.36*	124	.313	11.581	18.980	220	344
M CABLE	400 LF	2.61	1,044	.021	8.400	25.370	213	1,257
>>>DIRECT COST			2,449		58		1,313	3,762
MISC LABOR & MATERIAL		218	2,536		64		1,444	3,980
BLDG FACTOR (102)		144			70		1,588	4,124
MATL ESC (CC) 17 MONTHS		134	2,670					4,258
LABR ESC (CC) 17 MONTHS		84					1,672	4,342
CATEGORY SUBTOTAL			2,670		70		1,672	4,342
DVH-PFT-BND (25.3X)			676				423	1,099
TOTAL CATEGORY COSTS			3,346				2,095	5,441

***** PROJECT TITLE: 881 HILLSIDE CARBON ABSORPTION OPT *****
 QUANT UNIT MATERIAL COST/UNIT LABOR HRS TOTAL MTL COSTS TOTAL LABOR HOURS LABOR RATE TOTAL MTL & LABOR COSTS

390001/17000 PIPED UTILITIES
 (5)

QUANT	UNIT	MATERIAL COST/UNIT	LABOR HRS	TOTAL MTL COSTS	PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
1	LS	25.00	2.500	25	2.500	2.500	26.740	67	92
1	LS	25.00	2.500	25	2.500	2.500	26.740	67	92
200	LF	6.00*	.167	1,200	.167	33,400	26.740	893	2,093
5	EA	65.00	.700	325	.700	3,500	26.740	94	419
110	CY	2.94*	.196	323	.196	21,560	18.980	409	732
24	CY	8.00*	.159	192	.159	3,816	18.980	72	264
82	CY	3.36*	.313	276	.313	25,666	18.980	487	763
1	EA	727.00*	2.000	727	2.000	2,000	26.740	53	780
3	EA	321.00*	1.500	963	1.500	4,500	26.740	120	1,083
3	EA	139.65*	1.300	419	1.300	3,900	26.740	104	523
5	EA	25.00	1.000	125	1.000	5,000	26.740	134	259
22	LF	6.50*	.190	143	.190	4,180	26.740	112	255
>>>DIRECT COST				4,743		113		2,612	7,355
MISC LABOR & MATERIAL				431		124		2,873	7,786
BLDG FACTOR (10%)				287		136		3,160	8,073
MATL ESC (CC) 17 MONTHS				260					8,333
LABR ESC (CC) 17 MONTHS				167				3,327	8,500
CATEGORY SUBTOTAL				5,173		136		3,327	8,500
OVH-PFT-BND (25.3%)				1,309				842	2,151
TOTAL CATEGORY COSTS				6,482				4,169	10,651

390001/17000 STEAM & CONDENSATE
 (6)

200	LF	2.27*	.160	454	.160	32,000	26.740	856	1,310
200	LF	1.43*	.130	286	.130	26,000	26.740	695	981

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	LABOR TOTAL COSTS	TOTAL MTL & LABOR COSTS
1" BUTTWELD			1.100	8.800	26.740	235	235
1-1/2" BUTTWELD			1.300	10.400	26.740	278	278
STEAM TRAP	250.00	1.500	2.000	12.000	26.740	321	1,821
EL, 90, 1-1/2", WELD	10.54	42	1.200	4.800	26.740	128	170
EL, 90, 1", WELD	10.00	40	1.100	4.400	26.740	118	158
CONDENS RETURN SYS DUPLEX	2,420.00	2,420	32.000	32.000	26.740	856	3,276
PRESS REDUCING STATION	835.00	835	1.000	1.000	26.740	27	862
INSUL 2" FBRL, 1-1/2" PIPE	4.42	884	.084	16.800	26.740	449	1,333
INSUL 2" FBRL, 1" PIPE	3.98	796	.080	16.000	26.740	428	1,224
.016 ALUM JACKET	.37	74	.133	26.600	26.740	711	785
STANTION, SINGLE	700.00	16,100	3.500	80.500	22.490	1,810	17,910
CAISSON FOR STANTION	60.00	1,360	2.500	57.500	22.490	1,293	2,673
CABLE & ROLLER SUPPORT	50.00	1,150	2.500	57.500	20.910	1,202	2,352
TIE-IN			8.000	8.000	26.740	214	214
>>>DIRECT COST		25,961	394			9,621	35,582
MISC LABOR & MATERIAL	1.553	26,552	433			10,583	37,135
BLDG FACTOR (10%)	1.058		476			11,641	38,193
MATL ESC (CC) 17 MONTHS	1.405	27,957					39,598
LABR ESC (CC) 17 MONTHS	616					12,257	40,214
CATEGORY SUBTOTAL		27,957	476			12,257	40,214
OVH-PFT-BND (25.3%)		7,073				3,101	10,174
TOTAL CATEGORY COSTS		35,030				15,358	50,388

330001/17000 RENDEL EXST BUILDING (7)

INSUL R-11 VINYL FACE	1.200 SF	.22	264	.005	6.000	20.910	125	389
INSUL R-19 VINYL FACE	850 SF	.34	289	.007	5.950	20.910	124	413

***** PROJECT TITLE: 881 HILLSIDE CARBON ABSORPTION OPT *****
 QUANT UNIT MATERIAL COST/UNIT TOTAL MTL COSTS TOTAL LABOR HOURS LABOR TOTAL COSTS RATE

QUANT	UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
FLOOR DRAIN W/PIPE	1 LS	800.00	800	8.000	8.000	26.740	214	1,014
STD 35/8 18G W/5/8GYP B SIDE	480 SF	1.42*	682	.035	26.400	20.910	552	1,234
GYPBD CEILING	200 SF	1.06	212	.080	16.000	20.910	335	547
COVE BASE 4" HIGH	60 LF	.45*	27	.025	1.500	20.910	31	58
TILE ASP C-B 1/8 ON CONC FLR	200 SF	.70*	140	.020	4.000	23.220	93	233
PAINT DRYWALL BRUSH INT P+2C	680 SF	.09*	61	.008	5.440	24.100	131	192
PAINT WINDOW DR DOOR P+2 C	130 SF	.12*	16	.021	2.730	24.100	66	82
>>>DIRECT COST			2,491		76		1,671	4,162
MISC LABOR & MATERIAL			2,605		84		1,838	4,443
BLDG FACTOR (10%)					92		2,022	4,627
MATL ESC (CC) 17 MONTHS			2,743					4,765
LABR ESC (CC) 17 MONTHS							2,129	4,872
CATEGORY SUBTOTAL			2,743		92		2,129	4,872
DVH-PFT-BND (25.3%)			694				539	1,233
TOTAL CATEGORY COSTS			3,437				2,668	6,105

330001/00000 MODIFY BLDG-ELEC & ALARMS
 (8)

BLDG POWER DISTRIBUTION	1 LS	5,000.00	5,000					5,000
LIGHTNING PROTECTION	1 LS	5,000.00	5,000					5,000
FIRE TELEPHONE STATION	1 EA	224.64*	225	2.000	2,000	25.370	51	276
WATCHTOHR TELEPHONE STATION	1 EA	199.68*	200	2.000	2,000	25.370	51	251
FC72-2-BCH-DCP DELUGE CONTRL	1 EA	655.00*	655	2.000	2,000	25.370	51	706
REMOTE FIRE ALARM INDIC RAI-2	1 EA	12.60*	13	.500	.500	25.370	13	26
WATER FLOW RISER DETECTOR	1 EA	70.00*	70	.500	.500	25.370	13	83
ION SMK DET CPD-7021/CPD-002	2 EA	56.87*	114	1.170	2,340	25.370	59	173
TELEPHONE	1 EA	50.00	50					50

***** PROJECT TITLE: 881 HILLSIDE CARBON ABSORPTION OPT *****

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	LABOR TOTAL COSTS	TOTAL MTL & LABOR COSTS
SPEAKER 8IN DUAL VOICE 5A451	11.33*	11	.650	.650	25.370	16	27
TRANSFORMER	5.46	5	.500	.500	25.370	13	18
PUBLIC ADDRESS HORN	37.86*	38	.250	.250	25.370	6	44
>>>DIRECT COST		11,381				273	11,654
BLDG FACTOR (10%)	27			12		300	11,681
MATL ESC (CC) 17 MONTHS	602	11,983					12,283
LABR ESC (CC) 17 MONTHS	16					316	12,299
CATEGORY SUBTOTAL		11,983		12		316	12,299
OVH-PFT-BND (25.3%)		3,032				80	3,112
TOTAL CATEGORY COSTS		15,015				396	15,411

330001/00000 NEW BLDG - PIPING/HVAC
(9)

FIRE PROT ORD HAZ	800 SF	2.61		2,088			2,088
PIPE BLK STL SCH 40 3/4"	60 LF	.72*	.100	6,000	26.740	160	203
3/4" BI FITTINGS	1 LB	50.00	8,000	8,000	26.740	214	264
INSTANTANEOUS WATER HEATER	1 LS	108.00	3,500	3,500	26.740	94	202
BINK SERVICE	1 EA	246.00	5,330	5,330	26.740	143	389
VALVES	1 LS	250.00	4,000	4,000	26.740	107	357
2" CI DRAIN PIPE	30 LF	2.98	.320	9,600	26.740	257	346
PAINT PIPES UP TO 4"D P+1 C	150 LF	.05*	.020	3,000	24.100	72	80
PIPE BLK STL SCH 40 1-1/2"	40 LF	1.52*	.135	5,400	26.740	144	205
PIPE BLK STL SCH 40 1"	230 LF	.97*	.100	23,000	26.740	615	838
ELBOW 90 BS 150# SCH 1"	16 EA	1.18*	.650	10,400	26.740	278	297
TEE BLK STL 150# SCH 1"	6 EA	1.76*	.970	5,820	26.740	156	167
INSULATION, 1" FBRL- 1" PIPE	300 LF	1.27*	.073	21,900	26.740	586	967
FIN TUBE HEATER W/THERMOSTAT	30 LF	26.70	.500	15,000	26.740	401	1,202

***** PROJECT TITLE: 881 HILLSIDE CARBON ABSORPTION OPT *****
 QUANT UNIT MATERIAL TOTAL MTL LABOR HRS TOTAL LABOR LABOR TOTAL LABOR TOTAL MTL &
 COSTS COSTS PER UNIT HOURS COSTS RATE COSTS LABOR COSTS

CATEGORY SUBTOTAL 106,585 106,585
 TOTAL CATEGORY COSTS 106,585 *****

370001/17000 SPEC FAC INSTL (11)	QUANT	UNIT	MATERIAL COSTS	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR TOTAL COSTS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
U/V PEROXIDE SYSTEM	1	LB	48.000	48.000	48.000	48.000	26.740	1.284	1.284	1.284
INDUCTOR ASSEMBLY	1	LB	16.000	16.000	16.000	16.000	26.740	428	428	428
ROUGHING FILTER	1	EA	10.700	10.700	10.700	10.700	26.740	286	286	286
FULFLO SEDIMENT FILTER	6	EA	10.700	64.200	64.200	64.200	26.740	1.717	1.717	1.717
CENTRIFUGAL PUMP, SHP	4	EA	10.000	40.000	40.000	40.000	26.740	1.070	1.070	1.070
TANK, CS, 15,000 GAL	3	EA	64.000	192.000	192.000	192.000	26.740	5.134	5.134	5.134
TANK, CS, 300 GAL	1	EA	5.300	5.300	5.300	5.300	26.740	142	142	142
INSTALL CARBON BINS	3	EA	2.000	6.000	6.000	6.000	26.740	160	160	160
PRESSURE INDICATOR	3	EA	770.00	2.310	7.000	21.000	26.740	562	562	2.872
LEVEL INDICATOR-SENSALL, 1 PT	3	EA	800.00	2.400	4.000	12.000	26.740	321	321	2.721
2" CS ADV	4	EA	1,500.00	6,000	3.000	12.000	26.740	321	321	6.321
1" CS ADV	2	EA	925.00	1,850	3.000	6.000	26.740	160	160	2.010
PLUG VALVE, 1" CS	7	EA	110.00	770	1.400	9.800	26.740	262	262	1.032
PLUG VALVE, 2" CS	23	EA	180.00	4,140	1.600	36.800	26.740	984	984	5.124
CONTROL PANEL FOR PUMPS/TANKS	1	LB	2,000.00	2,000	16.000	16.000	25.370	406	406	2.406
RKY FLT A CABLE BELDEN 9578	400	LF	.27*	108	.012	4.800	25.370	122	122	230
RKY FLT C CABLE BELDEN 9574	100	LF	.17*	17	.009	.900	25.370	23	23	40
CONDUIT, GRC 3/4"	500	LF	.76*	380	.100	50.000	25.370	1,267	1,267	1.647
2" UNDERGROUND CONDUIT	50	LF	1.90	95	.053	2.650	25.370	67	67	162
EXC, SM BCKHDE, CLASSC 3.9CF	13	CY	2.94*	38	.196	2.548	18.980	48	48	86

QUANT UNIT	MATERIAL COST/UNIT	TOTAL MTL COSTS	LABOR HRS PER UNIT	TOTAL LABOR HOURS	LABOR RATE	TOTAL LABOR COSTS	TOTAL MTL & LABOR COSTS
FILL, SAND, MACH PLACED	4 CY 8.00*	32	.159	.636	18.980	12	44
BACKFIL W/LOADR & COMPCT CLC	9 CY 3.36*	30	.313	2.817	18.980	53	83
25 PAIR CABLE	50 LF 2.53	128	.060	3.000	25.370	76	204
LEAK DETECTION	1 LB 1,000.00	1,000					1,000
EXC, 5N BCKHDE, CLASSC 3.9CF	200 CY 2.94*	588	.196	39.200	18.980	744	1,332
FILL, SAND, MACH PLACED	40 CY 8.00*	320	.159	6.360	18.980	121	441
BACKFIL W/LOADR & COMPCT CLC	160 CY 3.36*	538	.313	50.080	18.980	951	1,489
SELECT FILL MAT'L	160 CY 8.00	1,280					1,280
2" POLYPROPYLENE PIPE	500 LF 1.94	970	.050	25.000	26.740	669	1,639
TANK PAD	110 CY 105.00	11,550	2.000	220.000	22.490	4,948	16,498
>>>DIRECT COST		36,544		904		22,340	58,884
BLDG FACTOR (10%)	2,234			994		24,574	61,118
MATL ESC (CC) 17 MONTHS	1,933	38,477					63,051
LABR ESC (CC) 17 MONTHS	1,300					25,874	64,351
CATEGORY SUBTOTAL		38,477		994		25,874	64,351
OVH-PFT-BND (25.3%)		9,735				6,546	16,281
TOTAL CATEGORY COSTS		48,212				32,420	80,632

400000/00000 STANDARD EQUIPMENT (12)

CHAIR AND DESK	1 LS 760.00	760					760
FILE CABINET/SHELVES	1 LS 200.00	200					200
>>>DIRECT COST		960		0		0	960

***** PROJECT TITLE: 881 HILLSIDE CARBON ABSORPTION OPT *****
 QUANT UNIT MATERIAL TOTAL MTL LABOR HRS TOTAL LABOR LABOR TOTAL LABOR TOTAL MTL &
 COST/UNIT COSTS PER UNIT HOURS COSTS COSTS LABOR COSTS

CATEGORY SUBTOTAL 960 960

TOTAL CATEGORY COSTS 960 *****

>>> CONSTRUCTION MARKUP SUMMARY <<<

PROJECT: 881 HILLSIDE CARBON ABSORPTION OPT
 JOB: 986124/04

	MATERIAL COSTS	LABOR COSTS	TOTAL COSTS
	\$	\$	\$
TOTAL MISC LABOR & MATERIAL COSTS	1,171	1,893	3,064
TOTAL BLDG FACTOR COSTS	0	4,343	4,343
TOTAL RESPIRATOR COSTS	0	0	0
TOTAL FULL FACE COSTS	0	0	0
TOTAL SUPPLIED AIR COSTS	0	0	0
TOTAL SUBCONTRACT COSTS	0	0	0
TOTAL ESCALATION COSTS	10,182	2,528	12,710
TOTAL CPFF LABOR FRINGE COSTS	0	0	0
SUM TOTAL OF MARKUPS	\$ 11,353	\$ 8,764	\$ 20,117
TOTAL DIRECT COSTS	192,270	41,547	233,817
SUBTOTAL	\$ 203,623	\$ 50,311	\$ 253,934
TOTAL OVH-PFT-BND COSTS	24,309	12,729	37,038
TOTAL CPFF OVERHEAD COSTS	0	0	0
TOTAL CPFF FEE COSTS	0	0	0
TOTAL CONTRACT COSTS	\$ 227,932	\$ 63,040	\$ 290,972

ED&I (AS CONTAINED IN THE BODY OF THE ESTIMATE)		347,261	638,233
ADDITIONAL CONST. INSP. & APPROX 3.0% OF ITEMS C, D, & E.		8,729	646,962
CONTINGENCY & APPROX 21 % OF ALL OTHER COSTS.		133,038	780,000

JOB: 986124/04
DATE: 02/26/88

*** ESTIMATED COST SUMMARY ***

PROJECT: 881 HILLSIDE CARBON ABSORPTION OPT

A. ENG. DESIGN AND INSP.-----\$ 355,990

ED&I @ 12% OF ITEMS C, D, & E.

ENGR. TITLE I-----\$ 87,514

ENGR. TITLE II-----\$ 188,289

ENGR. TITLE III-----\$ 71,458

CONSTRUCTION INSPECTION-----\$ 8,729

B. LAND AND LAND RIGHTS-----\$ 0

C. CONSTRUCTION COSTS-----\$ 290,012

(1) IMPROVEMENTS TO LAND-----\$ 0

(2) BUILDINGS-----\$ 36,315

(A) NEW-----\$ 36,315

(B) MODIFICATIONS-----\$ 0

(3) OTHER STRUCTURES-----\$ 0

(4) SPECIAL FACILITIES-----\$ 187,217

(5) UTILITIES-----\$ 66,480

(6) PROJECT & CONSTRUCTION MGMT-----\$ 0

D. STANDARD EQUIPMENT-----\$ 960

E. REMOVAL COST LESS SALVAGE-----\$ 0

F. CONTINGENCY @ APPROX 21%-----\$ 133,038
OF ALL OTHER COSTS.

G. TOTAL ESTIMATED COST (TEC)-----\$ 780,000