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FLUOR

June 30, 2003

Fernald Closure Project
Letter No. C:CONT(CA/PC):2003-0067

Mr. Robert J. Bell, Contracting Officer
Acquisition and Asset Management
Department of Energy
Fernald Closure Project
P. O. Box 538705
Cincinnati, Ohio 45253-8705

Dear Mr. Bell:

CONTRACT DE-AC24-01OH20115, COMPREHENSIVE GROUNDWATER STRATEGY

Pursuant to Section J, Attachment 3 – Reporting Requirements, General Management section, of the subject contract, enclosed for your approval is the Comprehensive Groundwater Strategy report. The report contains twelve alternatives for your review regarding the ongoing groundwater restoration program at the Fernald Closure Project (FCP).

Alternative 1 is in the current baseline and is compliant with the subject contract and regulatory requirements. All other alternatives would require DOE to obtain substantial regulatory relief. The report identifies the date by which regulatory relief is required for each alternative. If regulatory relief for the selected alternative is not achieved by the applicable date, Fluor Fernald, Inc. (Fluor Fernald) will continue to implement Alternative 1 unless otherwise directed by DOE. DOE direction to implement an Alternative for which regulatory relief has not been achieved by the applicable date will seriously impact achievement of site closure, for which Fluor Fernald will pursue a request for equitable adjustment.

Fluor Fernald recognizes that DOE's goals are to achieve Site Closure by 2006 or sooner and implement a groundwater restoration program with the lowest life-cycle costs. However, depending on the Alternative, a lower life-cycle cost could negatively impact a 2006 Site Closure because of higher operational risk of not being able to handle unexpected wastewater stream quantities or durations. Fluor Fernald recommends further discussions with DOE concerning life-cycle costs, impacts to 2006 Site Closure, expectations of successful regulatory relief, etc., associated with the various Alternatives.

As noted in the report, groundwater remediation will not be completed by 2006 under any Alternative. Consistent with the subject contract, Fluor Fernald will submit a declaration of completion when all other work required by the subject contract is complete regardless of the status of groundwater remediation.

Approval of this report and selection of an Alternative is requested by July 30, 2003. If you have any questions, please contact Dennis Carr at 648-3799 or me at 648-4425.

Sincerely,

Adam W. Rector

Adam W. Rector, Manager
Prime Contract

AWR:awr
Enclosure

c: w/o Enclosure
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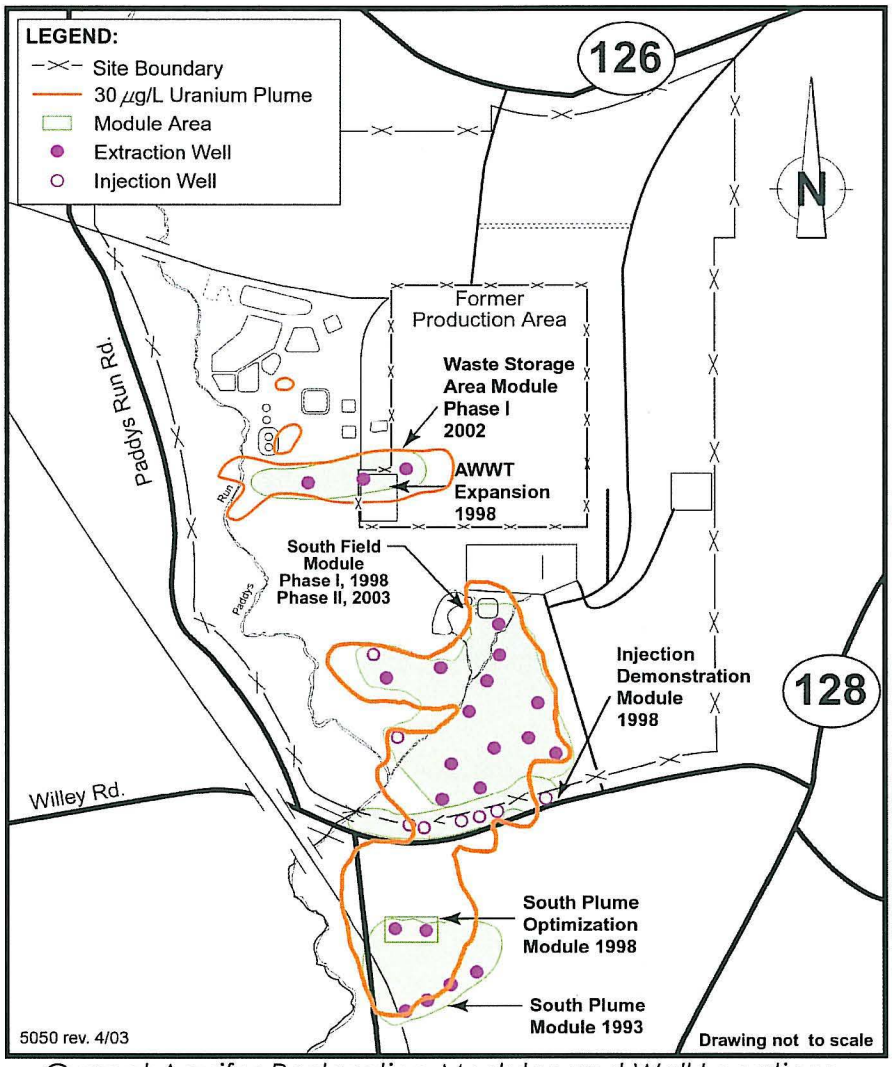
Dennis Sizemore, MS40
Loraine D. Tipton, MS41
DOE Records Center, #FE-BTAS
File Record Subject: Groundwater Strategy
Administrative Record, MS6

FERNALD
Closure Project

June 30, 2003



Current Aquifer Restoration Modules and Well Locations

COMPREHENSIVE GROUNDWATER STRATEGY REPORT

Submitted by Fluor Fernald, Inc.

51900-RP-0001, Final, Rev. 0

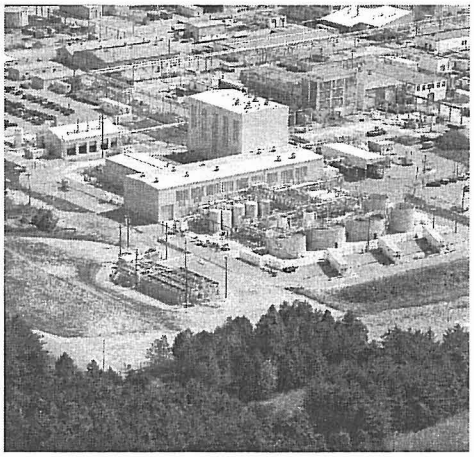
EXECUTIVE SUMMARY

This report fulfills a contractual requirement specified in modifications (Section J, Attachment 3) to Flour Fernald, Inc.'s prime contract, which became effective March 29, 2003. The requirement for the Comprehensive Groundwater Strategy Report is further clarified in Section C.1.2 End State: "In order to achieve Site Closure, the following activities including all Contract and Statement of Work requirements, shall be completed: All the work required by the five approved Records of Decision (RODs) including approved changes. In the event that groundwater remediation has not been achieved by December 31, 2006, or sooner if all other work is completed, the Contractor shall implement a groundwater remediation approach that results in the most cost effective infrastructure remaining at site closure and is consistent with the Comprehensive Groundwater Strategy (ref. Section J, Attachment 3)."

The Fernald Closure Project (FCP) is on a path to closure by June 2006. With the exception of groundwater remediation, all remedial actions at the site are scheduled to be complete by June 2006. Based on the aquifer response to the aggressive restoration efforts completed to date and the refined groundwater modeling performed in support of this report, groundwater restoration will extend beyond June 2006. In light of the anticipated continuation of groundwater restoration remedy beyond Site Closure, this report provides the U.S. Department of Energy (DOE) with various alternatives regarding the ongoing groundwater restoration program at the FCP. The report analyzes twelve groundwater alternatives with respect to duration, water treatment needs, life cycle costs, contract compliance, and regulatory impact.

Alternative 1 is in the current baseline and is compliant with the contract and regulatory requirements. All other alternatives would require DOE to obtain substantial regulatory relief. The report identifies what regulatory relief is required and when it is required for each alternative. If regulatory relief for the selected alternative is not obtained by the applicable date, Fluor Fernald, Inc. will continue to implement Alternative 1 unless otherwise directed by DOE. DOE direction to implement an alternative for which regulatory relief has not been achieved by the applicable date will seriously impact achievement of site closure, for which Fluor Fernald, Inc. will pursue a request for equitable adjustment.

It is recognized that DOE's goals are to achieve site closure by 2006 and implement a groundwater restoration program with the lowest life cycle costs. However, depending on the alternative, a lower life cycle cost could negatively impact a 2006 Site Closure because of the higher operational risk of not being able to accommodate unexpected wastewater stream quantities or durations. Fluor Fernald Inc. recommends further discussions with DOE concerning life cycle costs, impacts to 2006 site closure, and expectations of success in obtaining regulatory relief associated with the various alternatives.



1.0 INTRODUCTION

1.1 Purpose of Report

This report fulfills a contractual requirement specified in modifications (Section J, Attachment 3) to Flour Fernald, Inc's. prime contract which became effective March 29, 2003. The requirement for the Comprehensive Groundwater Strategy Report is further clarified in Section C.1.2 End State: "In order to achieve Site Closure, the following activities including all Contract and Statement of Work requirements, shall be completed: All the work required by the five approved Records of Decision (RODs) including approved changes. In the event that groundwater remediation has not been achieved by December 31, 2006, or sooner if all other work is completed, the Contractor shall implement a groundwater remediation approach that results in the most cost effective infrastructure remaining at site closure and is consistent with the Comprehensive Groundwater Strategy (ref. Section J, Attachment 3)."

The Fernald Closure Project (FCP) is on a path to closure by June 2006. With the exception of groundwater remediation, all remedial actions at the site are scheduled to be complete by June 2006. Since groundwater restoration will extend beyond June 2006, this report provides the U.S. Department of Energy (DOE) with various alternatives regarding the ongoing groundwater restoration program at the FCP. The report analyzes twelve groundwater alternatives with respect to duration, water treatment needs, life cycle costs, contract compliance, and regulatory impact.

1.2 Report Organization

The remainder of the report is organized as follows:

- Section 1.3 identifies regulatory commitments pertaining to groundwater and wastewater
- Section 1.4 provides the current status of aquifer restoration
- Section 2.0 provides the descriptions and comparison of alternatives
- Section 3.0 provides conclusions of the report
- Appendix A provides more detailed information on 1) the groundwater modeling conducted in support of this report (Appendix A, Attachment A.1), and 2) how future uranium concentrations in the extraction wells were estimated for the purposes of determining when treatment will no longer be required to meet uranium discharge limits (Appendix A, Attachment A.2)
- Appendix B provides more detailed information on how the cost estimates were generated

1.3 Groundwater and Wastewater Regulatory Commitments

Regulatory commitments pertaining to groundwater, wastewater and treatment of the site's discharges have been established in the following documents:

- OU5 Record of Decision (OU5 ROD), January 1996
- OU5 Remedial Design Work Plan, August 1996
- OU5 Remedial Action Work Plan, June 1997
- Baseline remedial strategy report, remedial design for aquifer restoration, June 1997 (BRSR)
- Operations and Maintenance Master Plan for the aquifer restoration and wastewater project, December 1999 (OMMP)

The following are the groundwater restoration commitments specified in the OU5 ROD:

- Restore Great Miami Aquifer through extraction methods.
- Pump & treat up to 27 years to fully attain the final remediation levels.
- Examine enhancement techniques during Remedial Design (Reinjection - Will be applied only with the specific approval of EPA). Extract contaminated groundwater until final remediation levels are attained at all points. Collect recovered groundwater for treatment and/or discharge to the Great Miami River or reinjection (if deemed appropriate).

The following commitments for storm water and wastewater are also specified in the OU5 ROD:

- Maintain a storm water collection system which includes conveyance systems and retention basins.
- Prevent contaminated storm water from entering the SSOD and Paddys Run.
- Continue to operate this system (collection, conveyance, and retention systems) until soil final remediation levels are attained on a site-wide basis or until jointly deemed unnecessary by DOE and EPA.
- Collect and treat, as required, wastewater generated during the conduct of remedial actions at all FEMP operable units.
- The OU5 ROD also listed the commitments for the treatment of discharges as follows:
- Construct and operate the treatment facilities necessary to attain discharge limits to the Great Miami River.

- Treat storm water, wastewater and groundwater in existing and expanded facilities such that the monthly average concentration in the combined discharges to the river do not exceed the final remediation levels for surface water in Paddys Run or the Great Miami River.
- Treat such that the total mass and blended effluent concentration of uranium discharged to the River does not exceed 600 pounds per year.
- Treat highest concentration streams first to minimize the concentration and mass of uranium in the blended effluent discharged to the River. Treat wastewater, storm water and groundwater to ensure that the maximum concentration of total uranium in the blended effluent to the River does not exceed 30 ppb based upon a monthly average concentration. Expand the AWWT facility within the confines of existing Building 51. This expansion will have a minimum additional design capacity of 1800 gpm.

The above noted uranium discharge limits to the river were adopted during development of the OU5 ROD based on 1995 projections (Note that the discharge limit was revised in November 2001 to reflect the 30 ppb final drinking water MCL for uranium). In general the 1995 projections indicated that, for the groundwater extraction/reinjection scenarios evaluated, a 20 ppb concentration limit and a 600 pound annual mass limit for uranium could be attained under average operating conditions. DOE projected that continuous attainment with these limits could not be assured for periods of exceptional operating conditions.

Discussions at that time centered on the basis for imposing a 20 ppb total uranium discharge limit as a provision of the ROD. It was recognized that the application of such a limit was not being considered as a required component of the remedy necessary to ensure protectiveness. EPA considered such a limit an appropriate performance-based requirement that appeared to be reasonably attainable for all groundwater extraction/reinjection scenarios that were under consideration through the application of a demonstrated wastewater treatment technology at a sensible level. It was recognized that such a limit, being performance-based, would need to accommodate the exceptional operating conditions reasonably anticipated to occur over the duration of the remedial action.

In consideration of EPA's and OEPA's desire for such a concentration-based limit to be applied as part of the remedy, DOE agreed to adopt such a limit coupled with the following modifying considerations:

The FEMP will be allowed to by-pass storm water directly from the retention basin to the river for up to 10 days per year to accommodate periods of significant precipitation. The intent of allowing these direct by-passes to occur is to provide the relief needed to accommodate periods of precipitation that exceed retention and treatment capacities. The uranium concentration in the blended discharge during these 10 days will be considered in the 600 pound per year mass-based limit, but will not be included in the monthly averaging for purposes of demonstrating compliance with the 20 ppb concentration-based limit. Uranium concentrations in the effluent discharged to the river for these 10 days will not permit exceedance of the final remediation level (530 ppb total uranium outside the mixing zone) for the river. Notification will be provided to EPA and OEPA within seven days of the implementation of such a by-pass.

The FEMP will be allowed periods of significantly reduced treatment plant operation to accommodate scheduled maintenance activities. The uranium concentration in the blended discharge during these periods will be considered in the 600 pound per year mass-based limit. EPA approval will be obtained in advance when notification of these planned maintenance periods is accompanied by a request to not include the uranium concentration in the discharge in the monthly averaging conducted for demonstrating compliance with the 20 ppb limit.

The following additional commitments regarding groundwater restoration and water treatment were made in the OU5 Remedial Design or Remedial Action Work Plans:

- Prepare a BRSR – evaluate 25, 15, 10 and 7.5 year aquifer restoration scenarios
- Develop an OMMP for aquifer restoration and water treatment – "living guidance document"
- Established design, construction, and start-up schedules for:
  - Aquifer restoration modules
  - AWWT expansion
- Specified 10-year aquifer restoration timeframe as preferred based on:
  - Short–term capital versus
  - Longer-term operational costs

The following contingencies regarding the aquifer cleanup time were specified in the OU5 Remedial Action Work Plan:

- There are uncertain hydraulic and geochemical constraints in the aquifer, such as: Hydraulic capacity; Distribution coefficient, K_d; Localized recalcitrant zones
- The need to minimize hydraulic impacts at neighboring properties adjoining the FEMP
- Injection rate and quality.
- Timely surface access for aquifer restoration modules.
- It is not possible to provide specific date for completion of the aquifer restoration remedial action
- Modeling projections and uncertainty analyses indicated that it could be feasible to restore the aquifer within 10 years,
  - With an estimated range of cleanup time (due to uncertainties) of eight to 20 years (Draft BRSR)

Regarding the dismantlement and final disposition of the Advanced Wastewater Treatment (AWWT) Facility, the following commitments were made in the OU5 RA Work Plan:

- Will occur when treatment of FEMP wastewaters is no longer necessary.
- Dependent upon completion of site activities for projects under the other operable units
  - Contaminated stormwater, perched groundwater, process water, decontamination rinsates, and leachate (from the OSDF).
  - During post-remedial operation and maintenance, unknown quantities of leachate from the OSDF will be generated which may require treatment.
  - Continued use of the AWWT Facility is a post-remedial operation and maintenance activity - independent of the completion of aquifer restoration.

The following groundwater treatment commitments were made in the BRSR and in the OMMP:

- A dedicated groundwater treatment capacity of at least 2000 gallons per minute (gpm) will be available
- Additional treatment capacity beyond the 2000 gpm dedicated capacity may be available during dry seasons or when the other remediation-related wastewater flows decrease.

1.3.1 Meeting the Water Treatment Needs

The following summarizes the prioritized water treatment needs and schedules based on the current closure baseline submittal (currently undergoing DOE review):

1) OSDF leachate to be treated for the life of the Facility – up to 1000 years as needed. The flow is expected to be <10 gpm after March 2006 when the caps will be on all 8 cells and the storm water can be directed to free release. From now until April 1, 2006 the combined OSDF leachate and storm water treatment needs will be 200 to 300 gallons per minute for peak storm flows. These flows need to be drained from the cells as quickly as possible so that the head on the liner is minimized as per OSDF design requirements.

2) Other Remediation Wastewater streams: These flows consist of water from the WPRAP project, from soil excavations in areas where volatile organic contamination is suspected and from the Silos Project. The WPRAP peak flows are on the order of 200 gpm and will end by September 2004 when pit excavation is complete. The flow from soil excavations is anticipated to be 50 gpm or less and will end when soil excavation is complete in the Former Production Area in March 2005. The silos wastewater and D&D water is anticipated to be <10 gpm and will end when those activities are compete in March 2006.

3) The sewage treatment plant: This facility will be shutdown in June 2005. Until then flows are expected to average 30 gpm with a uranium concentration of <200 ppb.

4) Storm water: This need consists of flows from controlled areas where soil remediation/certification is not yet completed. The current peak treatment need is on the order of 800 gpm. This peak need will decline in steps as soil remediation and certification proceed and area-specific storm flows can be free released to the Storm Sewer Outfall Ditch or Paddys Run without treatment. According to the above noted requirements, storm water can be free released after soil certification as long as the uranium concentration is below the surface water FRL for uranium (530 ppb). By end of March 2005 it is anticipated that the peak storm water treatment need will be on the order of 200 gallons per minute and the need will end in December 2005, when all soil remediation is scheduled to be complete.

5) Groundwater: For groundwater, the FCP is required to maintain a minimum treatment capacity of 2000 gallons per minute (gpm) until EPA approves a lower capacity. For groundwater re injection, source water requirements are 1400 gpm of treated groundwater. This capacity is required until EPA approves shut down of reinjection (2009 per approved South Field Phase II design).

The following identifies the currently available treatment facilities required to meet the regulatory commitments:

- For Groundwater:
  - AWWT Phase III (1800 gpm)
  - SPIT (200 gpm)
- For Storm Water:
  - AWWT Phase I (500 gpm)
  - IAWWT (300 gpm)
- For Remediation Wastewater:
  - AWWT Phase II (300 gpm)

1.3.2 Impacts of the Regulatory Commitments on the Various Alternatives

As noted above the there are numerous regulatory commitments related to the groundwater and wastewater. These commitments are being accommodated by the current aquifer restoration and water treatment approach that is provided for in the current closure baseline submittal. If DOE chooses an alternative that is different from the currently compliant approach, then regulatory relief will be required as a Government Furnished Service or Item (GFSI). All alternatives that require a higher level of funding than the currently compliant approach will require an equitable adjustment to avoid cost and schedule impacts.

1.4 Current Status of Aquifer Restoration

Groundwater restoration at the FCP has proceeded in accordance with the commitments noted in Section 1.2. All major groundwater restoration modules are in place with the exception of the Waste Storage Area Phase II Module. To date, the planned groundwater restoration infrastructure has been installed and has become operational on or ahead of schedule. The groundwater pumping rates have been maximized to the degree possible within the constraints imposed by the uranium discharge limits to the Great Miami River (established in the OU5 ROD). As a result of the aggressive pumping, the site is ahead of schedule with respect to volume of groundwater pumped, amount of uranium removed from the aquifer, and the amount of groundwater treated – all of which are key performance measures outlined in the BRSR.

The FCP is behind schedule on one performance measure, groundwater re-injection. The schedule for re-injection has not been met due to residual plugging of the injection wells that became apparent during operation in the year 2000. A solution has subsequently been found and all the required property boundary injection wells are now operational. The FCP has also experienced higher than planned uranium concentrations in treatment plant effluents and in water that bypasses treatment, which at times has resulted in the need to reduce groundwater pumping rates in order to maintain compliance with uranium discharge limits.

Although the volume of groundwater pumped and the uranium removal are ahead of the schedule established in the 1997 BRSR, it has become apparent that the desired groundwater restoration completion schedule (Aquifer Restoration complete by 2006) is not being achieved (i.e., uranium concentrations in the aquifer remain higher than modeled and substantially more uranium mass is being removed from the aquifer than anticipated in the 1997 BRSR). Since the desired schedule is not being achieved, additional evaluation of the uranium soil/water partitioning co-efficient (K_d), a key groundwater modeling parameter, has been undertaken in an effort to provide better estimates of when aquifer restoration will be complete. Refinements to the uranium K_d are based on uranium leaching experiments conducted on Fernald Site aquifer sediments by Sandia National Laboratory in 2002 and early 2003. The final report on the leaching experiments was received at the FCP in April 2003. The results of the experiments indicate the uranium K_d is somewhat higher (2.5 L/Kg vs 1.78 L/Kg) than that used in previous groundwater modeling at the FCP.

A conservative upper bound K_d of 3.0 L/kg was used in all the groundwater modeling runs conducted for this report (Appendix A, Attachment A.1). While the actual (true) K_d value in the aquifer is unknown, the best available information suggests the 3.0 K_d value, assumed to represent aquifer conditions for this study is conservative. The modeling results using the conservative K_d will indicate the time required to reach the uranium cleanup level will be substantially longer than the best case estimates of 10 years noted in the BRSR. The current conservative modeling results still predict groundwater clean up times within the 27 year range predicted in the OU5 ROD for many of the alternatives provided in this report.

2.0 Description and Comparison of Alternatives

This section provides summary level descriptions and comparisons of the 12 alternatives evaluated for the report. Also included for each alternative are the objectives, contract compliance status, regulatory relief required, schedule (including the schedules for new or enhanced facilities where appropriate), and life cycle costs.

2.1 Key Features of the Alternatives

Table 2-1 provides a summary overview of many of the features and assumptions pertaining to each alternative for comparative purposes. Table 2-2 provides the estimated annual and lifecycle costs for each alternative. Table 2-3 identifies the major activities contributing to the cost by year, for each alternative. Cost estimates for all alternatives were completed using constant 2003 dollars with no escalation. Figure 2-1 provides the project schedule for those alternatives that require construction of new facilities or upgrades to existing facilities.

Table 2-1
Alternative and Assumptions

Alternative	Required Regulatory Relief						Water Treatment Post April 1, 2005			Disposal Of Treatment Facilities
	530 ppb and No Mass Limit at Out Fall By 4/1/05	Stop Carbon Treatment of OSDF Leachate By 4/1/05	OSDF Cell 8 Temporary Cover By 12/31/05	Reduce Treatment Capacity By 4/1/05	Stop GW Injection By 4/1/05	Reduce GW Pumping Rate By 4/1/05	AWWT	Enhanced 800 gpm SPIT/AWWT With Carbon Filter	New Mobile 800 gpm Treatment Units	
1							X			OFF SITE
2			X				X			OSDF
2A& 2B			X	X	X	X	Reduced			OSDF
3 & 3B				X	X	X		X		OFF SITE
4 & 4B			X	X	X	X		X		OSDF
5 & 5B				X	X	X			X	OFF SITE
6	X	X		X	X	X				OSDF
7	X	X		X	Reduced	X			X	OFF SITE

Overall Key Assumptions:

- ❑ Install groundwater recovery wells as currently planned for all alternatives.
- ❑ Use the same more aggressive pumping and injection rates and schedule for Alternatives 1, and 2.
- ❑ Use the same reduced pumping rates and schedule with no re-injection after 4/01/05 for Alternatives 2A, 2B, 3, 3B, 4, 4B, 5 and 5B.
- ❑ Use a reduced pumping rate and schedule with no re-injection after 4/01/05 for Alternative 6.
- ❑ Use an aggressive pumping and injection rate considering the constrained treatment capacity for Alternative 7.
- ❑ Design of the new/enhanced facilities must begin by 10/03 so the facilities will be operational by 12/31/04 (Alternatives 3, 4, 5, and 7).

Specific Assumptions For Alternatives 2A, 2B, 3, 3B, 4, 4B, 5, 5B

- ❑ Maintain the designated groundwater treatment facility/capacity until the outfall limits can be satisfied without treatment (end of 2011 for Alternatives 2A, 3, 4, and 5 – end of 2006 for Alternatives 2B, 3B, 4B, and 5B).
- ❑ No standby groundwater treatment capacity afterward (may need regulatory relief).
- ❑ Shutdown all other treatment facilities by 4/1/05 and D&D by 12/31/05.
- ❑ OSDF leachate will be trucked to a metropolitan wastewater treatment plant (MWWTP) or be treated in a small carbon filtration unit after March 2006.

Specific Assumptions For Alternatives 6 and 7:

- ❑ All existing treatment facilities will be shutdown by 4/1/05 and D&D by 12/31/05.
- ❑ Impacted storm water will be pumped directly to GMR between 4/1/05 and 3/31/06.
- ❑ OSDF leachate will be trucked to MWWTP after the groundwater pumping operation is completed.

2.2 Alternative Summaries

Alternative 1 – Currently Compliant Groundwater Restoration Remedy

Description: Continue operating the AWWT facility until minimum life-cycle costs are achieved. Decontaminate and demolish (D&D) the facility and underlying soil and dispose of the D&D waste off site (estimated to be 70,000 cubic yards of soil and 15,000 cubic yards of debris), since the D&D activity is projected to occur after 2006 capping and closure of the on-site disposal facility. Other wastewater treatment units (SPIT and IAWWT) will be D&D according to the current 2006 baseline schedule.

Objectives: This alternative represents the "base case" alternative for comparison, and requires no regulatory relief from Record of Decision requirements. This alternative is currently represented in the Fernald Closure Project 2006 baseline submittal.

Contract Compliance Status: This is the only alternative whose life-cycle costs are the result of complying with existing standards and Record of Decision obligations and approved changes. This alternative is therefore the only alternative that is compliant with Section C.1.2 the Fernald Closure Contract. Key Record of Decision based requirements that are currently part of the compliant remedy are: Outfall discharge limits of 600 lbs/yr (mass limit) and 30 parts per billion (concentration limit) for uranium; carbon treatment of all remediation wastewaters and On-site Disposal Facility leachate; use of re-injection to enhance the groundwater restoration remedy; use of the expanded AWWT treatment capacity; and groundwater extraction rates and expected cleanup times that are consistent with the 1997 Groundwater Baseline Remedial Strategy Report. The use of the multi-layer final cover on the On-Site Disposal Facility at facility shutdown is an EPA-based Remedial Design requirement for the facility (i.e., temporary or interim caps are currently not allowed by EPA if the facility is shut down for more than one year).

Regulatory Relief Required as Government Furnished Services and Items (GFSI): None necessary.

Schedule: Current groundwater modeling indicates that the groundwater final remediation level (FRL) for uranium (30 µg/L) would be achieved site wide by 2021 with the off-property portion of the South Plume falling below the FRL in 2013.

Life Cycle Costs: The estimated life cycle cost for this alternative is $167.8 million with the estimated cost through the June 30, 2006 target closure date $27.2 million. The total yearly and life cycle costs for all alternatives are provided in Table 2-2. The major activities contributing to the annual cost for all alternatives are provide in Table 2-3. More detailed information on the life cycle cost estimates is provided in Appendix B.

Alternative 2 – Same as Alternative 1, but with Future On-site Disposal of AWWT D&D Waste

Description: Same as Alternative 1, except the D&D waste will be disposed of on-site in the On-site Disposal Facility (at a future date after 2006 disposal facility closure), through the use of an agency-approved partial interim cap on Cell 8. The interim cap will bridge the time required after 2006 to achieve minimum life-cycle costs associated with the groundwater remedy.

Objectives: Same objectives as Alternative 1 where life cycle costs reflect maintaining a groundwater remedy compliant with the regulatory commitments identified in Section 1.2 (i.e., meeting current outfall discharge limits, maintaining the full treatment capacity of AWWT, and employing reinjection to enhance the groundwater remedy), but takes advantage of the lower costs of on-site disposal of D&D wastes, provided regulatory relief can be obtained to utilize the interim cap. This alternative was developed because EPA approval of an interim cap may be more palatable to the agency in the event they will not agree to revise the outfall discharge limits as required by Alternatives 6 and 7 below.

Contract Compliance Status: This alternative is not contractually compliant with Section C.1.2 of the Fernald Closure Contract, since relief is necessary from current obligations (to permit use of interim cap). The alternative is not viable until DOE obtains such relief.

Regulatory Relief Required as GFSI: EPA approval to employ an interim cap on Cell 8 of the On-site Disposal Facility. Key Date for relief: needs to be obtained by December 31, 2005 as the last possible date to hold the 2006 baseline schedule.

Schedule: Current groundwater modeling indicates that the groundwater final remediation level (FRL) for uranium (30 µg/L) would be achieved site wide by 2021 with the off-property portion of the South Plume falling below the FRL in 2013.

Life Cycle Costs: The estimated life cycle cost for this alternative is $136.4 million with the estimated cost through the June 30, 2006 target closure date $24.2 million. This alternative was estimated to cost $31.4 million less than the base case (Alternative 1) due to the difference in costs between on- and off-site disposal of the AWWT and associated soils. The total yearly and life cycle costs for all alternatives are provided in Table 2-2. The major activities contributing to the annual cost for all alternatives are provide in Table 2-3. More detailed information on the life cycle cost estimates is provided in Appendix B.

Alternatives 2A and 2B – Reduced Post-Closure Groundwater Treatment Capacity Supplied by the AWWT System, With Future On-site Disposal of D&D Waste

Description: Same as Alternatives 4 and 4B, except the AWWT will supply the reduced treatment capacity.

Objectives: These alternatives permit the same comparison between Alternatives 2A/2B, 3, 4, and 5, but considering the use of the existing AWWT facility to meet a reduced treatment capacity without the need for the facility enhancements (SPIT/IAWWT) or new construction specified in Alternatives 3, 4, and 5.

Contract Compliance Status: This alternative is not contractually compliant with Section C.1.2 of the Fernald Closure Contract, since relief is necessary from current Record of Decision obligations (reducing treatment capacity, operating the groundwater system at lower extraction rates, discontinuing reinjection, extending the groundwater cleanup schedule beyond current plans, and use of an interim cap on Cell 8). The alternative is not viable until DOE obtains such relief.

Regulatory Relief Required as GFSI: Same as Alternative 3, 4 and 5, plus the need for use of the interim cap on Cell 8. Same key dates as above.

Schedule: Same as Alternatives 3, 4, and 5.

Life Cycle Costs: The estimated life cycle costs for Alternatives 2A and 2B are $109.4 and $100.0 million respectively. The estimated costs through the June 30, 2006 target closure date are $23.3 million for both Alternatives 2A and 2B. More detailed information on the life cycle cost estimates is provided in Appendix B.

Alternative 3 & 3B – Reduced Post-Closure Groundwater Treatment Capacity Supplied by SPIT and IAWWT System, With Future Off-site Disposal of D&D Waste

Description: Continue operating the AWWT facility until March 31, 2005, and then begin the D&D process in order to place the AWWT facility D&D waste into the On-site Disposal Facility per the 2006 closure schedule. Keep the SPIT and IAWWT facility for remaining remediation wastewater and storm water needs, and groundwater treatment needs (including post 2006 groundwater treatment needs). Enhance as necessary to meet remaining storm water and remediation wastewater treatment requirements. Operate the SPIT and IAWWT facility until minimum life-cycle groundwater restoration costs are achieved, while meeting existing mass and concentration discharge limits. Once the SPIT and IAWWT facility is no longer needed (post-2006), D&D the facility and dispose of the D&D waste off site (estimated to be 5,000 cubic yards). The only difference between Alternatives 3 and 3B is the date when SPIT/IAWWT are no longer needed to meet uranium discharge limits. For Alternative 3 the no treatment required date is at the end of 2011 and was conservatively estimated based on the 95% upper confidence limit decline curve data from the extraction wells. For Alternative 3B (and all other "B" alternatives) the no treatment required date is at the end of 2006 and was estimated based on actual decline curve data from the extraction wells. The details concerning the estimation of the treatment needs to meet discharge limits are provided in Appendix A, Attachment A.2

Objectives: These alternatives permit the closure of the AWWT facility and restoration of the affected footprint in time to meet the 2006 on-site disposal date. It does not permit continued aggressive restoration of the groundwater plume at existing flow, treatment, and reinjection rates, since the additional treatment capacity of the AWWT is no longer available beyond March 31, 2005. Agency approval will be necessary to discontinue reinjection and operate the overall groundwater system at lower extraction rates (governed by SPIT and IAWWT treatment capacity), which will prolong the post-2006 groundwater restoration schedule. This alternative reduces the amount of D&D debris requiring off-site disposal after 2006 compared to Alternative 1 (estimated 70,000 cubic yards of soil and 15,000 cubic yards of debris for Alternative 1; estimated 5000 cubic yards total for Alternative 3).

Contract Compliance Status: This alternative is not contractually compliant with Section C.1.2 of the Fernald Closure Contract, since relief is necessary from current Record of Decision obligations (reducing treatment capacity, operating the groundwater system at lower extraction rates, discontinuing reinjection, and extending the groundwater cleanup schedule beyond current plans). The alternative is not viable until DOE obtains such relief.

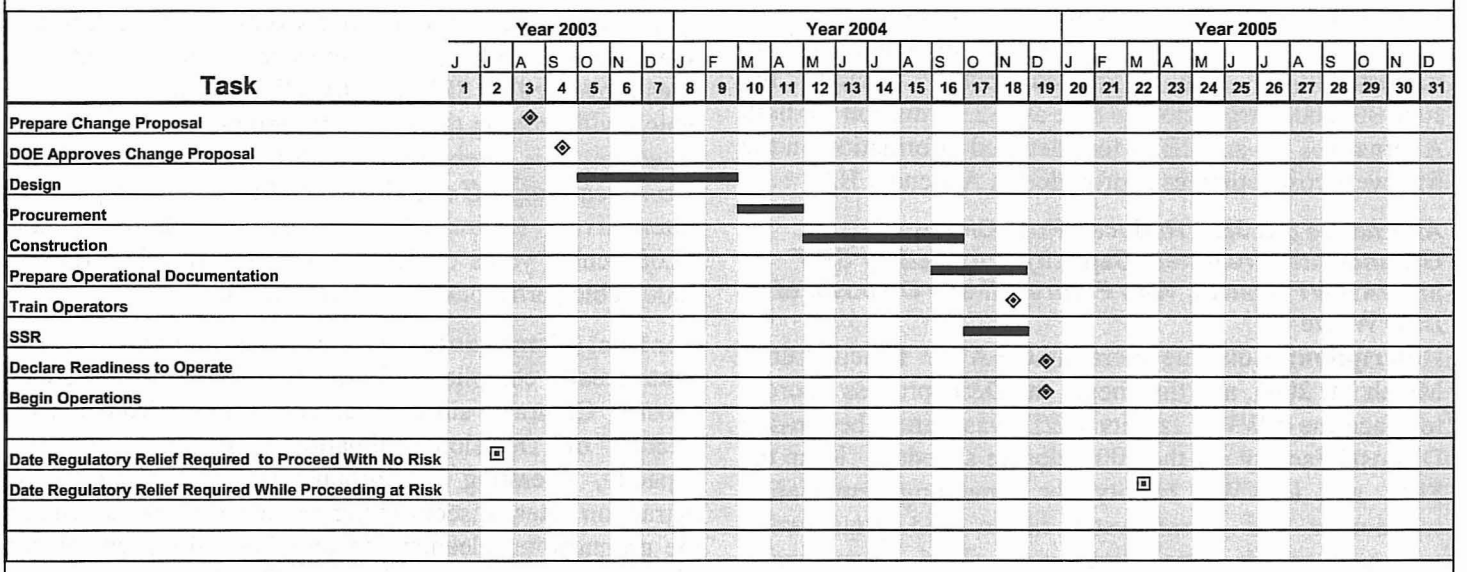
Regulatory Relief Required as GFSI: EPA approval to operate water treatment and groundwater pumping systems at the lower performance rates over the long term, and approval to discontinue reinjection. Key date for relief as last possible date: April 1, 2005.

Schedule: Current groundwater modeling indicates that the groundwater final remediation level (FRL) for uranium (30 µg/L) would be achieved site wide by 2026 with the off-property portion of the South Plume falling below the FRL in 2016. As noted above, to meet discharge limits groundwater treatment would be required until the end of 2011 (Alternative 3) or the end of 2006 (Alternative 3B) depending on the extraction well uranium concentration decline curves used. As shown in Figure 2-1, the design for the enhancements to SPIT/IAWWT must begin by October 2003 to meet a start-up date of December 2004 for the enhanced facility.

The December 2004 start-up date is required so that the enhanced facility can be operated in tandem with the AWWT to ensure the facility can perform as designed prior to the shut down of AWWT on April 1, 2005. Also shown in Figure 2-1, the regulatory relief required in 2005 must be granted by the EPA by August 2003 in order to proceed with no risk. DOE would be at risk by proceeding with the needed SPIT/IAWWT enhancements prior to EPA granting the regulatory relief noted above.

Life Cycle Costs: The estimated life cycle costs for Alternatives 3 and 3B are $110.0 and $100.8 million respectively. The estimated costs through the June 30, 2006 target closure date are $32.4 million for both Alternatives 3 and 3B. More detailed information on the life cycle cost estimates is provided in Appendix B.

Figure 2-1
Project Schedule For New Construction
Alternatives 3, 4, 5, and 7



Note: Alternatives 3 and 4 include enhancements to SPIT/IAWWT to bring its capacity up to 800gpm, carbon filtration, a process control laboratory, and a distributed control system (DCS) for the treatment facility and well field. Alternative 5 includes a new mobile 800 gpm capacity treatment facility with the same features as the enhanced SPIT/IAWWT facility. Alternative 7 includes a new mobile 800 gpm capacity treatment facility for re-injecton , a process control lab and a DCS for the treatment facility and well field.

Alternatives 4 & 4B – Reduced Post-Closure Groundwater Treatment Capacity Supplied by SPIT and IAWWT System, With Future On-site Disposal of D&D Waste

Description: Same as Alternatives 3 and 3B, except the D&D waste will be disposed of on site in the On-site Disposal Facility (at a future date after 2006 disposal facility closure), through the use of an agency-approved partial interim cap on Cell 8. The interim cap will bridge the time required after 2006 to achieve minimum life-cycle costs associated with the groundwater remedy.

Objectives: These alternatives permit the same comparison between Alternatives 3 and 4 (benefits of the interim cap) as for the comparison between Alternatives 1 and 2, but considering the reduced D&D waste volumes associated with the SPIT and IAWWT facility.

Contract Compliance Status: This alternative is not contractually compliant with Section C.1.2 of the Fernald Closure Contract, since relief is necessary from current Record of Decision obligations (reducing treatment capacity, operating the groundwater system at lower extraction rates, discontinuing reinjection, extending the groundwater cleanup schedule beyond current plans, and use of an interim cap on Cell 8). The alternative is not viable until DOE obtains such relief.

Regulatory Relief Required as GFSI: Same as Alternative 3, plus the need for use of the interim cap on Cell 8. Same key dates as above.

Schedule: Same as Alternative 3.

Life Cycle Costs: The estimated life cycle costs for Alternatives 4 and 4B are $109.5 and $100.3 million respectively. The estimated costs through the June 30, 2006 target closure date are $29.4 million for both Alternatives 4 and 4B. More detailed information on the life cycle cost estimates is provided in Appendix B.

Alternative 5 & 5B – Reduced Post-Closure Groundwater Treatment Capacity Supplied by a New Mobile Treatment System With Future Transfer to Another DOE Facility

Description: Same as Alternatives 3 and 3B except the SPIT and IAWWT capacity will be replaced with a new mobile system that could be relocated to another DOE facility off site after groundwater restoration is complete.

Objectives: These alternatives permit D&D of the SPIT and IAWWT facility (along with the AWWT facility) in time for placement in the On-site Disposal Facility per the 2006 baseline schedule. This would result in minimum D&D requirements after 2006 for remaining groundwater infrastructure.

Contract Compliance Status: This alternative is not contractually compliant with Section C.1.2 of the Fernald Closure Contract, since relief is necessary from current Record of Decision obligations (reducing treatment capacity, operating the treatment and extraction groundwater systems at lower rates, discontinuing reinjection, and extending the groundwater cleanup schedule beyond current plans). The alternative is not viable until DOE obtains such relief.

Regulatory Relief Required as GFSI: Same as Alternative 3.

Schedule: Same as Alternative 3.

Life Cycle Costs: The estimated life cycle costs for Alternatives 5 and 5B are $112.2 and $103.3 million respectively. The estimated costs through the June 30, 2006 target closure date are $37.1 million for both Alternatives 5 and 5B. The total yearly and life cycle costs for all alternatives are provided in Table 2-2. The major activities contributing to the annual cost for all alternatives are provide in Table 2-3. More detailed information on the life cycle cost estimates is provided in Appendix B.

Alternative 6 – Regulatory Relief from Current Outfall Discharge Limits and Leachate Treatment Requirements, With No Groundwater Reinjection, and Total Facility D&D Before 2006 Closure

Description: Pursue aggressive relief of current discharge limits (600 lbs/yr and 30 parts per billion uranium concentrations at the outfall) in order to reduce groundwater treatment requirements while maintaining or (further enhancing) current groundwater restoration rates and schedules. In this alternative the AWWT, SPIT, and IAWWT facilities would remain in service as long as possible (March 31, 2005) to meet remediation wastewater and stormwater treatment requirements, and then D&D in time for placement in the On-site Disposal Facility under the 2006 closure baseline schedule.

Objectives: This alternative permits comparison of the benefits of relaxation of the discharge limits in order to reduce groundwater treatment requirements and durations to the absolute minimum.

Based on modeling results, with no treatment of groundwater, outfall discharge limits would be exceeded for a period ranging from 1 to 7 years. Groundwater would be extracted and blended without further treatment at rates that permit compliance with a new standard (530 parts per billion uranium) represented by the Operable Unit 5 Record of Decision surface water health-based final remediation level. Since no treatment capacity would be available, groundwater reinjection would be discontinued under this alternative when the treatment systems are removed from service.

Contract Compliance Status: This alternative is not contractually compliant with Section C.1.2 of the Fernald Closure Contract, since relief is necessary from current Record of Decision obligations (relaxation of the current Record of Decision based outfall discharge limits, reducing treatment capacity, and discontinuing reinjection). The alternative is not viable until DOE obtains such relief.

Regulatory Relief Required as GFSI: EPA approval to discontinue the mass-based 600 lbs/yr discharge limit, and replace the current 30 parts per billion concentration limit with the 530 parts per billion final remediation level for surface water. EPA approval to not treat impacted storm water and remediation wastewater. EPA would also need to approve reducing treatment capacity and the discontinuation of reinjection service. Key Date for relief: must be obtained by April 1, 2005 in order to meet the On-site Disposal Facility closure schedule in the 2006 baseline. Any date earlier than this would enhance the overall impact, and reduce schedule risk.

Schedule: Current groundwater modeling indicates that the groundwater final remediation level (FRL) for uranium (30 µg/L) would be achieved site wide by 2024 with the off-property portion of the South Plume falling below the FRL in 2016.

Life Cycle Costs: The estimated life cycle cost for this alternative is $86.6 million with the estimated cost through the June 30, 2006 target closure date $26.5 million. More detailed information on the life cycle cost estimates is provided in Appendix B.

Alternative 7– Regulatory Relief from Current Outfall Discharge and Leachate Treatment Requirements, With New Mobile Treatment System to Maintain Groundwater Reinjection, and Total D&D of Existing Treatment Facilities Before 2006 Closure

Description: Same as Alternative 6, except a new mobile treatment system would be added to produce treated water suitable for reinjection.

Objectives: This alternative permits an evaluation to see if continuing with reinjection can further enhance life cycle cost reductions and shorten total groundwater remediation time compared to Alternative 6.

Contract Compliance Status: This alternative is not contractually compliant with Section C.1.2 of the Fernald Closure Contract, since relief is necessary from current Record of Decision obligations (relaxation of the current Record of Decision based outfall discharge limits and reducing treatment capacity). The alternative is not viable until DOE obtains such relief.

Regulatory Relief Required as GFSI: Same as Alternative 6 except only partial reinjection relief is necessary.

Schedule: Current groundwater modeling indicates that the groundwater final remediation level (FRL) for uranium (30 µg/L) would be achieved site wide by 2022 with the off-property portion of the South Plume falling below the FRL in 2013. The overall cleanup time for this alternative is 2 years less than that for Alternative 6 while the South Plume cleanup time for this alternative is 3 years less than Alternative 6.

Life Cycle Costs: The estimated life cycle cost for this alternative is $135.4 million with the estimated cost through the June 30, 2006 target closure date $37.6 million. More detailed information on the life cycle cost estimates is provided in Appendix B.

Table 2-2
Annual and Life Cycle Costs for All Alternatives
Yearly Costs Million $

Year	Alt 1	Alt 2	Alt 2A	Alt 2B	Alt 3	Alt 3B	Alt 4	Alt 4B	Alt 5	Alt 5B	Alt 6	Alt 7
2004	10.3	10.3	10.3	10.3	12.1	12.1	12.1	12.1	16.2	16.2	10.3	16.3
2005	9.5	9.5	9.0	9.0	13.3	13.3	13.3	13.3	14.0	14.0	10.5	14.2
2006	10.8	7.8	7.0	7.0	9.9	9.9	6.9	6.9	9.9	9.9	7.5	10.2
2007	6.5	6.5	5.5	13.6	5.4	5.4	5.4	7.9	5.4	3.1	3.2	5.8
2008	6.5	6.5	5.5	3.1	5.4	3.1	5.4	3.1	5.4	3.1	3.2	5.8
2009	6.5	6.5	5.5	3.1	5.4	3.1	5.4	3.1	5.4	3.1	3.2	5.8
2010	6.5	6.5	5.5	3.1	5.4	3.1	5.4	3.1	5.4	3.1	3.2	5.8
2011	6.8	6.8	4.0	3.4	4.0	3.4	4.0	3.4	3.7	3.4	3.5	6.1
2012	6.5	6.5	13.5	3.1	5.4	3.1	7.9	3.1	3.1	3.1	3.2	5.8
2013	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2014	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2015	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2016	6.8	6.8	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.5	6.1
2017	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2018	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2019	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2020	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2021	45.6	17.2	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.5	6.1
2022			3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	6.8
2023			3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	
2024			2.9	3.1	2.9	3.1	2.9	3.1	2.9	3.1	3.0	
2025			2.9	3.1	2.9	3.1	2.9	3.1	2.9	3.1		
2026			3.2	3.4	3.2	3.4	3.2	3.4	3.2	3.4		
Cost Total thru 6-06	27.2	24.2	23.3	23.3	32.4	32.4	29.4	29.4	37.1	37.1	26.5	37.6
Life Cycle Cost Total	167.8	136.4	109.4	100.0	110.0	100.8	109.5	100.3	112.2	103.3	86.6	135.4

Table 2-3
Timeline of Major Activities Affecting Cost for All Alternatives

Alternative	2004	2005	2006	2007 to 2026
1. Operate AWWT post closure	- Operate existing wells and treatment	- Operate existing wells and AWWT treatment - Shut down, D&D, and dispose IAWWT/SPIT	- Operate wells, reinjection, and AWWT - Final cap OSDF	- Operate wells, reinjection, and AWWT until 2021 - D&D with off-site disposal AWWT
2. Alternative 1 and reopen OSDF for post closure waste disposal	- Operate existing wells and treatment	- Operate existing wells and AWWT treatment - Shut down, D&D, and dispose IAWWT/SPIT	- Operate wells, reinjection, and AWWT - Temporary cap OSDF	- Operate wells, reinjection, and AWWT until 2021 - D&D with on-site disposal AWWT - Final cap OSDF
2A & 2B. Alternative 2 with reduced treatment, aquifer pumping, and no reinjection	- Operate existing wells and treatment	- Operate existing wells and AWWT treatment - Shut down, D&D, and dispose IAWWT/SPIT and reinjection - Lower well pumping rate	- Operate wells and AWWT at reduced rate - Temporary cap OSDF	- Shut down AWWT in 2007 (2B) or as late as 2011 (2A) - D&D on-site disposal AWWT - Final cap OSDF - Operate wells until 2026
3 & 3B. Operate IAWWT /SPIT post closure	- Operate existing wells and treatment - Design, build, and start up IAWWT/SPIT upgrades	- Operate IAWWT/SPIT - Lower well pumping rate - Shut down, D&D, and dispose AWWT and reinjection	- Operate wells and IAWWT/SPIT - Final cap OSDF	- Shut down IAWWT/SPIT in 2007 (3B) or as late as 2011 (3) - D&D off-site disposal IAWWT/SPIT - Operate wells until 2026
4 & 4B. Alternative 3 and reopen OSDF for post closure waste disposal	- Operate existing wells and treatment - Design, build, and start up IAWWT/SPIT upgrades	- Operate IAWWT/SPIT - Lower well pumping rate - Shut down, D&D, and dispose AWWT and reinjection	- Operate wells and IAWWT/SPIT - Temporary cap OSDF	- Shut down IAWWT/SPIT in 2007 (4B) or as late as 2011 (4) - D&D on-site disposal IAWWT/SPIT - Final cap OSDF - Operate wells until 2026
5 & 5B. Operate new mobile treatment system and salvage	- Operate existing wells and treatment - Design, build, and start up mobile system	- Operate mobile system - Lower well pumping rate - Shut down, D&D, and dispose AWWT, IAWWT/SPIT, and reinjection	- Operate wells and mobile system - Final cap OSDF	- Shut down mobile system in 2007 (5B) or as late as 2011 (5) - D&D/salvage mobile system off-site disposition - Operate wells until 2026
6. Relaxed effluent limits, no treatment needed for groundwater	- Operate existing wells and treatment	- Operate wells - Activated carbon treatment for leachate or regulatory relief - Shut down, D&D, and dispose AWWT, IAWWT/SPIT, and reinjection	- Operate wells - Final cap OSDF	- Operate wells until 2024
7. Alternatives 5 and 6 (treated water to be reinjected)	- Operate existing wells and treatment - Design, build, and start up mobile system	- Operate mobile system and reinjection - Shut down, D&D, and dispose AWWT, and IAWWT/SPIT	- Operate wells, mobile system and reinjection - Final cap OSDF	- Operate wells, mobile system and reinjection until 2022 - D&D/salvage mobile system reinjection off-site disposal

3.0 CONCLUSIONS

Table 3-1 provides an overall summary of the key features of the alternatives. These features are discussed below.

Life Cycle Cost/Regulatory Relief/ Contract Compliance

While Alternative 1 has the highest estimated life cycle cost, as noted above it is the only alternative that is compliant with the current contract. All other alternatives require regulatory relief as GFSI. In addition to regulatory relief, if Alternative 3, 3B, 4, 4B, 5, 5B or 7 are selected Fluor Fernald, Inc. will pursue a request for equitable adjustment since their estimated costs through June 2006 are greater than Alternative 1 (baseline alternative).

As indicated in Table 3-1, *Alternative 6* has the overall least life cycle cost. However, as noted in Section 2.0, Alternative 6 does not comply with current contract requirements, as substantial regulatory relief is required to make this a viable alternative.

Alternative 6 can be implemented only if the required regulatory relief is obtained by DOE by April 1, 2005. *Alternative 2A and 2B* are the least cost alternatives when evaluated with respect to the costs through the June 2006 projected site closure date.

Aquifer Cleanup Time Estimates

All alternatives show estimated cleanup times that extend well beyond some previous estimates. A conservative upper bound K_d of 3.0 L/kg was used in all the groundwater modeling runs conducted for this report (Appendix A). While the actual (true) K_d value in the aquifer is unknown, the best available information suggests the 3.0. K_d value assumed to represent aquifer conditions for this study is conservative. The modeling results using the conservative K_d indicate the time required to reach the uranium cleanup level will be substantially longer than the best case estimates of 10 years noted in the BRSR. The current conservative modeling results still predict groundwater clean up times within the 27-year range predicted in the OU5 ROD for many of the alternatives.

Treatment End Dates

The treatment end dates (after which treatment will no longer be required to meet uranium discharge limits at the river) for Alternatives 2A, 2B, 3, 3B, 4, 4B, 5, 5B, have significant uncertainty associated with them. The 2006-2011 range of treatment end dates given for these alternative pairs illustrates the uncertainty that surrounds the estimates. Details on how these dates were derived are provided in Appendix A, Attachment A.2. Some of the factors contributing to the treatment end date uncertainty are such things as:

- Variation from the scheduled groundwater pumping rates
- Number of additional extraction wells required and/or higher than anticipated uranium concentrations in future extraction wells

Table 3-1
Comprehensive Groundwater Strategy Alternatives
Overall Summary

Alternative	Regulatory Relief Required as GFSI	Compliant With Contract	Modeled Aquifer Cleanup Date	Groundwater Treatment End Date[a]	Costs[b] through June 2006	Life Cycle Cost[b]
1	No	Yes	2021	2021	27.2	167.8
2	Yes	No	2021	2021	24.2	136.4
2A/2B	Yes	No	2026	2011/2006	***23.3***	109.4/100.0
3/3B	Yes	No	2026	2011/2006	32.4	110.0/100.8
4/4B	Yes	No	2026	2011/2006	29.4	109.5/100.3
5/5B	Yes	No	2026	2011/2006	37.1	112.2/103.3
6	Yes	No	2024	4/01/05	26.5	***86.6***
7	Yes	No	2022	2022	37.6	135.4

[a]For Alternatives 2A, 3, 4, and 5 the no treatment required date of 2011 was conservatively estimated based on the 95 % upper confidence limit decline curve data from the extraction wells. For Alternatives 2B, 3B, 4B, and 5B the no treatment required date of 2006 was estimated based on actual decline curve data from the extraction wells. The details concerning the estimation of the treatment needs to meet discharge limits are provided in Appendix A, Attachment A.2.

[b]All costs in millions of dollars, non-escalated.

- Rebound when pumping wells are turned off, and
- Long term and seasonal aquifer water table fluctuations
- Schedule extension of wastewater treatment streams from other projects

Variation from the scheduled pumping rates defined for each groundwater alternative will have an impact on the estimated date for ending groundwater treatment. If the wells are pumped slower than the scheduled rate then it will take relatively longer for the individual well uranium concentrations to decline, resulting in a extended treatment times to meet discharge limits. Conversely if the wells are pumped harder than scheduled, then the uranium concentration decline times can be expected to be shorter, resulting in an earlier treatment end date. There is also uncertainty in the expected number of new extraction wells required to complete the groundwater remedy, and uranium concentration in water from extraction wells to be installed in the future. If there are more future wells than planned and/or the future wells have higher than anticipated uranium concentrations, they may require treatment to be applied for a longer time than planned.

Re-bound refers to an increase in dissolved contamination concentrations in the aquifer once pumping stops. This situation is well documented in the industry for groundwater pump-and-treat remediations. It is believed that rebound results from changes in flow behavior and rises in water levels once the pumping stops. Flow behavior within an aquifer is usually not homogenous and isotropic. During pumping, preferential flow pathways within the aquifer are established and it is these preferential flow pathways where most contamination flushing occurs. When pumping stops, any contamination in the less flushed areas of the aquifer has an increased opportunity to diffuse or migrate into the more flushed preferential pathway areas, raising dissolved concentrations in these areas once more.

Since the groundwater remediation at the FCP is not near completion, a formal measure of rebound cannot be made at the FCP. However, some observed dissolved uranium increases at extraction wells, following periods of non-operation, have been documented and attributed to rebound.

Another contributing factor to the uncertainty of the provided time estimates is the impact that higher water levels or fluctuating aquifer recharge rates in the future could have on dissolved uranium concentrations in the aquifer. In the Great Miami Aquifer below the FCP, uranium contamination is adsorbed to aquifer sediments both below and above the current water table in the unsaturated zone (SNL 2003). Higher water levels in the future could dissolve some of the unsaturated zone contamination back into the groundwater. Higher water levels in 2002 appear to be the cause for the documented rise in uranium concentrations in several extraction and monitoring wells at the FCP (Integrated Site Environmental Monitoring Report for 2002).

Schedule extension of treatment needs for other wastewater streams also contributes the uncertainty regarding when treatment of water at the FCP will no longer be required. If projects that generate wastewater requiring treatment are delayed beyond the dates assumed in this study then treatment needs for their wastewater will likewise be extended and thereby potentially extend the date when treatment will no longer be required.

Certification Sampling Protocol

In the June 4, 2003 meeting with DOE regarding this report, DOE suggested that a groundwater remedy completion certification strategy be developed in the near term. At the meeting Fluor Fernald, Inc. noted that the strategy had not yet been developed since the aquifer restoration completion time appears to be many years off, and that regulatory guidance regarding groundwater remedy completion certification protocol will likely be evolving between now and the time that certification protocol are required. The groundwater modeling conducted for this report provides additional support that certification protocol will not be required in the near term, therefore Fluor Fernald, Inc. recommends that the development of certification protocol be postponed until just prior to when it is required.

Recommendation For Additional Discussion

It is recognized that DOE's goals are to achieve site closure by 2006 and implement a groundwater restoration program with the lowest life cycle costs. However, depending on the alternative, a lower life cycle cost could negatively impact a 2006 Site Closure because of the higher operational risk of not being able to accommodate unexpected wastewater stream quantities or durations. Fluor Fernald Inc. recommends further discussions with DOE concerning life cycle costs, impacts to 2006 site closure, and expectations of success in obtaining regulatory relief associated with the various alternatives.

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Appendix A

COMPREHENSIVE GROUNDWATER STRATEGY REPORT

APPENDIX A

This appendix documents the calculations and assumptions used to evaluate model scenarios 1 through 4 with respect to:

- aquifer clean up times with respect to uranium
- duration required for treatment systems,
- mass of uranium extracted from the Great Miami Aquifer,
- mass of uranium discharged to the Great Miami River, and outfall uranium concentrations at the river.

These four model scenarios support the 12 alternatives evaluated in Section 2.0.

Attachment A.1 provides supporting detail for the groundwater flow and transport model (VAM3D) scenarios with a discussion of model parameters, scenario pumping rates and performance measures, model uncertainty and the contribution that uncertainty makes to the predicted clean up times.

Attachment A.2 provides supporting detail for the post-processing of VAM3D groundwater transport model results for each alternative. An Excel spreadsheet called Testpump was used to incorporate transport model results with various treatment system operational assumptions to arrive at predicted outfall concentrations and masses at the Great Miami River. The Testpump spreadsheet was also used to perform similar outfall concentration and mass computations with wellhead concentration decline curves generated from operational history.

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COMPREHENSIVE GROUNDWATER STRATEGY REPORT

Attachment A.1

Groundwater Modeling in Support of the Alternatives

ATTACHMENT A.1

GROUNDWATER MODELING IN SUPPORT OF THE ALTERNATIVES

Groundwater treatment alternatives for this study were modeled with the VAM3D flow and transport modeling code using the fourteen-layer zoom model (101 x 51 x 14 = 72114 finite difference nodes with a spacing of 100 feet in both the x and y directions). Development of this model has been described in detail in Section 3.0 of Design for Remediation of the Great Miami Aquifer, South Field Phase II Module (DOE, May 2002).

Flow Modeling Assumptions

Extraction well pumping rates for the various scenarios are shown in Tables A.1-1 through A.1-4. On-property extraction well pumping rates were increased in the out years of each scenario after the off-property South Plume concentrations dropped below the 30 μg/L FRL for total uranium. Extraction and re-injection well locations are shown in Figure A.1-1. No additional extraction/re-injection wells were assumed for this modeling study over and above those discussed in the above reference.

October 1998 (nominal) boundary conditions were used for all steady-state flow runs in this modeling study. Boundary conditions for the zoom flow models were obtained from the large VAM3D twelve-layer model (112 x 120 x 12) as described in Section 3.3 of the above reference. Figure A.1-2 shows the large model and the zoom model boundaries.

Transport Modeling Assumptions

Initial conditions for the transport model are the same as those used in the South Plume Optimization Phase II modeling study completed first quarter 2003. Initial conditions were developed from Kriged monitoring and direct-push total uranium sampling data obtained through the end of December 2002. Initial conditions for model layer 12 (the layer with maximum persistent concentrations of total uranium) are shown in Figure A.1-3

All transport source terms were reduced to zero after April 2006 with the exception of source terms representing re-injection wells or basins. Total uranium concentration of re-injection water was assumed to be 5 μg/L.

Previous groundwater transport modeling studies at the FCP have been performed using a constant soil-water partitioning coefficient (K_d) for uranium of 1.78 L/Kg. Based on a recent geochemical study (Selective Sequential Extraction Analysis of Uranium in Great Miami Aquifer Sediment Samples, Fernald DOE site, Ohio, Sandia National Laboratories, April 2003), GMA sediments have an average K_d of 2.5 L/Kg for uranium with a standard deviation of 1.7 L/Kg (Refer to Table A.1-5). Therefore, for this modeling study, a constant K_d of 3.0 L/Kg was used in the transport model and is believed to be

conservative and more representative of the total uranium partitioning on the GMA sediments than using a K_d of 1.78 L/Kg. A larger K_d value implies higher mass sorbed onto aquifer sediments and longer desorption times which extends the clean up times.

Transport Modeling Results

Table A.1-6 shows the times that the South Field, South Plume and Pilot Plant Drainage Ditch portions of the total uranium plume are predicted to be at or below 30 μg/L. As seen from this table, Scenario 2 (Alternatives 2A, 2B, 3, 3B, 4, 4B, 5, & 5B) is predicted to take the longest time to remediate the GMA with the South Field total uranium concentrations dropping below 30 μg/L in 2026. Scenario 1 (Alternatives 1 & 2) has the shortest remediation time with the South Field total uranium concentrations dropping below 30 μg/L in 2021. Figure A.1-4 shows representative wellhead concentration decline curves for South Field Extraction Well 32276 under scenarios 1 through 4 from 2005 to year 2023. As shown in the figure, total uranium concentrations at this well are predicted to fall below 30 μg/L between 2007 under scenario 1 to 2011 under scenario 4, a range of approximately four years.

Summary performance measures for each scenario are shown in Tables A.1-7 through A.1-10.

Modeling Uncertainty

The scenarios in the South Plume Optimization Phase II modeling study with a total uranium K_d of 1.78 L/Kg predicted concentrations in the GMA would be less than 30 μg/L by 2009 off property and 2017 on property. Clean up times using a total uranium K_d of 3.0 L/Kg under the same pumping rates extends these dates to approximately 2021 and 2029 respectively, a difference of approximately twelve years.

A second model run was performed on the South Plume Optimization Phase II model scenario using a total uranium K_d of 4.0 L/Kg as an additional estimate of model uncertainty. With a K_d of 4.0 L/Kg, total uranium concentrations in the GMA did not drop below 30 μg/L until approximately 2038, an extension of another ten years under an increase in K_d from 3.0 to 4.0 L/Kg. Figure A.1-5 illustrates the difference in clean up times for different K_d values. In this figure, the 30 μg/L total uranium concentration contour is displayed at year 2015 using the original K_d of 1.78 L/Kg and an upper limit K_d of 4.0 L/Kg. As shown in the figure, there are significant differences in the plume areas between these two model runs. Figure A.1-6 shows modeled wellhead concentrations for total uranium at South Field Extraction Well 32276 under K_d assumptions of 1.78, 3.0, and 4.0 L/Kg. As shown in the figure, the predicted wellhead total uranium concentrations drop below 30 μg/L from third quarter 2005 to approximately 2012 depending on the K_d value used.

Table A.1-1
Pumping/Re-Injection Rates for Scenario 1 (Alternatives 1 & 2)

	System/Well ID		Pumping/Re-injection Rates (gpm)		
			1/01/03 to 4/01/06	4/01/06 to 4/01/13	4/01/13 to end
South Plume					
SP-1	RW-1	3924	300	300	0
SP-2	RW-2	3925	300	300	0
SP-3	RW-3	3926	300	300	0
SP-4	RW-4	3927	400	400	0
SP-6	RW-6	32308	300	300	0
SP-7	RW-7	32309	300	300	0
		Sub Total	1900	1900	0
South Field					
SF-31	EW-15a	33262	200	200	400
SF17	EW-17	31567	275	275	500
SF18	EW-18	31550	200	200	200
SF19	EW-19	31560	200	200	200
SF20	EW-20	31561	200	200	400
SF21	EW-21a	33298	290	290	400
SF22	EW-22	32276	300	300	500
SF23	EW-23	32447	300	300	500
SF24	EW-24	32446	300	300	500
SF25	EW-25	33061	300	300	300
SF32	EW-30	33264	300	300	500
SF33	EW-31	33265	300	300	500
SF34	EW-32	33266	200	200	200
		Sub Total	3365	3365	5100
Waste Storage Area					
WSA-1	EW-26	32761	300	300	500
WSA-2	EW-27	33062	400	400	400
WSA-4	EW-28	33063		400	400
WSA-5				100	100
WSA-6				100	100
			700	1300	1500
		Total Pumping	5965	6565	6600
Re-Injection					
	IW-8a	33253	200	200	200
	IW-9a	33254	200	200	200
	IW-10	22109	200	200	200
	IW-10a	33255	200	200	200
	IW-11	22240	200	200	200
	IW-12	22111	0	0	0
	IW-16		200	200	200
	IW-29	33263	100	100	100
	Basins		100	100	100
		Total Re-injection	1400	1400	1400
		Net Pumping	4565	5165	5200

Table A.1-2

Pumping/Re-Injection Rates for Scenario 2 (Alternatives 2A, 2B, 3, 3B, 4, 4B, 5, & 5B)

System/Well ID			Pumping/Re-injection Rates (gpm)			
			1/01/03 to 4/01/05	4/01/05 to 4/01/06	4/01/06 to 4/01/16	4/01/16 to end
South Plume						
SP-1	RW-1	3924	300	200	200	0
SP-2	RW-2	3925	300	200	200	0
SP-3	RW-3	3926	300	200	200	0
SP-4	RW-4	3927	400	200	200	0
SP-6	RW-6	32308	300	200	200	0
SP-7	RW-7	32309	300	200	200	0
		Sub Total	1900	1200	1200	0
South Field						
SF-31	EW-15a	33262	200	200	200	300
SF17	EW-17	31567	275	175	175	175
SF18	EW-18	31550	200	100	100	100
SF19	EW-19	31560	200	100	100	100
SF20	EW-20	31561	200	100	100	400
SF21	EW-21a	33298	290	200	200	300
SF22	EW-22	32276	300	300	300	400
SF23	EW-23	32447	300	300	300	400
SF24	EW-24	32446	300	300	300	300
SF25	EW-25	33061	300	100	100	100
SF32	EW-30	33264	300	200	200	400
SF33	EW-31	33265	300	300	300	400
SF34	EW-32	33266	200	200	200	200
		Sub Total	3365	2575	2575	3575
Waste Storage Area						
WSA-1	EW-26	32761	300	300	300	500
WSA-2	EW-27	33062	400	200	200	200
WSA-4	EW-28	33063		0	200	200
WSA-5				0	100	100
WSA-6				0	100	100
			700	500	900	1100
		Total Pumping	5965	4275	4675	4675
Re-injection						
	IW-8a	33253	200	0	0	0
	IW-9a	33254	200	0	0	0
	IW-10	22109	200	0	0	0
	IW-10a	33255	200	0	0	0
	IW-11	22240	200	0	0	0
	IW-12	22111	0	0	0	0
	IW-16		200	0	0	0
	IW-29	33263	100	0	0	0
	Basins		100	0	0	0
		Total Re-injection	1400	0	0	0
		Net Pumping	4565	4275	4675	4675

Table A.1-3
Pumping/Re-Injection Rates for Scenario 3 (Alternative 6)

System/Well ID			Pumping/Re-injection Rates (gpm)			
			1/01/03 to 4/01/05	4/01/05 to 4/01/06	4/01/06 to 4/01/16	4/01/16 to end
South Plume						
SP-1	RW-1	3924	300	200	200	0
SP-2	RW-2	3925	300	200	200	0
SP-3	RW-3	3926	300	200	200	0
SP-4	RW-4	3927	400	200	200	0
SP-6	RW-6	32308	300	200	200	0
SP-7	RW-7	32309	300	200	200	0
		Sub Total	1900	1200	1200	0
South Field						
SF-31	EW-15a	33262	200	200	200	400
SF17	EW-17	31567	275	275	275	275
SF18	EW-18	31550	200	100	100	100
SF19	EW-19	31560	200	100	100	100
SF20	EW-20	31561	200	200	200	400
SF21	EW-21a	33298	290	200	200	400
SF22	EW-22	32276	300	300	300	400
SF23	EW-23	32447	300	300	300	500
SF24	EW-24	32446	300	300	300	300
SF25	EW-25	33061	300	200	200	200
SF32	EW-30	33264	300	300	300	400
SF33	EW-31	33265	300	300	300	400
SF34	EW-32	33266	200	200	200	200
		Sub Total	3365	2975	2975	4075
Waste Storage Area						
WSA-1	EW-26	32761	300	300	300	500
WSA-2	EW-27	33062	400	200	200	200
WSA-4	EW-28	33063		0	200	200
WSA-5				0	100	100
WSA-6				0	100	100
		Sub Total	700	500	900	1100
		Total Pumping	5965	4675	5075	5175
Re-Injection						
	IW-8a	33253	200	0	0	0
	IW-9a	33254	200	0	0	0
	IW-10	22109	200	0	0	0
	IW-10a	33255	200	0	0	0
	IW-11	22240	200	0	0	0
	IW-12	22111	0	0	0	0
	IW-16		200	0	0	0
	IW-29	33263	100	0	0	0
	Basins		100	0	0	0
		Total Re-injection	1400	0	0	0
		Net Pumping	4565	4675	5075	5175

TABLE A.1-4

PUMPING/RE-INJECTION RATES FOR SCENARIO 4 (ALTERNATIVE 7)

	System/Well ID		Pumping/Re-injection Rates (gpm)			
			1/01/03 to 4/01/05	4/01/05 to 4/01/06	4/01/06 to 4/01/13	4/01/13 to end
South Plume						
SP-1	RW-1	3924	300	300	300	0
SP-2	RW-2	3925	300	300	300	0
SP-3	RW-3	3926	300	300	300	0
SP-4	RW-4	3927	400	400	400	0
SP-6	RW-6	32308	300	300	300	0
SP-7	RW-7	32309	300	300	300	0
		Sub Total	1900	1900	1900	0
South Field						
SF-31	EW-15a	33262	200	200	200	400
SF17	EW-17	31567	275	275	275	500
SF18	EW-18	31550	200	100	100	100
SF19	EW-19	31560	200	100	100	100
SF20	EW-20	31561	200	200	200	400
SF21	EW-21a	33298	290	290	290	400
SF22	EW-22	32276	300	300	300	500
SF23	EW-23	32447	300	300	300	500
SF24	EW-24	32446	300	300	300	500
SF25	EW-25	33061	300	200	200	200
SF32	EW-30	33264	300	300	300	500
SF33	EW-31	33265	300	300	300	500
SF34	EW-32	33266	200	100	100	100
		Sub Total	3365	2965	2965	4700
Waste Storage Area						
WSA-1	EW-26	32761	300	300	300	500
WSA-2	EW-27	33062	400	300	300	300
WSA-4	EW-28	33063			200	200
WSA-5					100	100
WSA-6					100	100
		Sub Total	700	600	1000	1200
		Total Pumping	5965	5465	5865	5900
Re-Injection						
	IW-8a	33253	200	0	0	0
	IW-9a	33254	200	200	200	200
	IW-10	22109	200	0	0	0
	IW-10a	33255	200	200	200	200
	IW-11	22240	200	200	200	200
	IW-12	22111	0	0	0	0
	IW-16		200	0	0	0
	IW-29	33263	100	100	100	100
	Basins		100	100	100	100
		Total Re-injection	1400	800	800	800
		Net Pumping	4565	4665	5065	5100

TABLE A.1-5

CALCULATED K_d VALUES

Easting ('83)	Northing ('83)	Elevation (ft AMSL)	Calculated K_d (L/Kg)	Boring Name
1349751.5	477200.9	497.8	1.7	33264
1349751.5	477200.9	489.6	2.8	33264
1349751.5	477200.9	479.3	7.3	33264
1348150.0	477799.9	510.4	2.3	33262
1348150.0	477799.9	501.5	1.2	33262
1349088.1	476262.7	501.9	2.8	33255
1349088.1	476262.7	490.4	3.1	33255
1349088.1	476262.7	481.7	3.9	33255
1348037.2	480013.0	522.9	0.1	33062
1348037.2	480013.0	519.9	0.2	33062
1348037.2	480013.0	516.9	0.7	33062
1348037.2	480013.0	514.4	1.0	33062
1348037.2	480013.0	510.4	3.3	33062
1348037.2	480013.0	506.9	3.3	33062
1348037.2	480013.0	504.9	1.1	33062
1348037.2	480013.0	501.9	2.6	33062
1348037.2	480013.0	496.9	5.3	33062
1348037.2	480013.0	492.9	3.1	33062
1348037.2	480013.0	489.9	3.8	33062
1348037.2	480013.0	486.9	3.7	33062
1348037.2	480013.0	480.9	2.7	33062
1348037.2	480013.0	476.9	1.0	33062
1348037.2	480013.0	474.9	1.1	33062
		Average	2.5	
		Std. Dev	1.7	

TABLE A.1-6

PREDICTED CLEAN UP TIMES FOR SCENARIOS BY AREA

		Approximate time when when modeled concentration drops below 30 ug/L
Scenario 1 (Alternatives 1 & 2)		
	South Field	2021
	South Plume	2013
	Waste Storage Area	2021
Scenario 2 (Alternatives 2A, 2B, 3, 3B, 4, 4B, 5, & 5B)		
	South Field	2026
	South Plume	2016
	Waste Storage Area	2023
Scenario 3 (Alternative 6)		
	South Field	2024
	South Plume	2016
	Waste Storage Area	2023
Scenario 4 (Alternative 7)		
	South Field	2021
	South Plume	2013
	Waste Storage Area	2022

TABLE A.1-7

MODELED PERFORMANCE DATA FOR
SCENARIO 1, ALTERNATIVES 1 and 2

Year	Total Water Pumped (gpm)	Groundwater Treatment Capacity (gpm)	Other Water Treatment Capacity (gpm)	Groundwater To Treatment (gpm)	Groundwater Not Treated (gpm)	Conc. Not Treated (ug/L)	Annual U Extracted From GMA (lbs)	Injected Water (gpm)	Conc. Of Injected Water (ug/L)	Annual Uranium Injected (lbs)	Water Discharged[1] (gpm)	Conc. Of Discharge[2] (ug/L)	Annual Uranium Discharged (lbs)	Net Total U Removed From GMA Annually (lbs)
2003	5965	2325	631	2290	3675	25.7	1196	1400	5	31	5196	22.4	512	1165
2004	5965	2325	631	2165	3800	21.7	838	1400	5	31	5196	19.6	448	807
2005	5965	2000	400	1865	4100	19.9	703	1400	5	31	4965	17.5	382	672
2006	6565	2400	0	2165	4400	15.7	670	1400	5	31	5165	13.8	314	639
2007	6565	2400	0	2165	4400	14.1	593	1400	5	31	5165	12.4	282	562
2008	6565	2400	0	2365	4200	12.7	538	1400	5	31	5165	11.2	255	507
2009	6565	2400	0	2365	4200	11.7	492	1400	5	31	5165	10.4	236	461
2010	6565	2400	0	2365	4200	10.9	456	1400	5	31	5165	9.8	223	425
2011	6565	2400	0	2365	4200	10.2	424	1400	5	31	5165	9.2	209	393
2012	6565	2400	0	2365	4200	9.5	396	1400	5	31	5165	8.7	198	365
2013	6600	2400	0	2100	4500	10.1	387	1400	5	31	5200	9.2	211	356
2014	6600	2400	0	2100	4500	8.8	366	1400	5	31	5200	8.1	185	335
2015	6600	2400	0	2100	4500	8.0	331	1400	5	31	5200	7.4	169	300
2016	6600	2400	0	2300	4300	7.2	305	1400	5	31	5200	6.8	156	274
2017	6600	2400	0	2300	4300	6.7	282	1400	5	31	5200	6.4	146	251
2018	6600	2400	0	2300	4300	6.2	261	1400	5	31	5200	6.0	137	231
2019	6600	2400	0	2300	4300	5.9	244	1400	5	31	5200	5.7	130	213
2020	6600	2400	0	2300	4300	5.6	229	1400	5	31	5200	5.4	124	199
2021	6600	2400	0	2300	4300	5.3	215	1400	5	31	5200	5.2	119	184
2022	6600	2400	0	2300	4300	4.5	203	1400	5	31	5200	4.6	105	173
				Total U extracted from GMA (lbs)			9129	**Total U Injected (lbs)**		616	**Net Total U removed from GMA (lbs)**			8513

[1] Water Discharged = Total Water Pumped + Other Water Treatment Capacity - Injection

[2]Concentration Discharged is calculated using the Testpump Excel spreadsheet given the treatment assumptions applicable for the alternative under consideration

TABLE A.1-8
MODELED PERFORMANCE DATA FOR
SCENARIO 2, ALTERNATIVES 2A, 2B, 3, 3B, 4, 4B, 5, & 5B

Year	Total Water Pumped (gpm)	Groundwater Treatment Capacity (gpm)	Other Water Treatment Capacity (gpm)	Groundwater To Treatment (gpm)	Groundwater Not Treated (gpm)	Conc. Not Treated (ug/L)	Annual U Extracted From GMA (lbs)	Injected Water (gpm)	Conc. Of Injected Water (ug/L)	Annual Uranium Injected (lbs)	Water Discharged[1] (gpm)	Conc. Of Discharge[2] (ug/L)	Annual Uranium Discharged (lbs)	Net Total U Removed From GMA Annually (lbs)
2003	5965	2325	631	2290	3675	25.7	1196	1400	5	31	5196	22.4	512	1165
2004	5965	2325	631	2165	3800	21.7	838	1400	5	31	5196	19.6	448	807
2005	4275	800	0	400	3875	25.8	535	0	n/a	n/a	4275	23.0	433	535
2006*	4675	800	0	700	3975	21.4	530	0	n/a	n/a	4675	18.7	385	530
2007	4675	800	0	675	4000	20.0	482	0	n/a	n/a	4675	17.5	360	482
2008	4675	800	0	675	4000	18.6	445	0	n/a	n/a	4675	16.3	335	445
2009	4675	800	0	675	4000	17.4	412	0	n/a	n/a	4675	15.3	315	412
2010	4675	800	0	675	4000	16.3	385	0	n/a	n/a	4675	14.5	298	385
2011+	4675	800	0	675	4000	15.4	360	0	n/a	n/a	4675	13.6	280	360
2012	4675	800	0	675	4000	14.5	340	0	n/a	n/a	4675	12.9	265	340
2013	4675	800	0	675	4000	13.6	319	0	n/a	n/a	4675	12.2	251	319
2014	4675	800	0	675	4000	12.9	302	0	n/a	n/a	4675	11.6	239	302
2015	4675	800	0	675	4000	12.2	286	0	n/a	n/a	4675	11.0	226	286
2016	4675	800	0	675	4000	12.8	276	0	n/a	n/a	4675	11.5	237	276
2017	4675	800	0	675	4000	11.5	261	0	n/a	n/a	4675	10.4	214	261
2018	4675	800	0	775	3900	10.4	243	0	n/a	n/a	4675	9.5	195	243
2019	4675	800	0	775	3900	0.7	228	0	n/a	n/a	4675	8.9	183	228
2020	4675	800	0	775	3900	9.1	214	0	n/a	n/a	4675	8.4	173	214
2021	4675	800	0	775	3900	8.6	202	0	n/a	n/a	4675	8.0	165	202
2022	4675	800	0	775	3900	8.1	191	0	n/a	n/a	4675	7.6	156	191
2023	4675	800	0	775	3900	7.7	179	0	n/a	n/a	4675	7.2	148	179
2024	4675	800	0	775	3900	7.3	171	0	n/a	n/a	4675	6.9	142	171
2025	4675	800	0	775	3900	6.5	163	0	n/a	n/a	4675	6.2	128	163
2026	4675	800	0	775	3900	6.2	154	0	n/a	n/a	4675	6.0	123	154
2027	4675	800	0	775	3900	5.9	150	0	n/a	n/a	4675	5.7	117	150
				Total U extracted from GMA (lbs)			8861	**Total U Injected (lbs)**		62	**Net Total U removed from GMA (lbs)**			8800

[1] Water Discharged = Total Water Pumped + Other Water Treatment Capacity - Injection

[2]Concentration Discharged is calculated using the Testpump Excel spreadsheet given the treatment assumptions applicable for the alternative under consideration

*Treatment discontinued for cost estimating purposes after this date for Alternative 2B, 3B, 4B, and 5B since it is no longer needed to meet uranium discharge limits (See Appendix A.2 Tables A.2-11)

+Treatment discontinued for cost estimating purposes after this date for Alternative 2A, 3, 4, and 5 since it is no longer needed to meet uranium discharge limits (See Appendix A.2 Tables A.2-13)

TABLE A.1-9
MODELED PERFORMANCE DATA FOR
SCENARIO 3, ALTERNATIVE 6

Year	Total Water Pumped (gpm)	Groundwater Treatment Capacity (gpm)	Other Water Treatment Capacity (gpm)	Groundwater To Treatment (gpm)	Groundwater Not Treated (gpm)	Conc. Not Treated (ug/L)	Annual U Extracted From GMA (lbs)	Injected Water (gpm)	Conc. Of Injected Water (ug/L)	Annual Uranium Injected (lbs)	Water Discharged[1] (gpm)	Conc. Of Discharge[2] (ug/L)	Annual Uranium Discharged (lbs)	Net Total U Removed From GMA Annually (lbs)
2003	5965	2325	631	2290	3675	25.7	1196	1400	5	31	5196	22.4	512	1165
2004	5965	2325	631	2165	3800	21.7	838	1400	5	31	5196	19.6	448	807
2005	4675	0	0	0	4675	28.9	583	0	n/a	n/a	4675	28.9	595	583
2006	5075	0	0	0	5075	25.4	564	0	n/a	n/a	5075	25.4	567	564
2007	5075	0	0	0	5075	23.0	510	0	n/a	n/a	5075	23.0	514	510
2008	5075	0	0	0	5075	21.1	469	0	n/a	n/a	5075	21.1	471	469
2009	5075	0	0	0	5075	19.5	432	0	n/a	n/a	5075	19.5	436	432
2010	5075	0	0	0	5075	18.2	403	0	n/a	n/a	5075	18.2	407	403
2011	5075	0	0	0	5075	17.0	376	0	n/a	n/a	5075	17.0	380	376
2012	5075	0	0	0	5075	15.9	353	0	n/a	n/a	5075	15.9	355	353
2013	5075	0	0	0	5075	14.9	331	0	n/a	n/a	5075	14.9	333	331
2014	5075	0	0	0	5075	14.0	310	0	n/a	n/a	5075	14.0	313	310
2015	5075	0	0	0	5075	13.2	293	0	n/a	n/a	5075	13.2	295	293
2016	5175	0	0	0	5175	13.6	301	0	n/a	n/a	5175	13.6	310	301
2017	5175	0	0	0	5175	12.0	271	0	n/a	n/a	5175	12.0	273	271
2018	5175	0	0	0	5175	11.1	248	0	n/a	n/a	5175	11.1	253	248
2019	5175	0	0	0	5175	10.3	232	0	n/a	n/a	5175	10.3	235	232
2020	5175	0	0	0	5175	9.6	216	0	n/a	n/a	5175	9.6	219	216
2021	5175	0	0	0	5175	9.0	203	0	n/a	n/a	5175	9.0	205	203
2022	5175	0	0	0	5175	8.4	191	0	n/a	n/a	5175	8.4	191	191
2023	5175	0	0	0	5175	8.0	180	0	n/a	n/a	5175	8.0	182	180
2024	5175	0	0	0	5175	7.5	171	0	n/a	n/a	5175	7.5	171	171
2025	5175	0	0	0	5175	6.8	162	0	n/a	n/a	5175	6.8	155	162
				Total U extracted from GMA (lbs)			8833	**Total U Injected (lbs)**		62	**Net Total U removed from GMA (lbs)**			8771

[1] Water Discharged = Total Water Pumped + Other Water Treatment Capacity - Injection

[2]Concentration Discharged is calculated using the Testpump Excel spreadsheet given the treatment assumptions applicable for the alternative under consideration

TABLE A.1-10
MODELED PERFORMANCE DATA FOR
SCENARIO 4, ALTERNATIVE 7

Year	Total Water Pumped (gpm)	Groundwater Treatment Capacity (gpm)	Other Water Treatment Capacity (gpm)	Groundwater To Treatment (gpm)	Groundwater Not Treated (gpm)	Conc. Not Treated (ug/L)	Annual U Extracted From GMA (lbs)	Injected Water (gpm)	Conc. Of Injected Water (ug/L)	Annual Uranium Injected (lbs)	Water Discharged[1] (gpm)	Conc. Of Discharge[2] (ug/L)	Annual Uranium Discharged (lbs)	Net Total U Removed From GMA Annually (lbs)
2003	5965	2325	631	2290	3675	25.7	1196	1400	5	31	5196	22.4	512	1165
2004	5965	2325	631	2165	3800	21.7	838	1400	5	31	5196	19.6	448	807
2005	5465	800	0	790	4675	24.0	651	800	5	18	4665	24.0	493	633
2006	5865	800	0	775	5090	20.7	616	800	5	18	5065	20.7	461	598
2007	5865	800	0	775	5090	18.7	552	800	5	18	5065	18.7	417	535
2008	5865	800	0	775	5090	17.0	505	800	5	18	5065	17.0	379	487
2009	5865	800	0	775	5090	15.6	465	800	5	18	5065	15.6	348	447
2010	5865	800	0	775	5090	14.4	430	800	5	18	5065	14.4	321	413
2011	5865	800	0	775	5090	13.4	402	800	5	18	5065	13.4	299	385
2012	5865	800	0	775	5090	12.5	377	800	5	18	5065	12.5	279	359
2013	5900	800	0	500	5400	14.9	400	800	5	18	5100	14.9	334	382
2014	5900	800	0	500	5400	12.9	353	800	5	18	5100	12.9	290	336
2015	5900	800	0	600	5300	11.4	319	800	5	18	5100	11.4	256	302
2016	5900	800	0	600	5300	10.4	293	800	5	18	5100	10.4	233	276
2017	5900	800	0	600	5300	9.6	273	800	5	18	5100	9.6	215	255
2018	5900	800	0	600	5300	8.9	252	800	5	18	5100	8.9	200	234
2019	5900	800	0	600	5300	8.3	236	800	5	18	5100	8.3	186	219
2020	5900	800	0	600	5300	7.7	221	800	5	18	5100	7.7	173	203
2021	5900	800	0	600	5300	7.3	208	800	5	18	5100	7.3	164	190
2022	5900	800	0	600	5300	6.5	197	800	5	18	5100	6.5	146	180
2023	5900	800	0	600	5300	6.1	187	800	5	18	5100	6.1	137	169
				Total U extracted from GMA (lbs)			8971	**Total U Injected (lbs)**		396	**Net Total U removed from GMA (lbs)**			8575

[1] Water Discharged = Total Water Pumped + Other Water Treatment Capacity - Injection

[2]Concentration Discharged is calculated using the Testpump Excel spreadsheet given the treatment assumptions applicable for the alternative under consideration

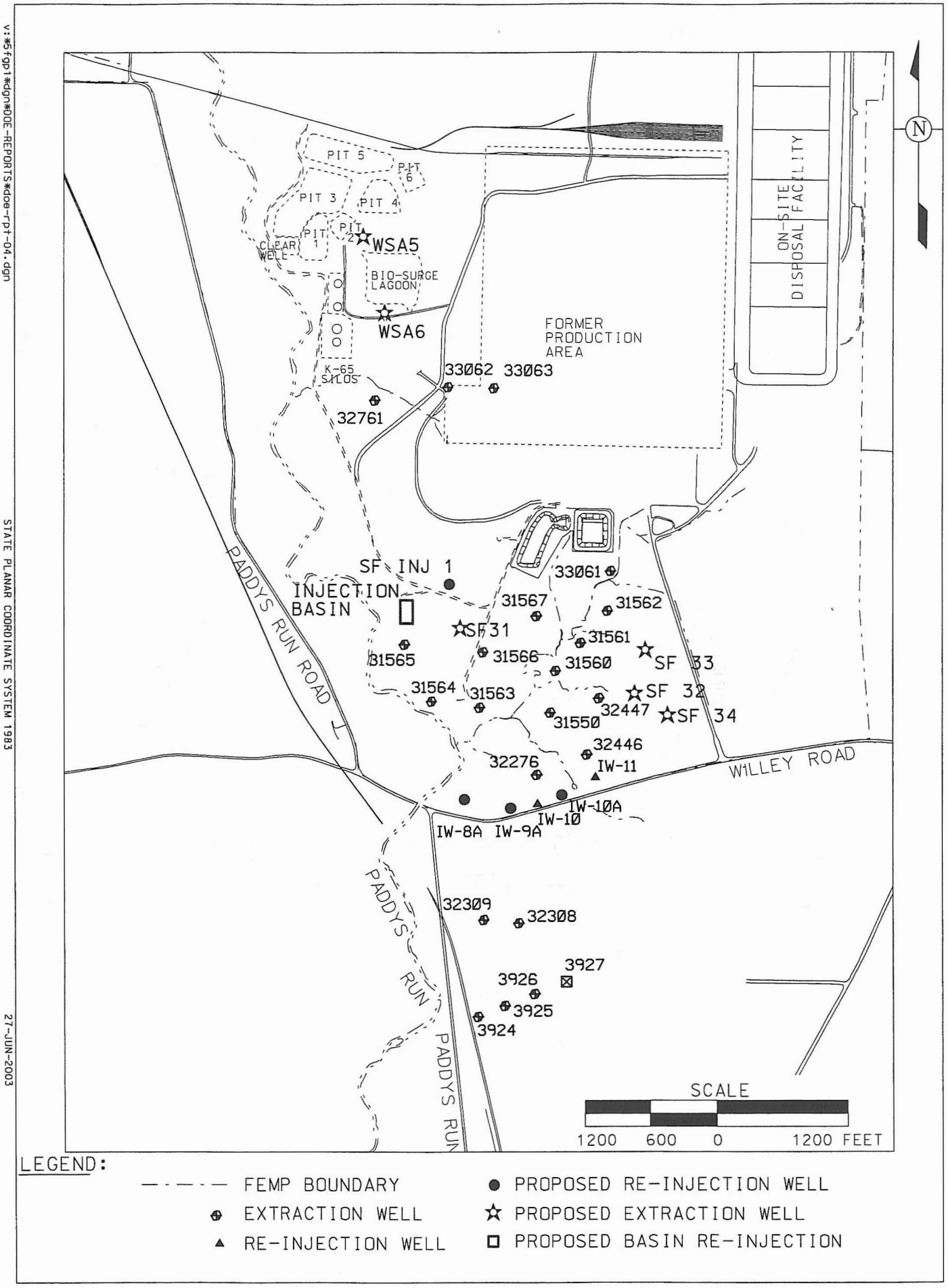
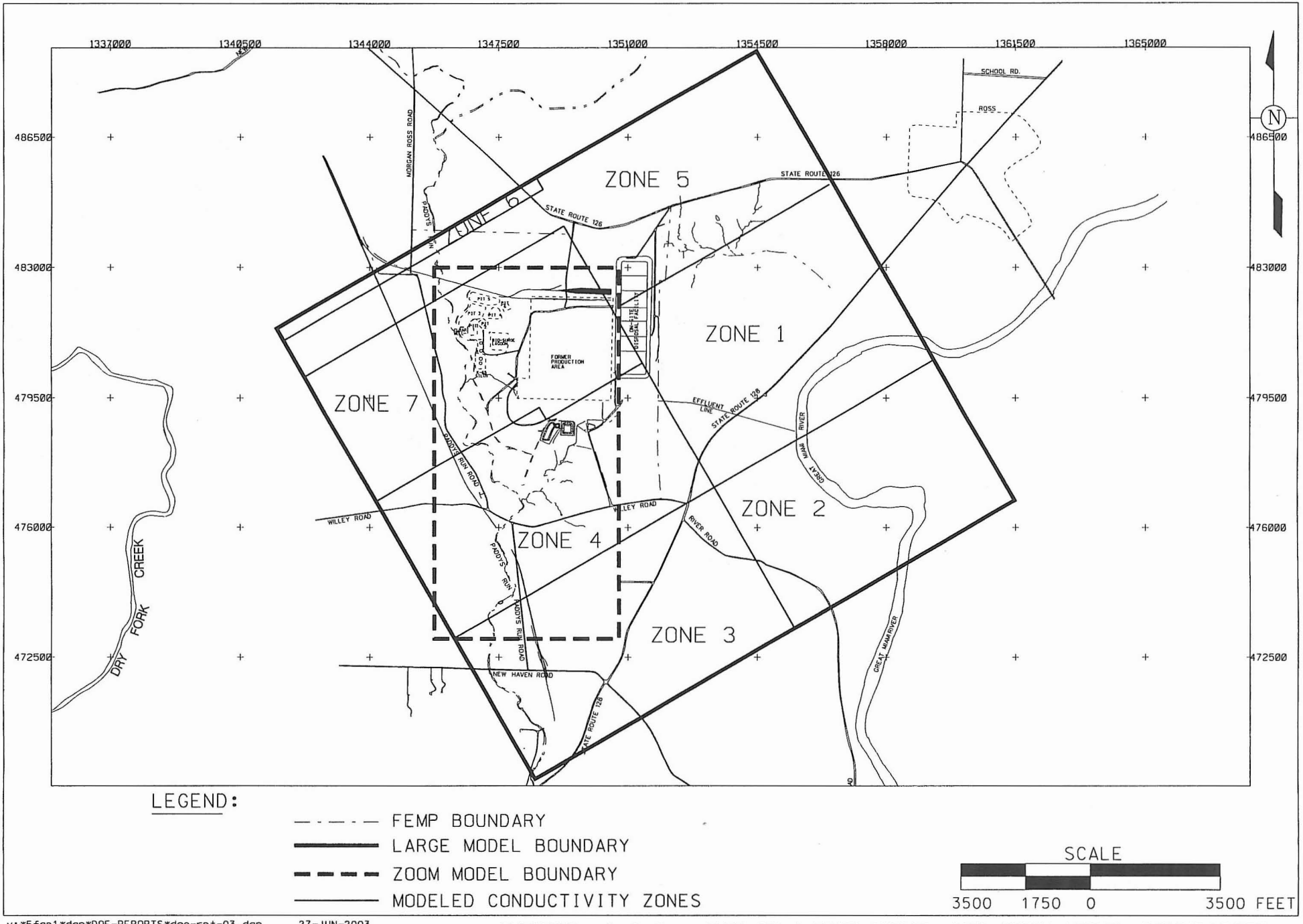


FIGURE A.1-1. EXTRACTION AND INJECTION WELL LOCATIONS

v:\5fgp1*dgn\DOE-REPORTS\doe-rpt-04.dgn

STATE PLANAR COORDINATE SYSTEM 1983

27-JUN-2003



v:*5fgp1*dgn*DOE-REPORTS*doe-rpt-03.dgn 27-JUN-2003
STATE PLANAR COORDINATE SYSTEM 1927

FIGURE A.1-2. VAM 3D LARGE MODEL AND ZOOM MODEL BOUNDARIES

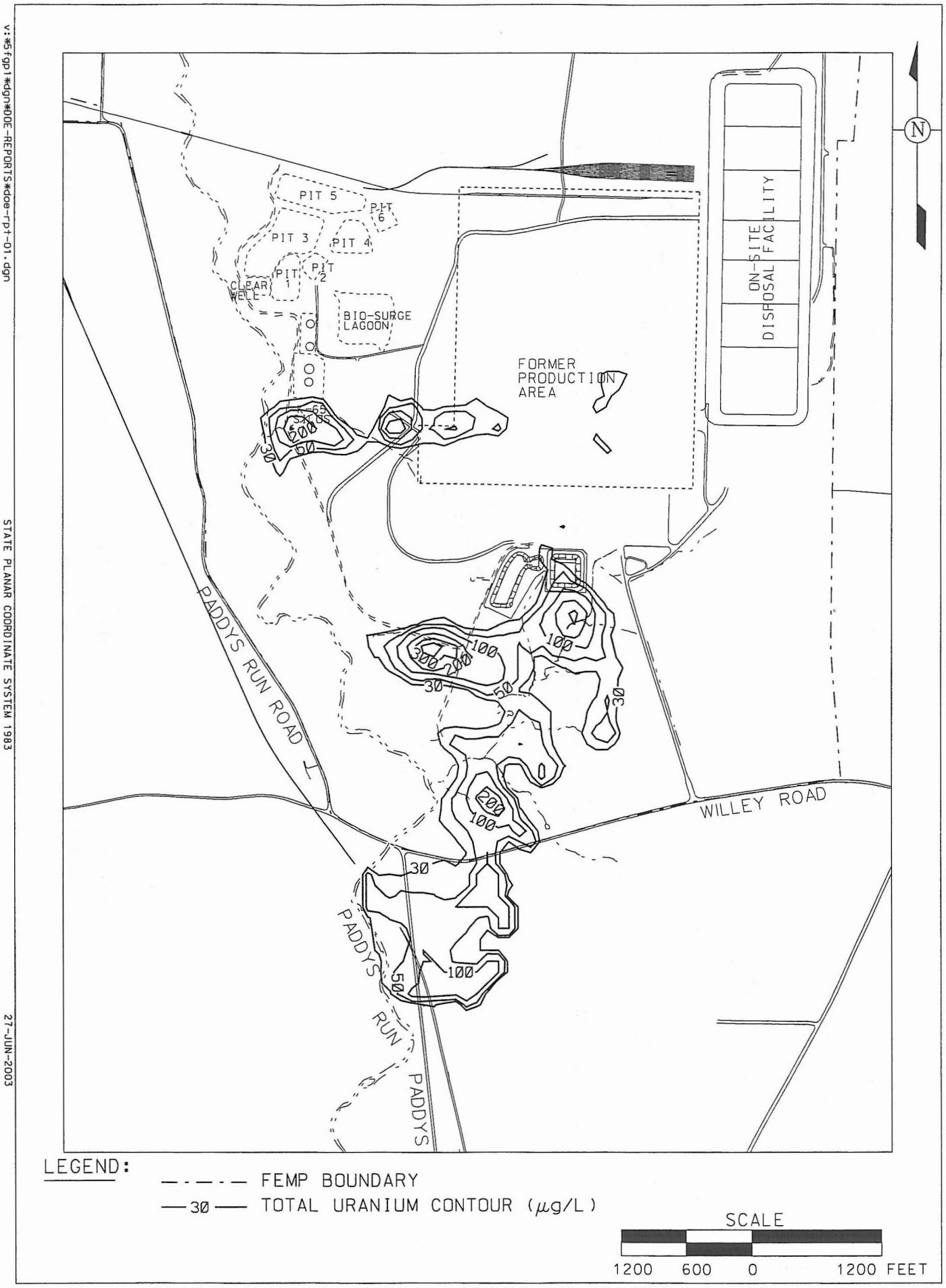


FIGURE A.1-3. INITIAL CONDITIONS (DECEMBER 2002) FOR TRANSPORT RUNS. MODEL LAYER 12

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STATE PLANAR COORDINATE SYSTEM 1983
27-JUN-2003

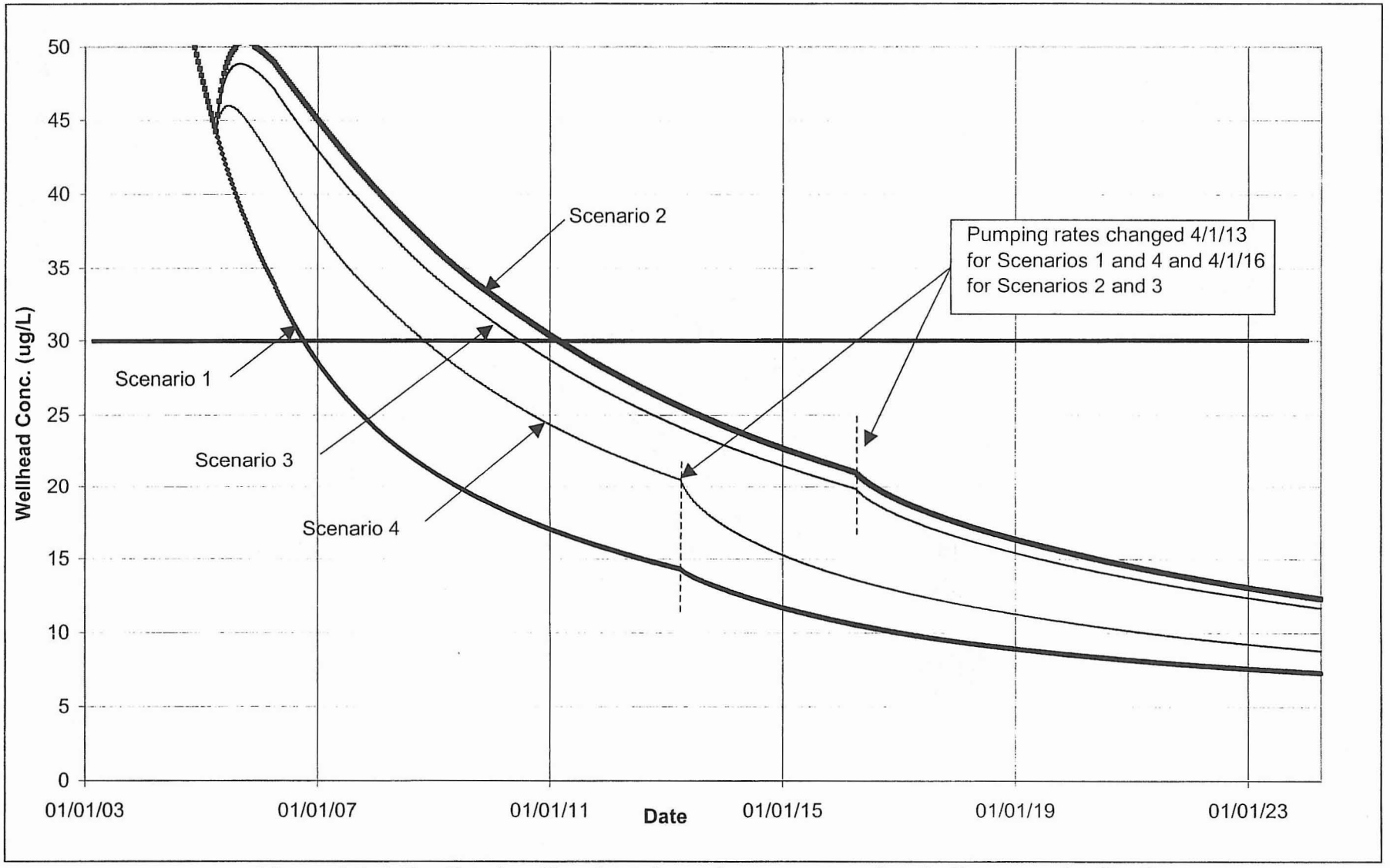
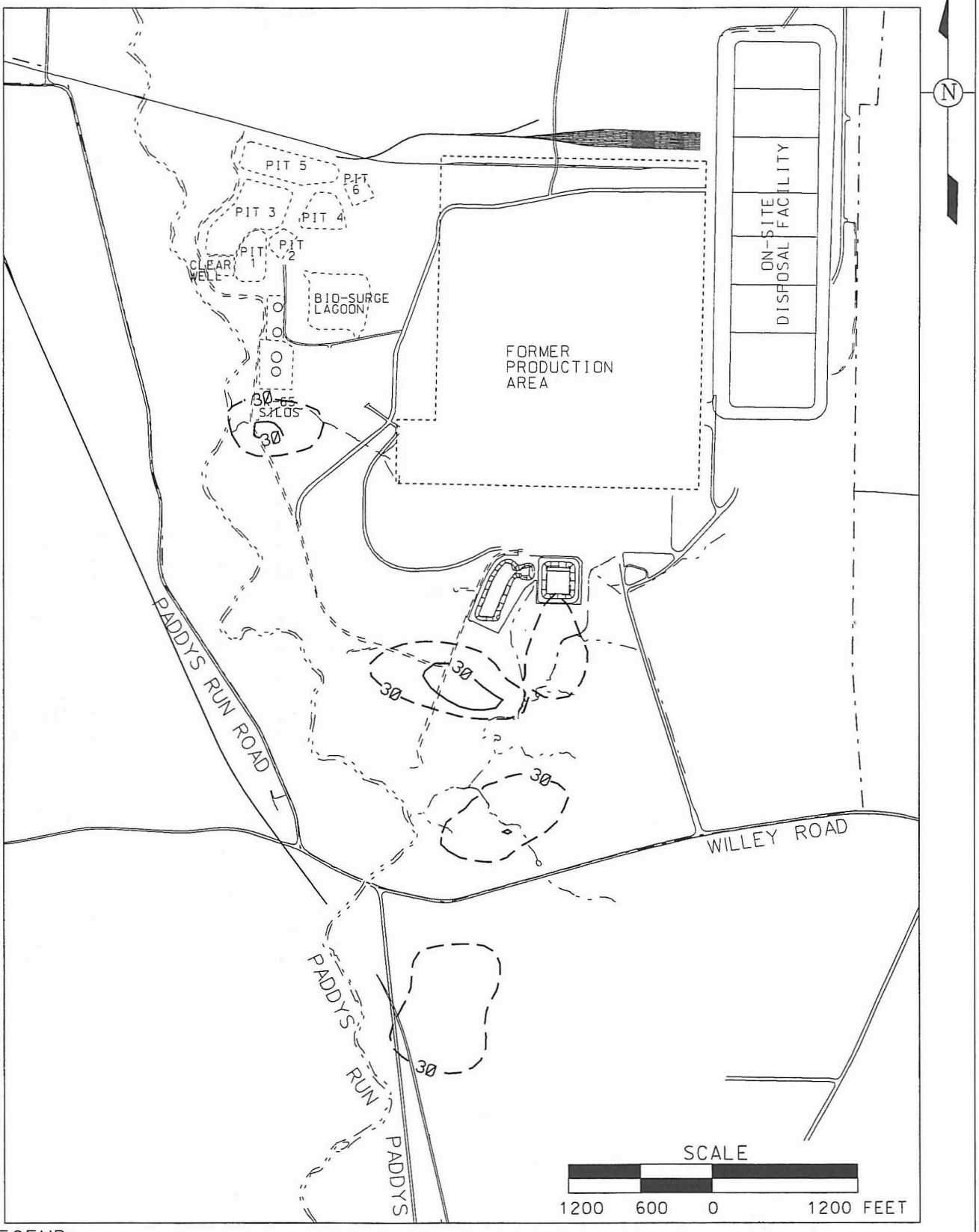


Figure A.1-4. Predicted wellhead total uranium concentration decline curve for South Field Extraction Well 32276 from VAM3D model for Scenarios 1, 2, 3, and 4



LEGEND:

—·30— - TOTAL URANIUM CONTOUR (μg/L) Kd 4.0 (L/kg)

—30— TOTAL URANIUM CONTOUR (μg/L) Kd 1.78 (L/kg)

—·—·— FEMP BOUNDARY

FIGURE A.1-5. COMPARISON OF PREDICTED TOTAL URANIUM PLUME IN MODEL LAYER 12 AT 2015 WITH A Kd OF 1.78 AND 4.0 L/kg

v:\5fgp1\dgn\DOE-REPORTS\doe-rpt-02.dgn
STATE PLANAR COORDINATE SYSTEM 1983
27-JUN-2003

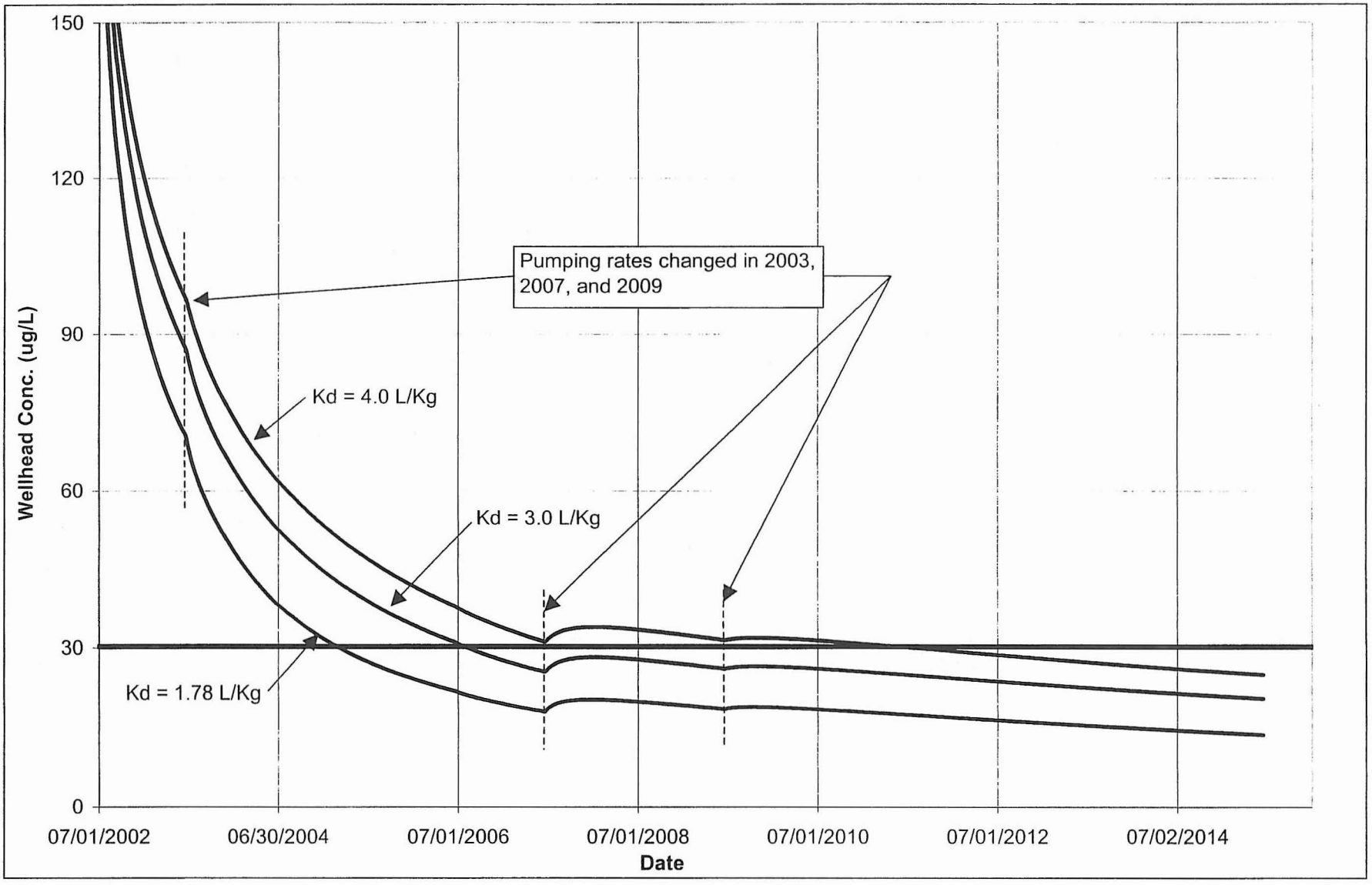


Figure A.1-6. Predicted wellhead total uranium concentrations for South Field Extraction Well 32276 for different K_d values

FERNALD
Closure Project

COMPREHENSIVE GROUNDWATER STRATEGY REPORT

Attachment A.2

Determination of Dates for Ending Groundwater Treatment

ATTACHMENT A.2

DETERMINATION OF DATES FOR ENDING GROUNDWATER TREATMENT

An Excel spreadsheet called Testpump was used to determine when water treatment would no longer be required for each of the groundwater alternatives. Yearly uranium discharges (average concentration and pounds of uranium) to the Great Miami River (GMR) for each groundwater alternative were calculated. Once calculated, an average uranium outfall discharge concentration of 30 μg/L and discharge mass of no more than 600 lbs. of uranium per year were used to identify when groundwater treatment would no longer be required for each of the groundwater alternatives.

Testpump calculates a flow weighted average uranium concentration for water discharged to the GMR and a weighted average mass of uranium discharged to the GMR using Water Treatment System and Well Field System Inputs. Table A.2-1 is a three-page printout of the Testpump calculation spreadsheet. Page one addresses Water Treatment Systems operations, which includes effluent concentrations and flow capacities for each water treatment system component. Page two addresses Well Field Systems operations, which includes pumping rates and uranium concentrations for each extraction well, and injection rates for each re-injection well. Page three provides the output, in the form of flow and concentration summaries for the net treatment effluent, groundwater being bypassed around treatment, and the outfall to the GMR.

The Water Treatment System parameters used in the Excel spreadsheet are provided in Tables A.2-2 through A.2-5 for each of the groundwater alternatives. Well pumping and re-injection rates for each groundwater alternative are presented in Attachment A.1. Using these parameters and pumping rates, Testpump was used with three different sets of input for the pumping well uranium concentrations, resulting in three different calculations that predict when treatment will no longer be needed for groundwater.

Calculation #1 used existing operational data, specifically: uranium concentration data measured in the water being pumped from the extraction wells where an operational history has been established. Modeled data was used for the six new wells where operational data was not available. A regression analysis was conducted on the data set. The slope of a fitted regression line was determined for the data set using Excel software. The fitted regression line was projected forward in time to predict future uranium concentrations at the pumping wells for each year of the groundwater alternative being considered. Regression analysis results were loaded into Testpump for each year of each alternative.

Calculation #2 used the 95% upper confidence level (UCL) for the operational data set used in Calculation #1. Modeled data was used for the six new wells where operational data was not available. The slope of a fitted regression line was determined for the 95% UCL data set using Excel software. Results from the regression analysis were then loaded into Testpump for each year of each alternative.

Calculation #3 used groundwater model (VAM3D) predicted pumping well uranium concentrations. Results provide a comparison against operational and 95% UCL data.

Calculation #1: Operational Data

EPA guidance suggests that the slope of a fitted regression line be used as a statistical measure to assess concentration versus time data (EPA 1992). Uranium concentration versus time data for each operating extraction well is provided in Table-A.2-6. Figure A.2-1 is an example of a concentration versus time plot for Extraction Well 17. The plot was made using Excel software. The trend lines were produced using the trendline function provided in Excel. Most of the operational data exhibit an exponential trend, although some of the trends were judged to be linear, polynomial, or power. The type of trend used for each well is specified on Table A.2-6, above each well number.

Some extraction wells used in the groundwater remedy have no operational history (Extraction Wells 15a, 30, 31, 32, WSA5 and WSA6). For these wells model predicted concentration output from the VAM3D model was used as input to the Testpump calculation. Model predicted concentration output from VAM3D for each groundwater alternative is provided in Tables A.2-7 through A.2-10.

Excel Testpump results using operation data are provided in Table A.2-11. Page 1 of the Table reports on Alternatives 1 & 2. Page 2 reports on Alternatives 2A, 2B, 3, 3B, 4, 4B, 5, and 5B. Page 3 reports on Alternative 6 and Page 4 reports on Alternative 7. With the Exception of Alternative 6, which has no treatment past April 1, 2005, the time period when the outfall limits are reached without treatment are presented at the bottom of each page. Should Alternative 6 be selected, operations data indicates that regulatory relief for discharge to the Great Miami River would be needed for approximately one year. Between October 1, 2005 and the outfall mass per year drops below 600 lbs. so regulatory relief would not be needed past April 1, 2006 if this concentration and mass decline scenario is borne out.

Calculation #2: 95% UCL for the Data Set Used in Calculation #1.

EPA guidance points out that the slope of a fitted regression line, by itself, is an insufficient statistical measure for determining concentration versus time trends because data always varies about the trend line (EPA 1992). EPA guidance suggests that the 95% confidence interval data should also be considered to help bracket uncertainty. Quality control considerations indicate that the majority of data should fall

within a 95% confidence interval about the regression line. Since regulators are concerned with the upper 95% confidence level, focus was placed on the upper 95% confidence limit data set (95% UCL).

A 95% UCL data set was derived from the data set used in Calculation #1 and a regression of the data was conducted. Table A.2-12 provides the resulting 95% UCL data set used as input for Testpump Calculation #2. Model predicted concentrations shown in Tables A.2-7 through A.2-10 were used for wells that did not have operational data.

Excel Testpump results using 95% UCL data are provided in Table A.2-13. Page 1 of the Table reports on Alternatives 1 & 2. Page 2 reports on Alternatives 2A, 2B, 3, 3B, 4, 4B, 5 and 5B. Page 3 reports on Alternative 6 and Page 4 reports on Alternative 7. With the Exception of Alternative 6, which has no treatment past April 1, 2005 the time period when the outfall limits are reached without treatment are presented at the bottom of each page. Should Alternative 6 be selected, operations data indicates that regulatory relief for discharge to the Great Miami River would be needed for approximately seven years. Between October 1, 2011 and October 1, 2012 the outfall mass per year drops below 600 pounds so regulatory relief would not be needed past October 1, 2012.

Calculation #3: Model (VAM3D) Predicted Concentrations

Individual well, uranium-concentration data resulting from the VAM3d groundwater model was used as input in Calculation #3. Tables A.2-7 through A.2-10 provide VAM3D modeled predicted concentrations for each extraction well in each groundwater alternative by year.

Excel Testpump results using modeled input data are provided in Table A.2-14. Page 1 of the Table reports on Alternatives 1 & 2. Page 2 reports on Alternatives 3, 4, and 5. Page 3 reports on Alternative 6 and Page 4 reports on Alternative 7. With the Exception of Alternative 6, which has no treatment past April 1, 2005, the time period when the outfall limits are reached without treatment are presented at the bottom of each page. Results using modeled concentrations as input indicate that no relief for the discharge limit to the Great Miami River would be required when treatment is stopped on April 1, 2005because the outfall mass going to the river each year is below 600 pounds.

Uncertainty

The range of dates given for each alternative for when water treatment will no longer be required illustrates the uncertainty that surrounds the estimates. For instance, if Alternative 1 was selected, the need for groundwater treatment should go away sometime between the years 2007 (operational data) and 2015 (95% UCL). This is the time period bracketed by the operational data and the 95% UCL of the

operational data. Model predictions are closer to the operational data dates. Contributing to this uncertainty are such things as:

- Variation from the scheduled pumping rates
- Rebound when pumping wells are turned off, and
- Long term and seasonal aquifer water table fluctuations

Variation from the scheduled pumping rates defined for each groundwater alternative will have an impact on the estimated date for ending groundwater treatment. This is illustrated for Extraction Well 22 in Figure A.1-4 The different pumping schedules outlined for each alternative impact when uranium concentrations in the well fall below 30 μg/L. This shows that not meeting the scheduled pumping rate for the chosen alternative will have an impact on when discharge concentrations of the remediation system meet established no-treatment criteria.

Re-bound refers to an increase in dissolved contamination concentrations in the aquifer once pumping stops. This situation is well documented in the industry for Pump-and-Treat Remediations. It is believed that rebound results from changes in flow behavior and rises in water levels once the pumping stops. Flow behavior within an aquifer is usually not homogenous and isotropic. During pumping, preferential flow pathways within the aquifer are established and it is these preferential flow pathways that get flushed of contamination the most. When pumping stops, any contamination in the less flushed areas of the aquifer has an increased opportunity to diffuse or migrate into the more flushed preferential pathway areas, raising dissolved concentrations in these areas once more.

Since the groundwater remediation is not near completion, no formal measure of rebound can be made at the FCP but some observed dissolved uranium increases at Extraction Wells following periods of non-operation have been informally attributed to rebound. For instance on August 11, 2001 Extraction Well 21 was shut down for 92 days to facilitate a pump/motor replacement. Prior to shutdown, the uranium concentration of the pumped water from this well was 71.6 μg/L. When the well was restarted in November, the uranium concentration in the pumped water had increased to 92.2 μg/L. As of March 25, 2002 the concentration had still not fallen back down to pre-maintenance concentrations.

Another contributing factor to the uncertainty of the provided time estimates is the impact that higher water levels or fluctuating aquifer recharge rates in the future could have on dissolved uranium concentrations in the aquifer. Uranium contamination is fixed to aquifer sediments above the water table in the vadose zone (SNL 2003). Higher water levels in the future could dissolve some of this contamination into the groundwater. Higher water levels appear to be the cause for a rise in uranium

concentrations in Extraction Well 17 in 2002. As shown in figure A.2-1 uranium concentrations in this well increased from the low 20 μg/L range (August 2001) to the high 20μg/L range (January 2003). The increase appears to correlate with an increase in water level recorded in nearby monitoring wells.

From a long term perspective water levels in the GMA at the FCP are lower today then they were in decades past. This is due to a combination of increased regional usage and localized FCP remediation pumping. If and when the water levels rise in the future, uranium contamination sorbed to the soils above the present day water table could desorb back into the groundwater and raise dissolved uranium concentration levels. Given historical perspective on aquifer usage, it is doubtful that regional usage of the aquifer will decrease in the future, but localized remediation pumping at the FCP will stop, and when it does water levels will rise locally.

References

EPA, 1992, "General Methods for Remedial Operation Performance Evaluations", January 1992, EPA/600/R-92/002, Robert S. Kerr Environmental Research Laboratory, Ada. OK.

SNL, 2003, "Selective Sequential Extraction Analysis of Uranium in Great Miami Aquifer Sediment Samples, Fernald DOE site, Ohio, April 2003, SAND2003-1092P, Sandia National Laboratories, Carlsbad, NM.

TABLE A.2-1

WATER TREATMENT SYSTEMS

2731

System Effluent Conc.	
System ID	Effluent Concentration (ppb)
AWWT/P1	12
AWWT/P2	30
IAWWT/T108	10
IAWWT/T109	10
AWWT/EXP	4.5
SPIT	1
STP	40

Treatment Excess (gpm)
0

Remediation Water	
System ID	Capacity (gpm)
AWWT/P1	0
AWWT/P2	33

Storm Water	
System ID	Capacity (gpm)
AWWT/P1	171
AWWT/P2	1
IAWWT/T108	15
IAWWT/T109	15

Sanitary Water	
System ID	Capacity (gpm)
STP	31

Groundwater	
System ID	Capacity (gpm)
AWWT/EXP	1829
SPIT	195
IAWWT/T108	122
IAWWT/T109	122
AWWT/P1	380
AWWT/P2	83

Injection Water	
Capacity (gpm)	Concentration (ppb)
1829	4.5

Net Treatment Effluent	
Flow Rate (gpm)	Concentration (ppb)
2397	8.3

TABLE A.2-1a

WELL FIELD SYSTEMS

South Plume Extraction System		
Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
RW-1	300	22.6
RW-2	300	21.9
RW-3	400	34.9
RW-4	500	3.0
RW-6	300	53.8
RW-7	300	55.7
S. Plume	2100	29.4

South Field Extraction System		
Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
EW 15A	220	18.4
EW 17	275	32.0
EW 18	110	49.4
EW 19	110	52.5
EW 20	110	38.0
EW 21	300	68.5
EW 22	330	100.9
EW 23	300	117.5
EW 24	200	67.2
EW 25	300	56.7
EW 30	0	0.0
EW 31	0	0.0
EW 32	0	0.0
S. Field	2255	65.5

Re-Injection Systems		
Well ID	Injection Rate (gpm)	Total U Concentration (ppb)
IW 8A	0	4.5
IW 9A	0	4.5
IW 10	200	4.5
IW 10A	0	4.5
IW 11	200	4.5
IW 12	200	4.5
IW 16	0	4.5
IW 29	0	4.5
Basins	0	4.5
S. Field	600	4.5

Waste Storage Area/Pilot Plant Draingage Ditch System		
Well ID	Pumping Rate (gpm)	Total U Concentration (ppb)
EW 26	300	89.2
EW 27	400	101.3
EW 28	400	57.8
5	0	0.0
6	0	0.0
WSA/PPDD	1100	82.2

Sorted Well List	T=Treat S = Split B = Bypass X = Not Pumping	Groundwater to Treatment	Groundwater to Bypass
EW 23	T	300	0
EW 27	T	400	0
EW 22	T	330	0
EW 26	T	300	0
EW 21	T	300	0
EW 24	T	200	0
EW 28	T	400	0
EW 25	T	300	0
EW 19	T	110	0
EW 18	B	0	110
EW 20	B	0	110
EW 17	B	0	275
S. Plume	B	0	2100
EW 15A	B	0	220
5	X	0	0
6	X	0	0
EW 30	X	0	0
EW 31	X	0	0
EW 32	X	0	0

Groundwater to Treatment (gpm)	Concentration to Treatment (ppb)
2640	61.7

Total Pumping All Systems (gpm)	Total Injection All Systems (gpm)	Net Pumping (Extraction - Injection) (gpm)
5455	600	4855

Groundwater to Bypass (gpm)	Concentration to Bypass (gpm)
2815	29.9

TABLE A.2-1b

CONCENTRATION SUMMARY

Component	Net Treatment Effluent Flow Rate (gpm)	Concentration (ppb)	Mass per Day (lbs)
Net Treated	2397	8.3	0.24
Excess	0	81.7	0.00

Groundwater to Bypass Flow Rate (gpm)	Concentration (ppb)	Mass per Day (lbs)
2815	29.9	1.01

Outfall Flow Rate (gpm)	Concentration ppb	Mass per Day (lbs)	Mass per Yr (lbs)
5212	19.9	1.25	455

TABLE A.2-2

ALTERNATIVES 1 and 2
WATER TREATMENT SYSTEM PARAMETERS

		Month	SW Treat (gpm)	RWW Treat (gpm)	GW Pumped	GW Inj (gpm)	Sanitary WW (gpm)	GW Treated (gpm)	GW Bypass	Net Flow To GMR
2003	June	1	300	300	5965	-1400	31	2325	3640	5196
	July	2	300	300	5965	-1400	31	2325	3640	5196
	August	3	300	300	5965	-1400	31	2325	3640	5196
	September	4	300	300	5965	-1400	31	2325	3640	5196
	October	5	300	300	5965	-1400	31	2325	3640	5196
	November	6	300	300	5965	-1400	31	2325	3640	5196
	December	7	300	300	5965	-1400	31	2325	3640	5196
2004	January	8	300	300	5965	-1400	31	2325	3640	5196
	February	9	300	300	5965	-1400	31	2325	3640	5196
	March	10	300	300	5965	-1400	31	2325	3640	5196
	April	11	300	300	5965	-1400	31	2325	3640	5196
	May	12	300	300	5965	-1400	31	2325	3640	5196
	June	13	300	300	5965	-1400	31	2325	3640	5196
	July	14	300	300	5965	-1400	31	2325	3640	5196
	August	15	300	300	5965	-1400	31	2325	3640	5196
	September	16	300	300	5965	-1400	31	2325	3640	5196
	October	17	300	300	5965	-1400	31	2325	3640	5196
	November	18	300	300	5965	-1400	31	2325	3640	5196
	December	19	300	300	5965	-1400	31	2325	3640	5196
2005	January	20	200	200	5965	-1400	31	2525	3440	4996
	February	21	200	200	5965	-1400	31	2525	3440	4996
	March	22	200	200	5965	-1400	31	2525	3440	4996
	April	23	200	200	5965	-1400	31	2000	3965	4996
	May	24	200	200	5965	-1400	31	2000	3965	4996
	June	25	200	200	5965	-1400	31	2000	3965	4996
	July	26	200	200	5965	-1400	0	2000	3965	4965
	August	27	200	200	5965	-1400	0	2000	3965	4965
	September	28	200	200	5965	-1400	0	2000	3965	4965
	October	29	200	200	5965	-1400	0	2000	3965	4965
	November	30	200	200	5965	-1400	0	2000	3965	4965
	December	31	200	200	5965	-1400	0	2000	3965	4965
2006	January	32	0	200	5965	-1400	0	2200	3765	4765
	February	33	0	200	5965	-1400	0	2200	3765	4765
	March	34	0	200	5965	-1400	0	2200	3765	4765
	April	35	0	0	6565	-1400	0	2400	4165	5165
	May	36	0	0	6565	-1400	0	2400	4165	5165
	June	37	0	0	6565	-1400	0	2400	4165	5165
	July	38	0	0	6565	-1400	0	2400	4165	5165
	August	39	0	0	6565	-1400	0	2400	4165	5165
	September	40	0	0	6565	-1400	0	2400	4165	5165
	October	41	0	0	6565	-1400	0	2400	4165	5165
	November	42	0	0	6565	-1400	0	2400	4165	5165
	December	43	0	0	6565	-1400	0	2400	4165	5165
					TO 4/01/13					

TABLE A.2-3

ALTERNATIVES 2A, 2B, 3, 3B, 4, 4B, 5 and 5B
WATER TREATMENT SYSTEM PARAMETERS

	Month	SW Treat (gpm)	RWW Treat (gpm)	GW Pumped	GW Inj (gpm)	Sanitary WW (gpm)	GW Treated (gpm)	GW Bypass	Net Flow To GMR
2003 June	1	300	300	5965	-1400	31	2325	3640	5196
July	2	300	300	5965	-1400	31	2325	3640	5196
August	3	300	300	5965	-1400	31	2325	3640	5196
September	4	300	300	5965	-1400	31	2325	3640	5196
October	5	300	300	5965	-1400	31	2325	3640	5196
November	6	300	300	5965	-1400	31	2325	3640	5196
December	7	300	300	5965	-1400	31	2325	3640	5196
2004 January	8	300	300	5965	-1400	31	2325	3640	5196
February	9	300	300	5965	-1400	31	2325	3640	5196
March	10	300	300	5965	-1400	31	2325	3640	5196
April	11	300	300	5965	-1400	31	2325	3640	5196
May	12	300	300	5965	-1400	31	2325	3640	5196
June	13	300	300	5965	-1400	31	2325	3640	5196
July	14	300	300	5965	-1400	31	2325	3640	5196
August	15	300	300	5965	-1400	31	2325	3640	5196
September	16	300	300	5965	-1400	31	2325	3640	5196
October	17	300	300	5965	-1400	31	2325	3640	5196
November	18	300	300	5965	-1400	31	2325	3640	5196
December	19	300	300	5965	-1400	31	2325	3640	5196
2005 January	20	200	200	5965	-1400	31	2525	3440	4996
February	21	200	200	5965	-1400	31	2525	3440	4996
March	22	200	200	5965	-1400	31	2525	3440	4996
April	23	100	200	4275	0	31	500	3775	4606
May	24	100	200	4275	0	31	500	3775	4606
June	25	100	200	4275	0	31	500	3775	4606
July	26	100	200	4275	0	0	500	3775	4575
August	27	100	200	4275	0	0	500	3775	4575
September	28	100	200	4275	0	0	500	3775	4575
October	29	100	200	4275	0	0	500	3775	4575
November	30	100	200	4275	0	0	500	3775	4575
December	31	100	200	4275	0	0	500	3775	4575
2006 January	32	0	200	4275	0	0	600	3675	4475
February	33	0	200	4275	0	0	600	3675	4475
March	34	0	200	4275	0	0	600	3675	4475
April	35	0	0	4675	0	0	800	3875	4675
May	36	0	0	4675	0	0	800	3875	4675
June	37	0	0	4675	0	0	800	3875	4675
July	38	0	0	4675	0	0	800	3875	4675
August	39	0	0	4675	0	0	800	3875	4675
September	40	0	0	4675	0	0	800	3875	4675
October	41	0	0	4675	0	0	800	3875	4675
November	42	0	0	4675	0	0	800	3875	4675
December	43	0	0	4675	0	0	800	3875	4675
				TO 4/01/16					

TABLE A.2-4

ALTERNATIVE 6
WATER TREATMENT SYSTEM PARAMETERS

		Month	SW Treat (gpm)	RWW Treat (gpm)	GW Pumped	GW Inj (gpm)	Sanitary WW (gpm)	GW Treated (gpm)	GW Bypass	Net Flow To GMR
2003	June	1	300	300	5965	-1400	31	2325	3640	5196
	July	2	300	300	5965	-1400	31	2325	3640	5196
	August	3	300	300	5965	-1400	31	2325	3640	5196
	September	4	300	300	5965	-1400	31	2325	3640	5196
	October	5	300	300	5965	-1400	31	2325	3640	5196
	November	6	300	300	5965	-1400	31	2325	3640	5196
	December	7	300	300	5965	-1400	31	2325	3640	5196
2004	January	8	300	300	5965	-1400	31	2325	3640	5196
	February	9	300	300	5965	-1400	31	2325	3640	5196
	March	10	300	300	5965	-1400	31	2325	3640	5196
	April	11	300	300	5965	-1400	31	2325	3640	5196
	May	12	300	300	5965	-1400	31	2325	3640	5196
	June	13	300	300	5965	-1400	31	2325	3640	5196
	July	14	300	300	5965	-1400	31	2325	3640	5196
	August	15	300	300	5965	-1400	31	2325	3640	5196
	September	16	300	300	5965	-1400	31	2325	3640	5196
	October	17	300	300	5965	-1400	31	2325	3640	5196
	November	18	300	300	5965	-1400	31	2325	3640	5196
	December	19	300	300	5965	-1400	31	2325	3640	5196
2005	January	20	200	200	5965	-1400	31	2525	3440	4996
	February	21	200	200	5965	-1400	31	2525	3440	4996
	March	22	200	200	5965	-1400	31	2525	3440	4996
	April	23	0	0	4675	0	31	0	4675	4706
	May	24	0	0	4675	0	31	0	4675	4706
	June	25	0	0	4675	0	31	0	4675	4706
	July	26	0	0	4675	0	0	0	4675	4675
	August	27	0	0	4675	0	0	0	4675	4675
	September	28	0	0	4675	0	0	0	4675	4675
	October	29	0	0	4675	0	0	0	4675	4675
	November	30	0	0	4675	0	0	0	4675	4675
	December	31	0	0	4675	0	0	0	4675	4675
2006	January	32	0	0	4675	0	0	0	4675	4675
	February	33	0	0	4675	0	0	0	4675	4675
	March	34	0	0	4675	0	0	0	4675	4675
	April	35	0	0	5075	0	0	0	5075	5075
	May	36	0	0	5075	0	0	0	5075	5075
	June	37	0	0	5075	0	0	0	5075	5075
	July	38	0	0	5075	0	0	0	5075	5075
	August	39	0	0	5075	0	0	0	5075	5075
	September	40	0	0	5075	0	0	0	5075	5075
	October	41	0	0	5075	0	0	0	5075	5075
	November	42	0	0	5075	0	0	0	5075	5075
	December	43	0	0	5075	0	0	0	5075	5075
					To 4/01/16					

TABLE A.2-5

ALTERNATIVE 7
WATER TREATMENT SYSTEM PARAMETERS

		Month	SW Treat (gpm)	RWW Treat (gpm)	GW Pumped	GW Inj (gpm)	Sanitary WW (gpm)	GW Treated (gpm)	GW Bypass	Net Flow To GMR
2003	June	1	300	300	5965	-1400	31	2325	3640	5196
	July	2	300	300	5965	-1400	31	2325	3640	5196
	August	3	300	300	5965	-1400	31	2325	3640	5196
	September	4	300	300	5965	-1400	31	2325	3640	5196
	October	5	300	300	5965	-1400	31	2325	3640	5196
	November	6	300	300	5965	-1400	31	2325	3640	5196
	December	7	300	300	5965	-1400	31	2325	3640	5196
2004	January	8	300	300	5965	-1400	31	2325	3640	5196
	February	9	300	300	5965	-1400	31	2325	3640	5196
	March	10	300	300	5965	-1400	31	2325	3640	5196
	April	11	300	300	5965	-1400	31	2325	3640	5196
	May	12	300	300	5965	-1400	31	2325	3640	5196
	June	13	300	300	5965	-1400	31	2325	3640	5196
	July	14	300	300	5965	-1400	31	2325	3640	5196
	August	15	300	300	5965	-1400	31	2325	3640	5196
	September	16	300	300	5965	-1400	31	2325	3640	5196
	October	17	300	300	5965	-1400	31	2325	3640	5196
	November	18	300	300	5965	-1400	31	2325	3640	5196
	December	19	300	300	5965	-1400	31	2325	3640	5196
2005	January	20	200	200	5965	-1400	31	2525	3440	4996
	February	21	200	200	5965	-1400	31	2525	3440	4996
	March	22	200	200	5965	-1400	31	2525	3440	4996
	April	23	0	0	5465	-800	31	800	4665	4696
	May	24	0	0	5465	-800	31	800	4665	4696
	June	25	0	0	5465	-800	31	800	4665	4696
	July	26	0	0	5465	-800	0	800	4665	4665
	August	27	0	0	5465	-800	0	800	4665	4665
	September	28	0	0	5465	-800	0	800	4665	4665
	October	29	0	0	5465	-800	0	800	4665	4665
	November	30	0	0	5465	-800	0	800	4665	4665
	December	31	0	0	5465	-800	0	800	4665	4665
2006	January	32	0	0	5465	-800	0	800	4665	4665
	February	33	0	0	5465	-800	0	800	4665	4665
	March	34	0	0	5465	-800	0	800	4665	4665
	April	35	0	0	5865	-800	0	800	5065	5065
	May	36	0	0	5865	-800	0	800	5065	5065
	June	37	0	0	5865	-800	0	800	5065	5065
	July	38	0	0	5865	-800	0	800	5065	5065
	August	39	0	0	5865	-800	0	800	5065	5065
	September	40	0	0	5865	-800	0	800	5065	5065
	October	41	0	0	5865	-800	0	800	5065	5065
	November	42	0	0	5865	-800	0	800	5065	5065
	December	43	0	0	5865	-800	0	800	5065	5065
					TO 4/01/13					

TABLE A.2-6

URANIUM CONCENTRATIONS Vs. TIME FOR EACH OPERATING EXTRACTION WELL

a) EXPONENTIAL C = A*EXP(B*DATE)	exponential	exponential	exponential	linear fit	exponential	exponential	exponential	exponential	exponential	exponential	linear	poly	power	exponential	exponential	exponential	exponential	exponential
b) LINEAR C = A*DATE + B	SF 17	SF 18	SF 19	SF 20	SF 21	SF 22	SF 23	SF 24	SF 25	SP 3924	SP 3925	SP 3926	SP 3927	SP OPT 6	SP OPT 7	WSA 1	WSA 2	WSA 4
c) POLY C = A*DATE^3 + B*DATE^2+C*DATE+D	5.43432E+07	2.36028E+11	1.10288E+14	1.59486E-03	2.90915E+07	2.06252E+11	6.56860E+09	3.74963E+11	1.63162E+16	1.16220E+06	-7.69735E-03	-2.05537E-09	6.28847E-31	6.56572E+04	7.70987E+06	2.03230E+24	2.98084E+35	6.01957E+52
d) POWER C = A*DATE^B	-3.89092E-04	-6.02945E-04	-7.60935E-04	-9.86765E+00	-3.42099E-04	-5.73330E-04	-4.70539E-04	-6.01387E-04	-8.89097E-04	-2.83938E-04	3.13306E+02	2.22291E-04	6.68213E+00	-1.87861E-04	-3.16933E-04	-1.36361E-03	-2.04215E-03	-3.11321E-03
												-7.99907E+00						
DATE												9.57898E+04						
10/01/03	21.5	28.2	33.1	50.6	68.2	75.6	118.5	47.5	38.0	24.7	21.6	27.9	2.5	53.2	46.9	73.5	73.4	35.0
04/01/04	20.0	25.2	28.8	50.9	64.0	68.1	108.7	42.5	32.3	23.4	20.2	24.6	2.6	51.4	44.2	57.3	50.5	19.8
10/01/04	18.6	22.6	25.0	51.2	60.2	61.3	99.7	38.1	27.5	22.2	18.8	20.3	2.6	49.6	41.8	44.6	34.7	11.2
04/01/05	17.3	20.3	21.8	51.4	56.5	55.2	91.5	34.2	23.4	21.1	17.4	15.0	2.7	48.0	39.4	34.8	24.0	6.3
10/01/05	16.1	18.1	19.0	51.7	53.1	49.7	84.0	30.6	19.9	20.1	16.0	8.5	2.8	46.3	37.2	27.1	16.5	3.6
04/01/06	15.0	16.3	16.5	52.0	49.9	44.8	77.1	27.4	16.9	19.0	14.6	0.9	2.9	44.8	35.1	21.2	11.4	2.0
10/01/06	14.0	14.6	14.4	52.3	46.9	40.4	70.7	24.6	14.4	18.1	13.2	-8.1	3.0	43.3	33.1	16.5	7.8	1.2
04/01/07	13.1	13.0	12.5	52.6	44.0	36.4	64.9	22.0	12.2	17.2	11.8	-18.5	3.1	41.8	31.3	12.9	5.4	0.7
10/01/07	12.2	11.7	10.9	52.9	41.4	32.7	59.6	19.7	10.4	16.3	10.4	0.0	3.2	40.4	29.5	10.0	3.7	0.4
04/01/08	11.3	10.5	9.5	53.2	38.8	29.5	54.6	17.7	8.8	15.5	9.0	0.0	3.3	39.0	27.8	7.8	2.6	0.2
10/01/08	10.5	9.4	8.2	53.5	36.5	26.5	50.1	15.8	7.5	14.7	7.6	0.0	3.4	37.7	26.3	6.1	1.8	0.1
04/01/09	9.8	8.4	7.2	53.8	34.3	23.9	46.0	14.2	6.4	14.0	6.2	0.0	3.5	36.4	24.8	4.7	1.2	0.1
10/01/09	9.1	7.5	6.2	54.1	32.2	21.5	42.2	12.7	5.4	13.2	4.7	0.0	3.6	35.2	23.4	3.7	0.8	0.0
04/01/10	8.5	6.7	5.4	54.4	30.3	19.4	38.8	11.4	4.6	12.6	3.3	0.0	3.7	34.0	22.1	2.9	0.6	0.0
10/01/10	7.9	6.0	4.7	54.6	28.4	17.5	35.6	10.2	3.9	11.9	1.9	0.0	3.8	32.9	20.9	2.2	0.4	0.0
04/01/11	7.4	5.4	4.1	54.9	26.7	15.7	32.6	9.1	3.3	11.3	0.5	0.0	3.9	31.8	19.7	1.8	0.3	0.0
10/01/11	6.9	4.8	3.6	55.2	25.1	14.2	30.0	8.2	2.8	10.8	0.0	0.0	4.1	30.7	18.6	1.4	0.2	0.0
04/01/12	6.4	4.3	3.1	55.5	23.6	12.8	27.5	7.3	2.4	10.2	0.0	0.0	4.2	29.7	17.5	1.1	0.1	0.0
10/01/12	6.0	3.9	2.7	55.8	22.1	11.5	25.2	6.6	2.0	9.7	0.0	0.0	4.3	28.7	16.5	0.8	0.1	0.0
04/01/13	5.6	3.5	2.4	56.1	20.8	10.3	23.1	5.9	1.7	9.2	0.0	0.0	4.4	27.7	15.6	0.6	0.1	0.0
10/01/13	5.2	3.1	2.1	56.4	19.5	9.3	21.2	5.3	1.5	8.7	0.0	0.0	4.6	26.8	14.7	0.5	0.0	0.0
04/01/14	4.8	2.8	1.8	56.7	18.4	8.4	19.5	4.7	1.3	8.3	0.0	0.0	4.7	25.9	13.9	0.4	0.0	0.0
10/01/14	4.5	2.5	1.6	57.0	17.2	7.6	17.9	4.2	1.1	7.9	0.0	0.0	4.8	25.0	13.1	0.3	0.0	0.0
04/01/15	4.2	2.2	1.4	57.3	16.2	6.8	16.4	3.8	0.9	7.5	0.0	0.0	5.0	24.1	12.4	0.2	0.0	0.0
10/01/15	3.9	2.0	1.2	57.6	15.2	6.1	15.1	3.4	0.8	7.1	0.0	0.0	5.1	23.3	11.7	0.2	0.0	0.0
04/01/16	3.6	1.8	1.0	57.9	14.3	5.5	13.8	3.0	0.7	6.7	0.0	0.0	5.3	22.5	11.0	0.1	0.0	0.0
10/01/16	3.4	1.6	0.9	58.1	13.4	5.0	12.7	2.7	0.6	6.4	0.0	0.0	5.4	21.8	10.4	0.1	0.0	0.0
04/01/17	3.2	1.4	0.8	58.4	12.6	4.5	11.6	2.4	0.5	6.1	0.0	0.0	5.6	21.0	9.8	0.1	0.0	0.0
10/01/17	2.9	1.3	0.7	58.7	11.9	4.0	10.7	2.2	0.4	5.8	0.0	0.0	5.8	20.3	9.3	0.1	0.0	0.0
04/01/18	2.7	1.2	0.6	59.0	11.1	3.6	9.8	2.0	0.3	5.5	0.0	0.0	5.9	19.7	8.8	0.1	0.0	0.0
10/01/18	2.5	1.0	0.5	59.3	10.5	3.3	9.0	1.8	0.3	5.2	0.0	0.0	6.1	19.0	8.3	0.0	0.0	0.0
04/01/19	2.4	0.9	0.4	59.6	9.8	2.9	8.3	1.6	0.2	4.9	0.0	0.0	6.3	18.4	7.8	0.0	0.0	0.0
10/01/19	2.2	0.8	0.4	59.9	9.2	2.7	7.6	1.4	0.2	4.7	0.0	0.0	6.4	17.7	7.4	0.0	0.0	0.0
04/01/20	2.1	0.7	0.3	60.2	8.7	2.4	6.9	1.3	0.2	4.5	0.0	0.0	6.6	17.1	6.9	0.0	0.0	0.0
10/01/20	1.9	0.7	0.3	60.5	8.1	2.2	6.4	1.1	0.2	4.2	0.0	0.0	6.8	16.6	6.6	0.0	0.0	0.0
04/01/21	1.8	0.6	0.3	60.8	7.7	1.9	5.9	1.0	0.1	4.0	0.0	0.0	7.0	16.0	6.2	0.0	0.0	0.0
10/01/21	1.7	0.5	0.2	61.1	7.2	1.7	5.4	0.9	0.1	3.8	0.0	0.0	7.2	15.5	5.8	0.0	0.0	0.0
04/01/22	1.5	0.5	0.2	61.3	6.8	1.6	4.9	0.8	0.1	3.6	0.0	0.0	7.4	14.9	5.5	0.0	0.0	0.0
10/01/22	1.4	0.4	0.2	61.6	6.3	1.4	4.5	0.7	0.1	3.4	0.0	0.0	7.6	14.4	5.2	0.0	0.0	0.0
04/01/23	1.3	0.4	0.1	61.9	6.0	1.3	4.2	0.7	0.1	3.3	0.0	0.0	7.8	13.9	4.9	0.0	0.0	0.0
10/01/23	1.3	0.3	0.1	62.2	5.6	1.1	3.8	0.6	0.1	3.1	0.0	0.0	8.0	13.5	4.6	0.0	0.0	0.0
04/01/24	1.2	0.3	0.1	62.5	5.3	1.0	3.5	0.5	0.0	2.9	0.0	0.0	8.3	13.0	4.4	0.0	0.0	0.0
10/01/24	1.1	0.3	0.1	62.8	4.9	0.9	3.2	0.5	0.0	2.8	0.0	0.0	8.5	12.6	4.1	0.0	0.0	0.0
04/01/25	1.0	0.2	0.1	63.1	4.6	0.8	2.9	0.4	0.0	2.7	0.0	0.0	8.7	12.2	3.9	0.0	0.0	0.0
10/01/25	0.9	0.2	0.1	63.4	4.4	0.8	2.7	0.4	0.0	2.5	0.0	0.0	8.9	11.7	3.7	0.0	0.0	0.0
04/01/26	0.9	0.2	0.1	63.7	4.1	0.7	2.5	0.3	0.0	2.4	0.0	0.0	9.2	11.4	3.5	0.0	0.0	0.0
10/01/26	0.8	0.2	0.1	64.0	3.9	0.6	2.3	0.3	0.0	2.3	0.0	0.0	9.4	11.0	3.3	0.0	0.0	0.0
04/01/27	0.8	0.2	0.0	64.3	3.6	0.6	2.1	0.3	0.0	2.2	0.0	0.0	9.7	10.6	3.1	0.0	0.0	0.0

TABLE A.2-7

ALTERNATIVES 1 AND 2
VAM3D PREDICTED URANIUM CONCENTRATIONS FOR EACH EXTRACTION WELL

Well	04/02/2003	04/01/2004	04/01/2005	04/01/2006	04/02/2007	04/01/2008	04/01/2009	04/01/2010	04/02/2011	04/01/2012	04/01/2013	04/01/2014	04/02/2015	04/01/2016	04/01/2017	04/01/2018	04/02/2019	04/01/2020	04/01/2021	04/01/2022	04/02/2023	04/01/2024
3924	13.5	12.1	10.6	9.6	8.9	8.3	7.8	7.4	7	6.6	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3925	5.1	8.1	10.3	11.6	12.2	12.4	12.4	12.2	11.9	11.5	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3926	1.1	2.9	5	6.8	8.2	9.2	9.9	10.4	10.6	10.7	10.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3927	2.7	2.8	2.9	3	3.1	3.1	3.2	3.3	3.4	3.4	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opt-6	34.9	28.6	28	27.1	25.6	24	22.4	20.8	19.4	18.1	17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opt-7	50.2	46.7	41.1	36.2	32.2	28.9	26.1	23.6	21.4	19.5	17.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF-31	124.9	84.9	66.9	55.6	46.2	40.1	35.3	31.3	28	25.2	22.8	19.1	16.6	14.5	12.9	11.5	10.3	9.4	8.5	7.8	7.2	6.6
SF-17	42.4	42.4	43.3	43.1	42.2	40.8	39	37	34.9	32.8	30.8	26.3	23.4	21	19	17.3	15.8	14.5	13.3	12.3	11.4	10.5
SF-18	52.6	44.6	41.3	38	35.3	32.7	30.2	27.9	25.8	24	22.3	21.6	20.4	19.2	18	16.9	15.9	15	14.1	13.4	12.7	12.1
SF-19	40.7	27.8	23.1	20.3	18.4	17	15.9	15	14.2	13.5	13	12	11.4	10.9	10.5	10.1	9.7	9.3	8.9	8.6	8.3	8
SF-20	15.8	15.1	16.1	16.9	16.8	16.6	16.4	16.1	15.7	15.3	14.9	12.7	11.5	10.6	9.8	9.1	8.5	8	7.6	7.1	6.7	6.4
SF-21	70.2	55.7	45	37.4	31.2	27.1	23.9	21.4	19.4	17.6	16.1	13.5	12	10.7	9.7	8.8	8	7.3	6.8	6.2	5.8	5.3
SF-22	130.2	65.3	44.2	34	27.3	23.2	20.4	18.3	16.7	15.4	14.3	12.6	11.4	10.5	9.8	9.3	8.8	8.4	8.1	7.8	7.5	7.3
SF-23	75.6	50.8	40.2	33.9	29.2	26	23.7	22	20.5	19.3	18.1	16	14.6	13.4	12.4	11.5	10.8	10.1	9.6	9.1	8.6	8.2
SF-24	23.7	21.1	20.3	19.4	18.1	16.8	15.6	14.6	13.6	12.7	11.9	10.7	9.9	9.3	8.8	8.4	8.1	7.8	7.5	7.3	7.1	6.9
SF-25	98.8	55	40.4	32.3	26.7	22.9	20.1	17.8	16	14.4	13.1	10.8	9.5	8.5	7.7	7	6.4	5.9	5.5	5.1	4.7	4.4
SF-32	96.2	41.5	26.9	19.6	15	12.2	10.2	8.8	7.7	6.8	6.1	4.7	4	3.5	3.1	2.8	2.6	2.4	2.2	2.1	1.9	1.8
SF-33	64	29.7	20	15	11.9	9.8	8.3	7.2	6.3	5.6	5	4	3.5	3	2.7	2.4	2.2	2	1.8	1.7	1.5	1.4
SF-34	13.6	5.7	4	3.1	2.6	2.2	2	1.8	1.7	1.5	1.5	1.3	1.2	1.2	1.1	1.1	1	1	1	1	0.9	0.9
WSA-1	54.3	38.4	36.8	36	35.7	34.5	33.1	31.5	30	28.5	27.1	23.5	21.6	20	18.6	17.4	16.3	15.3	14.4	13.6	12.9	12.2
WSA-2	46.9	38.1	30	24.7	19.9	16.6	14.4	12.9	11.9	11.1	10.5	9.8	9.3	8.8	8.5	8.2	8	7.8	7.6	7.5	7.3	7.2
WSA-4	34.3	18.8	14.5	12	10.2	8.9	7.9	7.1	6.4	5.9	5.4	5.1	4.7	4.5	4.2	4	3.9	3.7	3.6	0.0	0.0	0.0
WSA-5	8	7.4	7.3	7.3	7.4	7.5	7.5	7.5	7.5	7.4	7.3	7.2	7	6.8	6.6	6.3	6.1	5.8	5.6	0.0	0.0	0.0
WSA-6	13.8	11.8	10.8	10	9.4	8.8	8.2	7.7	7.1	6.5	5.9	5.4	4.9	4.5	4.1	3.7	3.4	3	2.8	0.0	0.0	0.0

TABLE A.2-8

ALTERNATIVES 2A, 2B, 3, 3B, 4, 4B, 5 AND 5B
VAM3D PREDICTED URANIUM CONCENTRATIONS FOR EACH EXTRACTION WELL

Well	04/02/2003	04/01/2004	04/01/2005	04/01/2006	04/02/2007	04/01/2008	04/01/2009	04/01/2010	04/02/2011	04/01/2012	04/01/2013	04/01/2014	04/01/2015	04/01/2016	04/01/2017	04/01/2018	04/02/2019	04/01/2020	04/01/2021	04/01/2022	04/02/2023	04/01/2024	04/01/2025	04/01/2026	04/02/2027
3924	13.5	12.1	10.6	10	9.3	8.8	8.3	7.8	7.4	7	6.7	6.3	6	5.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3925	5.1	8.1	10.3	11.4	12	12.3	12.4	12.3	12.1	11.9	11.6	11.2	10.9	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3926	1.1	2.9	5	6.4	7.6	8.6	9.5	10.1	10.6	11	11.2	11.4	11.4	11.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3927	2.7	2.8	2.9	3	3	3.1	3.2	3.3	3.3	3.4	3.5	3.5	3.6	3.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opt-6	34.9	28.6	28	27.3	26.5	25.6	24.7	23.7	22.7	21.8	20.8	19.9	19	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opt-7	50.2	46.7	41.1	38.4	35.2	32.3	29.7	27.3	25.1	23.1	21.3	19.7	18.1	16.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF-31	124.9	84.9	66.9	58.9	50.9	45.2	40.5	36.5	33	29.9	27.2	24.8	22.7	20.8	18.2	16.3	14.6	13.2	12	10.9	10	9.1	8.4	7.7	7.1
SF-17	42.4	42.4	43.3	40.2	38.2	36.3	34.5	32.7	31	29.3	27.7	26.2	24.8	23.4	22	20.6	19.3	18.1	17	15.9	14.9	14	13.2	12.4	11.7
SF-18	52.6	44.6	41.3	35.4	31.5	28.4	25.9	24	22.3	20.9	19.7	18.6	17.7	16.8	16.6	16	15.4	14.7	14	13.4	12.8	12.2	11.7	11.2	10.7
SF-19	40.7	27.8	23.1	20.3	19.5	19.3	19.4	19.6	19.9	20.1	20.3	20.4	20.5	20.5	18.5	17.3	16.4	15.6	15	14.4	13.9	13.4	12.9	12.4	12
SF-20	15.8	15.1	16.1	19.2	20.2	20.6	20.5	20.2	19.9	19.4	18.9	18.4	17.8	17.3	15.3	14.5	13.8	13.2	12.6	12	11.4	10.9	10.4	9.9	9.5
SF-21	70.2	55.7	45	42.5	37.8	34.1	31	28.4	26.1	24.2	22.4	20.9	19.5	18.2	15.7	14.1	12.8	11.8	10.8	10	9.3	8.7	8.1	7.6	7.1
SF-22	130.2	65.3	44.2	48.9	43.8	39.3	35.5	32.4	29.7	27.5	25.5	23.9	22.3	21	18.6	17.2	16.1	15.1	14.3	13.6	12.9	12.3	11.7	11.2	10.7
SF-23	75.6	50.8	40.2	36.6	31.4	27.2	23.8	21.1	18.9	17	15.5	14.3	13.2	12.4	11.5	10.8	10.2	9.7	9.2	8.8	8.4	8.1	7.7	7.4	7.1
SF-24	23.7	21.1	20.3	21.6	22	22	21.6	20.9	20.1	19.1	18.2	17.3	16.4	15.5	14.3	13.4	12.6	11.9	11.3	10.7	10.2	9.7	9.3	9	8.6
SF-25	98.8	55	40.4	34.8	30.6	27.5	25	22.9	21	19.5	18.1	16.9	15.8	14.8	12.9	11.7	10.8	10	9.3	8.6	8.1	7.6	7.2	6.8	6.5
SF-32	96.2	41.5	26.9	20.8	16.5	13.5	11.3	9.6	8.3	7.3	6.5	5.8	5.3	4.8	4.1	3.6	3.2	2.9	2.7	2.4	2.3	2.1	2	1.9	1.8
SF-33	64	29.7	20	15.4	12.5	10.5	9.1	8.1	7.2	6.6	6	5.6	5.2	4.8	4	3.6	3.2	2.9	2.7	2.5	2.3	2.1	2	1.8	1.7
SF-34	13.6	5.7	4	3.4	2.9	2.6	2.3	2.1	1.9	1.8	1.6	1.5	1.5	1.4	1.3	1.2	1.1	1.1	1	1	1	0.9	0.9	0.9	0.9
WSA-1	54.3	38.4	36.8	35.1	34.6	33.6	32.5	31.3	30.1	28.8	27.6	26.4	25.3	24.2	21.3	19.7	18.4	17.3	16.3	15.4	14.6	13.9	13.2	12.6	12
WSA-2	46.9	38.1	30	27.1	24.1	21.6	19.6	18	16.7	15.6	14.7	14	13.4	12.8	11.9	11.4	11	10.6	10.3	10	9.8	9.6	9.4	9.2	9.1
WSA-4	36.2	23	18.9	16.3	14.5	13.1	11.9	11	10.2	9.5	8.9	8.2	7.7	7.3	6.9	6.6	6.2	6	5.7	5.5	5.3	5.1	0.0	0.0	0.0
WSA-5	8.1	7.5	7.4	7.4	7.4	7.5	7.5	7.6	7.6	7.5	7.5	7.4	7.3	7.2	7.1	6.9	6.7	6.5	6.3	6	5.8	5.6	0.0	0.0	0.0
WSA-6	13.8	11.9	10.9	10.2	9.6	9.1	8.6	8.1	7.6	7.1	6.6	6.1	5.6	5.1	4.7	4.3	3.9	3.6	3.3	3	2.8	2.5	0.0	0.0	0.0

TABLE A.2-9

ALTERNATIVE 6
VAM3D PREDICTED URANIUM CONCENTRATIONS FOR EACH EXTRACTION WELL

Well	04/02/2003	04/01/2004	04/01/2005	04/01/2006	04/02/2007	04/01/2008	04/01/2009	04/01/2010	04/02/2011	04/01/2012	04/01/2013	04/01/2014	04/01/2015	04/01/2016	04/01/2017	04/01/2018	04/02/2019	04/01/2020	04/01/2021	04/01/2022	04/02/2023	04/01/2024	04/01/2025	04/01/2026	04/02/2027
3924	13.5	12.1	10.6	9.9	9.1	8.5	7.9	7.4	7	6.6	6.2	5.8	5.5	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3925	5.1	8.1	10.3	11.3	11.7	11.9	11.8	11.7	11.5	11.2	10.8	10.4	10.1	9.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3926	1.1	2.9	5	6.4	7.5	8.5	9.3	9.9	10.4	10.7	10.9	11.1	11.1	11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3927	2.7	2.8	2.9	3	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opt-6	34.9	28.6	28	27.2	26.5	25.6	24.7	23.7	22.8	21.8	20.8	19.9	19	18.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Opt-7	50.2	46.7	41.1	38.5	35.3	32.4	29.7	27.2	25	23	21.1	19.4	17.9	16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF-31	124.9	84.9	66.9	57.4	49.3	43.5	38.7	34.7	31.2	28.1	25.5	23.1	21	19.2	16.4	14.3	12.6	11.2	10	9	8.1	7.3	6.7	6.1	5.6
SF-17	42.4	42.4	43.3	39.6	37.5	35.6	33.6	31.6	29.7	27.9	26.2	24.6	23.1	21.7	20	18.5	17.1	15.9	14.8	13.8	12.8	12	11.2	10.5	9.8
SF-18	52.6	44.6	41.3	36	32.2	29.1	26.7	24.7	23	21.5	20.2	19	18	17	16.8	16.2	15.5	14.8	14.1	13.4	12.8	12.2	11.6	11.1	10.6
SF-19	40.7	27.8	23.1	19.9	18.5	17.4	16.6	16.1	15.7	15.4	15.2	15	14.8	14.6	13.2	12.4	11.9	11.3	10.9	10.5	10.1	9.8	9.4	9.1	8.8
SF-20	15.8	15.1	16.1	18.1	18.4	18.4	18	17.6	17.1	16.5	16	15.5	14.9	14.4	13	12.2	11.6	10.9	10.3	9.8	9.3	8.8	8.4	7.9	7.5
SF-21	70.2	55.7	45	40.8	35.4	31.4	28	25.3	23	21	19.3	17.8	16.4	15.2	12.7	11.3	10.2	9.2	8.4	7.8	7.2	6.6	6.2	5.7	5.4
SF-22	130.2	65.3	44.2	47.1	41.7	37.3	33.7	30.6	28.1	26	24.2	22.6	21.1	19.9	17.5	16.2	15.2	14.3	13.5	12.8	12.2	11.6	11.1	10.6	10.2
SF-23	75.6	50.8	40.2	35.6	30.4	26.4	23.3	20.7	18.6	16.9	15.5	14.2	13.2	12.3	11.1	10.3	9.7	9.2	8.7	8.3	7.9	7.5	7.2	6.8	6.6
SF-24	23.7	21.1	20.3	21.7	22.2	22.2	21.8	21.1	20.3	19.3	18.3	17.4	16.5	15.6	14	13	12.1	11.4	10.7	10.2	9.7	9.3	8.9	8.6	8.3
SF-25	98.8	55	40.4	32.9	27.9	24.4	21.7	19.5	17.6	16.1	14.7	13.6	12.5	11.6	9.9	8.9	8.1	7.5	6.9	6.5	6.1	5.7	5.4	5.1	4.8
SF-32	96.2	41.5	26.9	19.6	15	12	9.9	8.4	7.2	6.3	5.6	5	4.5	4.1	3.3	2.9	2.6	2.4	2.2	2	1.8	1.7	1.6	1.5	1.4
SF-33	64	29.7	20	14.6	11.5	9.5	8.1	7	6.2	5.6	5.1	4.6	4.2	3.9	3.2	2.8	2.5	2.3	2.1	1.9	1.8	1.6	1.5	1.4	1.3
SF-34	13.6	5.7	4	3.2	2.7	2.3	2.1	1.9	1.7	1.6	1.5	1.4	1.3	1.3	1.2	1.1	1.1	1	1	1	0.9	0.9	0.9	0.9	0.9
WSA-1	54.3	38.4	36.8	35.4	34.9	33.9	32.6	31.3	30	28.7	27.4	26.2	25	23.9	21	19.4	18.1	17	16	15.1	14.3	13.6	12.9	12.3	11.7
WSA-2	46.9	38.1	30	26.9	23.9	21.3	19.3	17.7	16.4	15.4	14.5	13.8	13.2	12.7	11.9	11.3	10.9	10.6	10.3	10	9.8	9.6	9.4	9.2	9.1
WSA-4	35.7	22.6	18.5	16	14.2	12.8	11.6	10.7	9.9	9.2	8.6	8	7.5	7	6.7	6.3	6	5.8	5.5	5.3	5.1	5	0.0	0.0	0.0
WSA-5	8.1	7.5	7.4	7.4	7.4	7.5	7.5	7.6	7.6	7.5	7.5	7.4	7.3	7.1	7	6.8	6.6	6.3	6.1	5.9	5.6	5.4	0.0	0.0	0.0
WSA-6	13.8	11.8	10.9	10.1	9.5	9	8.4	7.9	7.4	6.9	6.4	5.9	5.4	4.9	4.5	4.1	3.8	3.4	3.1	2.9	2.6	2.4	0.0	0.0	0.0

TABLE A.2-10

ALTERNATIVE 7
VAM3D PREDICTED URANIUM CONCENTRATIONS FOR EACH EXTRACTION WELL

Well	04/02/2003	04/01/2004	04/01/2005	04/02/2006	04/02/2007	04/01/2008	04/01/2009	04/01/2010	04/02/2011	04/01/2012	04/01/2013	04/01/2014	04/02/2015	04/01/2016	04/01/2017	04/01/2018	04/02/2019	04/01/2020	04/01/2021	04/01/2022	04/02/2023	04/01/2024
3924	13.5	12.1	10.6	9.5	8.7	8	7.5	7	6.6	6.2	5.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3925	5.1	8.1	10.3	11.4	11.9	12	12	11.7	11.4	10.9	10.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3926	1.1	2.9	5	6.7	7.9	8.9	9.6	10	10.3	10.3	10.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3927	2.7	2.8	2.9	3	3	3.1	3.1	3.2	3.2	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPT-6	34.9	28.6	28	26.9	25.4	23.9	22.4	21	19.7	18.5	17.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OPT-7	50.2	46.7	41.1	36.3	32.4	29.1	26.2	23.7	21.5	19.6	17.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SF-31	124.9	84.9	66.9	57.5	48.5	42.1	37	32.8	29.2	26.2	23.6	19.8	17.1	15	13.2	11.8	10.6	9.6	8.7	8	7.3	6.8
SF-17	42.4	42.4	43.3	41.4	39.9	38.2	36.2	34.2	32.2	30.3	28.4	25	22.5	20.3	18.5	16.9	15.4	14.1	13	12	11.1	10.3
SF-18	52.6	44.6	41.3	37.6	34.6	32	29.8	27.9	26.3	24.8	23.4	23.3	22.4	21.3	20.1	19	18	17	16	15.2	14.4	13.7
SF-19	40.7	27.8	23.1	20.4	18.9	17.7	16.8	16	15.5	15	14.6	13.6	13.1	12.6	12.1	11.7	11.3	10.9	10.6	10.2	9.9	9.5
SF-20	15.8	15.1	16.1	17.3	17.3	17.3	17	16.7	16.4	16	15.6	13.4	12.3	11.4	10.6	9.9	9.2	8.7	8.2	7.7	7.3	6.9
SF-21	70.2	55.7	45	38.5	32.8	28.7	25.5	22.9	20.8	18.9	17.4	14.6	12.9	11.5	10.4	9.4	8.6	7.9	7.3	6.7	6.2	5.7
SF-22	130.2	65.3	44.2	42.2	36.3	32	28.7	26	23.9	22	20.5	16.7	14.9	13.6	12.6	11.8	11.1	10.5	10	9.6	9.1	8.8
SF-23	75.6	50.8	40.2	34.7	29.9	26.4	23.7	21.6	19.8	18.4	17.1	15.2	13.9	12.9	12	11.2	10.6	9.9	9.4	8.9	8.5	8.1
SF-24	23.7	21.1	20.3	18.8	17.6	16.7	15.8	15	14.2	13.5	12.8	11.3	10.4	9.7	9.1	8.7	8.3	7.9	7.7	7.4	7.2	7
SF-25	98.8	55	40.4	32.8	27.8	24.2	21.5	19.3	17.4	15.9	14.5	11.9	10.5	9.4	8.6	7.8	7.2	6.6	6.1	5.7	5.3	5
SF-32	96.2	41.5	26.9	19.2	14.8	11.9	10	8.5	7.4	6.5	5.8	4.5	3.8	3.3	2.9	2.6	2.4	2.2	2	1.9	1.8	1.7
SF-33	64	29.7	20	14.9	11.8	9.7	8.2	7.1	6.3	5.6	5.1	4.1	3.5	3	2.7	2.4	2.2	2	1.8	1.7	1.6	1.5
SF-34	13.6	5.7	4	3.3	2.8	2.5	2.2	2	1.9	1.7	1.6	1.5	1.4	1.3	1.2	1.2	1.1	1.1	1.1	1	1	1
WSA-1	54.3	38.4	36.8	35.6	35	34	32.8	31.5	30.1	28.8	27.5	23.9	22	20.5	19.1	17.9	16.9	15.9	15	14.2	13.5	12.8
WSA-2	46.9	38.1	30	25.9	22	19.1	17	15.4	14.1	13.1	12.4	11.4	10.7	10.2	9.7	9.4	9.1	8.8	8.6	8.4	8.2	8
WSA-4	35.8	22.4	18.2	15.6	13.8	12.4	11.2	10.3	9.3	8.6	7.9	7.4	6.9	6.5	6.1	5.8	5.5	5.3	5.1	0.0	0.0	0.0
WSA-5	8.1	7.5	7.4	7.4	7.4	7.5	7.5	7.5	7.6	7.5	7.5	7.4	7.2	7.1	6.9	6.7	6.4	6.2	6	0.0	0.0	0.0
WSA-6	13.8	11.8	10.9	10.1	9.5	9	8.5	7.9	7.3	6.8	6.3	5.8	5.3	4.8	4.4	4	3.7	3.3	3.1	0.0	0.0	0.0

Table A.2-11
Excel Testpump Results using Operational Data

Alernatives 1 & 2

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2003	5965	2290	3675	30.5	25.7	590
10/01/2004	5965	2290	3675	24.5	21.6	494
04/01/2005	5965	1890	4075	22.3	19.7	440
10/01/2005	5965	1890	4075	17.4	17.4	387
04/01/2006	6565	2400	4165	15.2	13.3	300
10/01/2006	6565	2400	4165	13.2	11.6	262
10/01/2007	6565	2400	4165	10.2	9.2	208
04/01/2008	6565	2400	4165	8.4	7.8	176
10/01/2009	6565	2400	4165	7.1	6.7	151
10/01/2010	6565	2400	4165	6	5.8	131
10/01/2011	6565	2400	4165	5.1	5.1	116
10/01/2012	6565	2400	4165	4.5	4.6	104
10/01/2013	6600	2400	4200	2.9	3.3	75
10/01/2014	6600	2400	4200	2.4	2.9	65
10/01/2015	6600	2400	4200	2.1	2.7	61
10/01/2016	6600	2400	4200	1.7	2.3	53
10/01/2017	6600	2400	4200	1.4	2.1	49
10/01/2018	6600	2400	4200	1.4	2.1	47
10/01/2019	6600	2400	4200	1.2	2	45
10/01/2020	6600	2400	4200	1	1.7	39
10/01/2021	6600	2400	4200	0.8	1.6	37
10/01/2022	6600	2400	4200	0.7	1.5	35
		Treatment Turned Off				
10/01/2006	6565	0	6565	22.1	22.1	635
10/01/2007	6565	0	6565	18.3	18.3	526

Table A.2-11
Excel Testpump Results using Operational Data

Alternatives 2A, 2B, 3, 3B, 4, 4B, 5 and 5B

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2003	5965	2290	3675	30.5	25.2	578
10/01/2004	5965	2290	3675	24.5	21	482
04/01/2005	4275	500	3775	29.4	26	524
10/01/2005	4275	500	3775	26.2	23.2	464
04/01/2006	4675	800	3875	21.7	18.8	385
10/01/2006	4675	800	3875	17.4	15.3	312
04/01/2007	4675	800	3875	15.3	13.6	278
04/01/2008	4675	800	3875	12.7	11.3	232
04/01/2009	4675	800	3875	10.6	9.7	198
04/01/2010	4675	800	3875	9	8.3	171
04/01/2011	4675	800	3875	7.7	7.3	148
04/01/2012	4675	800	3875	6.8	6.5	132
04/01/2013	4675	800	3875	6	5.8	119
04/01/2014	4675	800	3875	5.3	5.3	108
04/01/2015	4675	800	3875	4.8	4.8	99
04/01/2016	4675	700	3975	4.9	4.9	103
04/01/2017	4675	700	3975	4.2	4.3	91
04/01/2018	4675	700	3975	3.6	3.9	81
04/01/2019	4675	700	3975	3.1	3.5	72
04/01/2020	4675	700	3975	2.7	3.1	65
04/01/2021	4675	700	3975	2.4	2.8	59
04/01/2022	4675	700	3975	2.1	2.8	55
04/01/2023	4675	800	3875	1.8	2.3	48
04/01/2024	4675	800	3875	1.5	2.1	44
04/01/2025	4675	800	3875	1.4	2	40
04/01/2026	4675	800	3875	1.2	1.9	38
04/01/2027	4675	800	3875	1.1	1.8	36
		Treatment Turned Off				
10/01/2005	4275	0	4275	32	32	599
04/01/2006	4675	0	4675	27	27	553

Table A.2-11
Excel Testpump Results using Operational Data

Alternative 6

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr	Outfall Mass/day
10/01/2003	5965	2290	3675	30.5	25.7	588.0	
04/01/2004	5965	2290	3675	27.4	23.6	541.0	
10/01/2004	5965	2290	3675	24.5	21.6	493.0	
04/01/2005	4675	0	4675	35.0	35.0	716.0	
10/01/2005	4675	0	4675	31.5	31.5	646.0	
04/01/2006	5075	0	5075	26.7	26.7	595.0	
10/01/2006	5075	0	5075	24.2	24.2	537.0	
04/01/2007	5075	0	5075	22.0	22.0	489.0	
10/01/2007	5075	0	5075	24.2	24.2	536.9	1.47
10/01/2008	5075	0	5075	17.4	17.4	387.2	1.06
10/01/2009	5075	0	5075	15.2	15.2	299.5	0.82
10/01/2010	5075	0	5075	13.3	13.3	295.9	0.81
10/01/2011	5075	0	5075	11.8	11.8	263.0	0.72
10/01/2012	5075	0	5075	10.6	10.6	310.5	0.85
10/01/2013	5075	0	5075	9.7	9.7	215.5	0.59
10/01/2014	5075	0	5075	8.8	8.8	197.2	0.54
10/01/2015	5075	0	5075	8.1	8.1	179.0	0.49
10/01/2016	5175	0	5175	9.8	9.8	295.9	0.81
10/01/2017	5175	0	5175	9.1	9.1	204.5	0.56
10/01/2018	5175	0	5175	8.5	8.5	193.6	0.53
10/01/2019	5175	0	5175	8.1	8.1	182.6	0.5
10/01/2020	5175	0	5175	7.7	7.7	175.3	0.48
10/01/2021	5175	0	5175	7.4	7.4	168.0	0.46
10/01/2022	5175	0	5175	7.1	7.1	160.7	0.44

Table A.2-11
Excel Testpump Results using Operational Data

Alternative 7

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2004	5965	2290	3675	24.5	21.6	494
10/01/2005	5465	790	4675	24.6	24.6	503
10/01/2006	5865	700	5165	18.9	18.9	427
10/01/2007	5865	700	5165	15.3	15.3	347
10/01/2008	5865	700	5165	13.0	13	293
10/01/2009	5865	700	5165	11.1	11.1	251
10/01/2010	5865	700	5165	9.6	9.6	217
10/01/2011	5865	700	5165	8.3	8.3	189
10/01/2012	5865	700	5165	7.4	7.4	167
10/01/2013	5900	800	5100	7.0	7.0	157
10/01/2014	5900	800	5100	5.9	5.9	133
10/01/2015	5900	800	5100	5.1	5.1	113
10/01/2016	5900	800	5100	4.3	4.3	97
10/01/2017	5900	800	5100	3.7	3.7	83
10/01/2018	5900	800	5100	3.2	3.2	72
10/01/2019	5900	800	5100	2.8	2.8	62
10/01/2020	5900	800	5100	2.4	2.4	54
10/01/2021	5900	800	5100	2.1	2.1	47
10/01/2022	5900	800	5100	1.9	1.9	42
10/01/2023	5900	800	5100	1.6	1.6	37
		Treatment Turned Off				
10/01/2006	5865	0	5865	23.8	23.8	612
10/01/2007	5865	0	5865	19.9	19.9	511

TABLE A.2-12

95% UCL URANIUM CONCENTRATIONS FOR EACH EXTRACTION WELL

a) EXPONENTIAL C = A*EXP(B*DATE)	exponential	exponential	exponential	linear fit	exponential	exponential	exponential	exponential	exponential	exponential	linear	poly	power	exponential	exponential	exponential	exponential	exponential
b) LINEAR C = A*DATE + B	SF 17 95% UCL	SF 18 95% UCL	SF 19 95% UCL	SF 20 95% UCL	SF 21 95% UCL	SF 22 95% UCL	SF 23 95% UCL	SF 24 95% UCL	SF 25 95% UCL	SP 3924 95% UCL	SP 3925 95% UCL	SP 3926 95% UCL	SP3927 95% UCL	SP OPT 6 95% UCL	SP OPT 7 95% UCL	WSA 1 95% UCL	WSA 2 95% UCL	WSA 4 95% UCL
c) POLY C = A*DATE^3 + B*DATE^2+C*DATE+D	6.34228E+05	9.69359E+06	7.36017E+08	-3.59083E-04	1.40617E+06	1.76756E+08	7.07980E+05	3.33729E+06	9.32809E+13	7.36784E+04	-6.01034E-03	-6.44556E-10	9.77310E-05	5.70545E+03	1.23246E+07	3.20767E+18	1.11421E+24	2.81210E+29
d) POWER C = A*DATE^B	-2.56103E-04	-3.12980E-04	-4.18759E-04	7.62797E+01	-2.50847E-04	-3.67763E-04	-2.17758E-04	-2.77442E-04	-7.46721E-04	-1.91989E-04	2.64200E+02	6.98448E-05	1.01963E+00	-1.18665E-04	-3.24558E-04	-9.99531E-04	-1.32990E-03	-1.66523E-03
												-2.51244E+00						
DATE												3.00375E+04						
10/01/03	38.7	68.5	94.4	62.7	104.6	156.6	184.6	90.6	47.9	51.0	36.4	52.2	4.6	63.6	56.1	113.8	144.6	110.5
04/01/04	36.9	64.7	87.5	62.6	99.9	146.4	177.4	86.2	41.8	49.2	35.3	52.8	4.6	62.2	52.9	94.8	113.3	81.5
10/01/04	35.2	61.1	81.0	62.5	95.5	136.9	170.5	81.9	36.5	47.5	34.2	53.3	4.6	60.9	49.9	79.0	88.8	60.1
04/01/05	33.6	57.7	75.1	62.5	91.2	128.0	163.8	77.9	31.8	45.9	33.1	53.4	4.6	59.6	47.0	65.8	69.7	44.4
10/01/05	32.1	54.5	69.5	62.4	87.1	119.7	157.4	74.0	27.8	44.3	32.0	53.2	4.6	58.3	44.3	54.8	54.7	32.7
04/01/06	30.6	51.5	64.4	62.3	83.2	112.0	151.3	70.4	24.2	42.8	31.0	52.7	4.7	57.1	41.7	45.7	42.9	24.2
10/01/06	29.2	48.6	59.7	62.3	79.5	104.7	145.4	66.9	21.1	41.3	29.9	51.9	4.7	55.8	39.3	38.1	33.7	17.8
04/01/07	27.9	45.9	55.3	62.2	75.9	97.9	139.8	63.6	18.5	39.9	28.8	50.7	4.7	54.6	37.1	31.7	26.4	13.2
10/01/07	26.6	43.4	51.2	62.1	72.5	91.5	134.3	60.4	16.1	38.5	27.7	49.1	4.7	53.5	34.9	26.4	20.7	9.7
04/01/08	25.4	40.9	47.4	62.1	69.3	85.6	129.1	57.4	14.0	37.2	26.6	47.1	4.8	52.3	32.9	22.0	16.2	7.2
10/01/08	24.2	38.7	43.9	62.0	66.2	80.0	124.0	54.6	12.2	35.9	25.5	44.6	4.8	51.2	31.0	18.3	12.7	5.3
04/01/09	23.1	36.5	40.7	62.0	63.2	74.8	119.2	51.9	10.7	34.7	24.4	41.7	4.8	50.1	29.3	15.3	10.0	3.9
10/01/09	22.1	34.5	37.7	61.9	60.4	69.9	114.5	49.3	9.3	33.5	23.3	38.3	4.8	49.0	27.6	12.7	7.8	2.9
04/01/10	21.1	32.6	34.9	61.8	57.7	65.4	110.1	46.9	8.1	32.3	22.2	34.4	4.8	48.0	26.0	10.6	6.1	2.1
10/01/10	20.1	30.8	32.4	61.8	55.1	61.2	105.8	44.6	7.1	31.2	21.1	29.9	4.9	46.9	24.5	8.8	4.8	1.6
04/01/11	19.2	29.1	30.0	61.7	52.6	57.2	101.7	42.4	6.2	30.1	20.0	24.9	4.9	45.9	23.1	7.4	3.8	1.2
10/01/11	18.3	27.4	27.8	61.6	50.3	53.5	97.7	40.3	5.4	29.1	18.9	19.3	4.9	45.0	21.8	6.1	3.0	0.9
04/01/12	17.5	25.9	25.7	61.6	48.0	50.0	93.9	38.3	4.7	28.1	17.8	13.1	4.9	44.0	20.5	5.1	2.3	0.6
10/01/12	16.7	24.5	23.8	61.5	45.9	46.7	90.2	36.4	4.1	27.1	16.7	6.3	5.0	43.0	19.3	4.3	1.8	0.5
04/01/13	15.9	23.1	22.1	61.4	43.8	43.7	86.7	34.6	3.6	26.2	15.6	0.0	5.0	42.1	18.2	3.5	1.4	0.3
10/01/13	15.2	21.8	20.5	61.4	41.9	40.9	83.3	32.9	3.1	25.3	14.5	0.0	5.0	41.2	17.2	3.0	1.1	0.3
04/01/14	14.5	20.6	19.0	61.3	40.0	38.2	80.1	31.3	2.7	24.4	13.4	0.0	5.0	40.3	16.2	2.5	0.9	0.2
10/01/14	13.8	19.5	17.6	61.2	38.2	35.7	77.0	29.7	2.4	23.6	12.3	0.0	5.0	39.5	15.2	2.1	0.7	0.1
04/01/15	13.2	18.4	16.3	61.2	36.5	33.4	74.0	28.3	2.1	22.8	11.2	0.0	5.1	38.6	14.4	1.7	0.5	0.1
10/01/15	12.6	17.4	15.1	61.1	34.9	31.2	71.1	26.9	1.8	22.0	10.1	0.0	5.1	37.8	13.5	1.4	0.4	0.1
04/01/16	12.0	16.4	14.0	61.0	33.3	29.2	68.3	25.5	1.6	21.2	9.0	0.0	5.1	37.0	12.8	1.2	0.3	0.1
10/01/16	11.5	15.5	12.9	61.0	31.8	27.3	65.6	24.3	1.4	20.5	7.9	0.0	5.1	36.2	12.0	1.0	0.3	0.0
04/01/17	10.9	14.6	12.0	60.9	30.4	25.5	63.1	23.1	1.2	19.8	6.8	0.0	5.2	35.4	11.3	0.8	0.2	0.0
10/01/17	10.4	13.8	11.1	60.8	29.0	23.9	60.6	21.9	1.1	19.1	5.7	0.0	5.2	34.7	10.7	0.7	0.2	0.0
04/01/18	10.0	13.1	10.3	60.8	27.7	22.3	58.3	20.9	0.9	18.5	4.6	0.0	5.2	33.9	10.1	0.6	0.1	0.0
10/01/18	9.5	12.3	9.5	60.7	26.5	20.9	56.0	19.8	0.8	17.8	3.5	0.0	5.2	33.2	9.5	0.5	0.1	0.0
04/01/19	9.1	11.6	8.8	60.6	25.3	19.5	53.8	18.8	0.7	17.2	2.4	0.0	5.2	32.5	8.9	0.4	0.1	0.0
10/01/19	8.7	11.0	8.2	60.6	24.2	18.3	51.7	17.9	0.6	16.6	1.3	0.0	5.3	31.8	8.4	0.3	0.1	0.0
04/01/20	8.3	10.4	7.6	60.5	23.1	17.1	49.7	17.0	0.5	16.0	0.2	0.0	5.3	31.1	7.9	0.3	0.0	0.0
10/01/20	7.9	9.8	7.0	60.4	22.0	16.0	47.7	16.2	0.5	15.5	0.0	0.0	5.3	30.4	7.5	0.2	0.0	0.0
04/01/21	7.5	9.3	6.5	60.4	21.1	14.9	45.9	15.4	0.4	15.0	0.0	0.0	5.3	29.8	7.1	0.2	0.0	0.0
10/01/21	7.2	8.7	6.0	60.3	20.1	14.0	44.1	14.6	0.4	14.4	0.0	0.0	5.4	29.1	6.6	0.2	0.0	0.0
04/01/22	6.9	8.3	5.6	60.2	19.2	13.1	42.4	13.9	0.3	13.9	0.0	0.0	5.4	28.5	6.3	0.1	0.0	0.0
10/01/22	6.5	7.8	5.2	60.2	18.4	12.2	40.7	13.2	0.3	13.5	0.0	0.0	5.4	27.9	5.9	0.1	0.0	0.0
04/01/23	6.2	7.4	4.8	60.1	17.5	11.4	39.1	12.6	0.2	13.0	0.0	0.0	5.4	27.3	5.6	0.1	0.0	0.0
10/01/23	6.0	7.0	4.4	60.0	16.7	10.7	37.6	11.9	0.2	12.5	0.0	0.0	5.5	26.7	5.2	0.1	0.0	0.0
04/01/24	5.7	6.6	4.1	60.0	16.0	10.0	36.1	11.4	0.2	12.1	0.0	0.0	5.5	26.1	4.9	0.1	0.0	0.0
10/01/24	5.4	6.2	3.8	59.9	15.3	9.3	34.7	10.8	0.2	11.7	0.0	0.0	5.5	25.6	4.7	0.1	0.0	0.0
04/01/25	5.2	5.9	3.5	59.9	14.6	8.7	33.4	10.3	0.1	11.3	0.0	0.0	5.5	25.0	4.4	0.0	0.0	0.0
10/01/25	4.9	5.5	3.3	59.8	13.9	8.2	32.1	9.8	0.1	10.9	0.0	0.0	5.5	24.5	4.1	0.0	0.0	0.0
04/01/26	4.7	5.2	3.0	59.7	13.3	7.6	30.8	9.3	0.1	10.5	0.0	0.0	5.6	24.0	3.9	0.0	0.0	0.0
10/01/26	4.5	4.9	2.8	59.7	12.7	7.1	29.6	8.8	0.1	10.2	0.0	0.0	5.6	23.5	3.7	0.0	0.0	0.0
04/01/27	4.3	4.7	2.6	59.6	12.2	6.7	28.5	8.4	0.1	9.8	0.0	0.0	5.6	23.0	3.5	0.0	0.0	0.0

Table A.2-13
Excel Testpump Results using 95% UCL Data

lternatives 1&2
95% UCL

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2003	5965	2290	3675	44.1	35.3	809
10/01/2004	5965	2290	3675	37.8	30.9	708
04/01/2005	5965	1890	4075	38.0	32.1	704
10/01/2005	5965	1890	4075	36.1	30.7	695
10/01/2006	6565	2290	4275	29.3	24.7	570
10/01/2007	6565	2400	4165	21.9	18.6	422
10/01/2008	6565	2400	4165	18.5	15.9	359
10/01/2009	6565	2400	4165	15.9	13.8	311
10/01/2010	6565	2400	4165	13.7	12	272
10/01/2011	6565	2400	4165	11.8	10.4	236
10/01/2012	6565	2400	4165	9.9	9	203
10/01/2013	6600	2300	4300	7.9	7.3	170
10/01/2014	6600	2300	4300	6.8	6.5	150
10/01/2015	6600	2300	4300	6	5.9	136
10/01/2016	6600	2400	4200	5.2	5.2	120
10/01/2017	6600	2300	4300	4.6	4.7	109
10/01/2018	6600	2300	4300	4.2	4.3	100
10/01/2019	6600	2300	4300	3.7	4	92
10/01/2020	6600	2300	4300	3.4	3.7	85
10/01/2021	6600	2300	4300	3	3.4	79
10/01/2022	6600	2300	4300	2.8	3.2	74
		Treatment Turned Off				
10/01/2014	6600	0	6600	21.2	21.2	614
10/01/2015	6600	0	6600	19.5	19.5	565

Table A.2-13
Excel Testpump Results using 95% UCL Data

Alternatives 2A, 2B, 3, 3B, 4, 4B, 5 and 5B
95% UCL

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2003	5965	2290	3675	44.1	34.8	797
10/01/2004	5965	2290	3675	37.8	30.4	696
04/01/2005	4275	500	3775	54.5	46.9	
10/01/2005	4275	500	3775	50.5	987.0	909
04/01/2006	4675	800	3875	36.9	31.5	644
10/01/2006	4675	800	3875	34.1	29.1	596
04/01/2007	4675	800	3875	31.6	27.1	554
04/01/2008	4675	800	3875	27.6	23.7	485
04/01/2009	4675	800	3875	24.3	21.0	430
04/01/2010	4675	800	3875	22.4	19.5	407
04/01/2011	4675	800	3875	19.8	17.3	362
04/01/2012	4675	800	3875	17.4	15.3	320
04/01/2013	4675	800	3875	15.8	14.0	300
04/01/2014	4675	800	3875	14.2	12.7	272
04/01/2015	4675	800	3875	12.9	11.6	247
04/01/2016	4675	700	3975	12.1	10.9	224
04/01/2017	4675	700	3975	10.8	9.8	200
04/01/2018	4675	700	3975	9.6	8.8	181
04/01/2019	4675	700	3975	8.6	8.0	164
04/01/2020	4675	700	3975	7.7	7.3	149
04/01/2021	4675	700	3975	7	6.6	136
04/01/2022	4675	700	3975	6.3	6.1	124
04/01/2023	4675	800	3875	5.7	5.6	114
04/01/2024	4675	800	3875	5.1	5.1	105
04/01/2025	4675	800	3875	4.6	4.7	96
04/01/2026	4675	800	3875	4.2	4.3	89
04/01/2027	4675	800	3875	3.8	4	83
		Treatment Turned Off				
04/01/2010	4675	0	4675	35.3	35.3	723
04/01/2011	4675	0	4675	28.3	28.3	580

Table A.2-13
Excel Testpump Results using 95% UCL Data

Alternative 6
95% UCL

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr	
10/01/2003	5965	2290	3675	44.1	35.3	807.2	2.21
10/01/2004	5965	2290	3675	37.8	37.8	708.6	1.94
10/01/2005	4675	0	4675	56.0	56.0	1146.9	3.14
10/01/2006	5075	0	5075	46.3	46.3	1030.0	2.82
10/01/2007	5075	0	5075	40.8	40.8	905.8	2.48
10/01/2008	5075	0	5075	36.4	36.4	807.2	2.21
10/01/2009	5075	0	5075	32.6	32.6	723.2	1.98
10/01/2010	5075	0	5075	29.3	29.3	650.1	1.78
10/01/2011	5075	0	5075	26.3	26.3	657.5	1.8
10/01/2012	5075	0	5075	23.6	23.6	522.3	1.43
10/01/2013	5075	0	5075	21.3	21.3	474.8	1.3
10/01/2014	5075	0	5075	19.6	19.6	434.6	1.19
10/01/2015	5075	0	5075	18.0	18.0	401.8	1.1
10/01/2016	5175	0	5175	20.6	20.6	467.5	1.28
10/01/2017	5175	0	5175	19.0	19.0	431.0	1.18
10/01/2018	5175	0	5175	17.7	17.7	401.8	1.1
10/01/2019	5175	0	5175	16.4	16.4	372.6	1.02
10/01/2020	5175	0	5175	15.4	15.4	347.0	0.95
10/01/2021	5175	0	5175	14.4	14.4	325.1	0.89
10/01/2022	5175	0	5175	13.5	13.5	306.8	0.84

Table A.2-13
Excel Testpump Results using 95% UCL Data

Alternative 7
95% UCL

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2004	5965	2290	3675	37.8	30.9	708
10/01/2005	5465	790	4675	44.3	44.3	945
10/01/2006	5865	700	5165	36.6	36.6	845
10/01/2007	5865	700	5165	32.1	32.1	740
10/01/2008	5865	700	5165	28.5	28.5	657
10/01/2009	5865	700	5165	24.0	24.0	532
10/01/2010	5865	700	5165	21.2	21.2	471
10/01/2011	5865	700	5165	18.7	18.7	414
10/01/2012	5865	700	5165	16.2	16.2	360
10/01/2013	5900	800	5100	19.9	19.9	471
10/01/2014	5900	800	5100	18.1	18.1	428
10/01/2015	5900	800	5100	16.6	16.6	392
10/01/2016	5900	800	5100	15.3	15.3	361
10/01/2017	5900	800	5100	14.9	14.9	360
10/01/2018	5900	800	5100	13.6	13.6	326
10/01/2019	5900	800	5100	12.3	12.3	296
10/01/2020	5900	800	5100	11.2	11.2	269
10/01/2021	5900	800	5100	10.2	10.2	245
10/01/2022	5900	800	5100	9.3	9.3	223
10/01/2023	5900	800	5100	8.4	8.4	204
		Treatment Turned Off				
10/01/2013	5900	0	5900	25.3	25.3	653
10/01/2014	5900	0	5900	23.1	23.1	597

Table A.2-14
Excel Testpump Results using Modeled Input

Alternatives 1 & 2

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2003	5965	2290	3675	25.7	22.4	514
10/01/2004	5965	2165	3800	21.7	19.6	460
10/01/2005	5965	1865	4100	19.9	17.5	392
10/01/2006	6565	2165	4400	15.7	13.8	325
10/01/2007	6565	2165	4400	14.1	12.4	294
10/01/2008	6565	2365	4200	12.7	11.2	255
10/01/2009	6565	2365	4200	11.7	10.4	237
10/01/2010	6565	2365	4200	10.9	9.8	222
10/01/2011	6565	2365	4200	10.2	9.2	209
10/01/2012	6565	2365	4200	9.5	8.7	197
10/01/2013	6600	2100	4500	10.1	9.2	221
10/01/2014	6600	2100	4500	8.8	8.1	195
10/01/2015	6600	2100	4500	8.0	7.4	179
10/01/2016	6600	2300	4300	7.2	6.8	157
10/01/2017	6600	2300	4300	6.7	6.4	147
10/01/2018	6600	2300	4300	6.2	6.0	139
10/01/2019	6600	2300	4300	5.9	5.7	133
10/01/2020	6600	2300	4300	5.6	5.4	126
10/01/2021	6600	2300	4300	5.3	5.2	121
10/01/2022	6600	2300	4300	4.5	4.6	107
		Treatment Turned Off				
10/01/2006	6565	0	6565	23.1	23.1	664
10/01/2007	6565	0	6565	20.5	20.5	590

Table A.2-14
Excel Testpump Results using Modeled Input

Alternatives 2A, 2B, 3, 3B, 4, 4B, 5, and 5B

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
04/01/2004	5965	2165	3800	21.7	19.1	448
04/01/2005	4275	400	3875	25.8	23.0	475
04/01/2006	4675	700	3975	21.4	18.7	391
04/01/2007	4675	675	4000	20.0	17.5	367
04/01/2008	4675	675	4000	18.6	16.3	343
04/01/2009	4675	675	4000	17.4	15.3	322
04/01/2010	4675	675	4000	16.3	14.5	304
04/01/2011	4675	675	4000	15.4	13.6	287
04/01/2012	4675	675	4000	14.5	12.9	271
04/01/2013	4675	675	4000	13.6	12.2	256
04/01/2014	4675	675	4000	12.9	11.6	243
04/01/2015	4675	675	4000	12.2	11.0	232
04/01/2016	4675	675	4000	12.8	11.5	242
04/01/2017	4675	675	4000	11.5	10.4	218
04/01/2018	4675	775	3900	10.4	9.5	196
04/01/2019	4675	775	3900	0.7	8.9	184
04/01/2020	4675	775	3900	9.1	8.4	173
04/01/2021	4675	775	3900	8.6	8.0	164
04/01/2022	4675	775	3900	8.1	7.6	156
04/01/2023	4675	775	3900	7.7	7.2	149
04/01/2024	4675	775	3900	7.3	6.9	142
04/01/2025	4675	775	3900	6.5	6.2	128
04/01/2026	4675	775	3900	6.2	6.0	123
04/01/2027	4675	775	3900	5.9	5.7	118
		Treatment Turned Off				
04/01/2004	5965	0	5965	33.5	33.5	875
04/01/2005	4275	0	4275	28.6	28.2	553

Table A.2-14
Excel Testpump Results using Modeled Input

Alternative 6

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2003	5965	2290	3675	25.7	22.4	513.8
10/01/2004	5965	2165	3800	21.7	19.6	460.2
10/01/2005	4675	0	4675	28.9	28.9	590.9
10/01/2006	5075	0	5075	25.4	25.4	563.8
10/01/2007	5075	0	5075	23.0	23.0	511.3
10/01/2008	5075	0	5075	21.1	21.1	469.9
10/01/2009	5075	0	5075	19.5	19.5	434.3
10/01/2010	5075	0	5075	18.2	18.2	403.6
10/01/2011	5075	0	5075	17.0	17.0	376.9
10/01/2012	5075	0	5075	15.9	15.9	352.9
10/01/2013	5075	0	5075	14.9	14.9	331.4
10/01/2014	5075	0	5075	14.0	14.0	311.8
10/01/2015	5075	0	5075	13.2	13.2	293.8
10/01/2016	5175	0	5175	13.6	13.6	307.9
10/01/2017	5175	0	5175	12.0	12.0	272.7
10/01/2018	5175	0	5175	11.1	11.1	250.4
10/01/2019	5175	0	5175	10.3	10.3	232.6
10/01/2020	5175	0	5175	9.6	9.6	217.1
10/01/2021	5175	0	5175	9.0	9.0	203.2
10/01/2022	5175	0	5175	8.4	8.4	191.4
10/01/2023	5175	0	5175	8.0	8.0	180.3
10/01/2024	5175	0	5175	7.5	7.5	170.4
10/01/2025	5175	0	5175	6.8	6.8	154.3

Table A.2-14
Excel Testpump Results using Modeled Input

Alternative 7

Date	Total Pumping	GW to Treatment	GW to Bypass	Bypass Concentration	Outfall Concentration	Outfall Mass/yr
10/01/2005	5465	790	4675	24.0	24.0	490
10/01/2006	5865	775	5090	20.7	20.7	461
10/01/2007	5865	775	5090	18.7	18.7	416
10/01/2008	5865	775	5090	17.0	17.0	379
10/01/2009	5865	775	5090	15.6	15.6	348
10/01/2010	5865	775	5090	14.4	14.4	321
10/01/2011	5865	775	5090	13.4	13.4	299
10/01/2012	5865	775	5090	12.5	12.5	280
10/01/2013	5900	500	5400	14.9	14.9	353
10/01/2014	5900	500	5400	12.9	12.9	304
10/01/2015	5900	600	5300	11.4	11.4	265
10/01/2016	5900	600	5300	10.4	10.4	243
10/01/2017	5900	600	5300	9.6	9.6	223
10/01/2018	5900	600	5300	8.9	8.9	206
10/01/2019	5900	600	5300	8.3	8.3	192
10/01/2020	5900	600	5300	7.7	7.7	179
10/01/2021	5900	600	5300	7.3	7.3	169
10/01/2022	5900	600	5300	6.5	6.5	151
10/01/2023	5900	600	5300	6.1	6.1	143
		Treatment Turned Off				
10/01/2006	5865	0	5865	24.0	24.0	617
10/01/2007	5865	0	5865	21.6	21.6	554

Figure A.2-1
Concentration vs. Time Decline Curves for Extraction Well 17 (31567)

FERNALD
Closure Project

COMPREHENSIVE GROUNDWATER STRATEGY REPORT

Appendix B

Cost Estimating Backup for All Alternatives

APPENDIX B

COST ESTIMATING BACKUP FOR ALL ALTERNATIVES

Capital and annual operating costs were estimated for the various alternatives. Costs were rounded to the nearest $100,000. A summary of the individual cost elements is included in the Yearly Costs Table B-1. This section includes a brief description of the methods used to estimate the various costs by element. Numbering is the same as on the Table. The following elements were not estimated since they are common to all alternatives:

- Groundwater remedy completion certification costs,
- D&D and disposal costs for the well field infrastructure,
- Plugging and abandonment of the monitoring well network,
- Costs for a smaller (10gpm) carbon treatment system for leachate treatment after all cells are capped in March 2006 or costs for trucking leachate to a MWWTP after March 2006;and
- Costs associated contaminant concentration rebound – should it occur.

Estimated Cost Elements:

1 and 2. AWWT and IAWWT/SPIT annual operating costs were provided as estimates from the baseline by AWWT management. A single control account includes costs for these areas and the sewage treatment plant. This account does not include utilities or lab expenses which were estimated and added on AWWT annual operating expense (including Phases I, II, and III, and the Slurry Dewatering Facility) was included through the end of 2005 for alternatives 1 and 2 and through March 2005 for the other alternatives. IAWWT/SPIT annual operating expenses were used through the end of 2005 for Alternatives 3 and 4 and through March 2005 for the other alternatives.

3. Wells annual operating expense were provided by AWWT management from the baseline. Electrical consumption was calculated based on 6,000 gallons per minute (gpm) with average well conditions at 70' lift, 75 pounds per square inch (psi), and 70% efficiency, with an electrical cost of $0.05/kw-hr. This cost element was used in all alternatives in 2004. Elements 19 through 24 were used in the various alternatives for future costs, reflecting differences in variable costs at differing pumping rates.

4. Re-injection annual operating costs were estimated at $0.1 million per year based on 1,400 gpm pumping, 70 psi, 70% efficiency, electrical consumption and well maintenance by contractor.

5. AWWT Phase III operation at 1900 gpm was estimated by AWWT management from the baseline. Utility and laboratory cost estimates were added.

6. 200 gpm activated carbon estimate was based on elements in the cost estimate for a mobile system (#7 below).

7. Mobile system contractor cost estimate was done by the Estimating Department based on a preliminary project scope developed by ARWWP Engineering. This estimate included mobile system contractor costs.

8. Mobile system Fluor Fernald costs were estimated by ARWWP Engineering to include project engineering, procurement, construction interfaces, SSR, operator/maintenance training, procedures, and documentation.

9. Upgrade IAWWT/SPIT contractor cost estimate was obtained by breaking out elements from the mobile system estimate.

10. Upgrade IAWWT/SPIT Fluor Fernald costs were estimated by ARWWP Engineering to include project engineering, procurement, construction interfaces, SSR, operator/maintenance training, procedures, and documentation.

11. IAWWT/SPIT yearly future cost estimate was based on the estimate for AWWT Phase III at 1900 gpm (#5). It assumed similar staffing for either system, but lower costs of ion exchange resin replacement, building heat, maintenance, and electricity. It is used starting in April 2005 for Alternatives 3 and 4.

12. Mobile system yearly future costs were expected to be the same as IAWWT/SPIT (#11).

13. D&D IAWWT/SPIT, dispose on-site estimate was obtained from D&D estimates and Soils and Disposal Facility Project (SDFP) management guidance of an expected $40/cu-yd for excavation and certification, $10/cu-yd for on-site disposal, and 5,000 cu-yd of soil and debris.

14. D&D IAWWT/SPIT, dispose off-site was obtained from data used in #13, with a SDFP management provided estimate of $400/cu-yd for off-site disposal.

15. D&D AWWT, dispose on-site estimate was obtained from D&D estimates ($2.2 million) and SDFP management guidance of an expected $40/cu-yd for excavation and certification, $10/cu-yd for on-site disposal, 70,000 cu-yd of soil, and 15,000 cu-yd debris.

16. D&D AWWT, dispose off-site was obtained from data used in #15, with a SDFP management provided estimate of $400/cu-yd for off-site disposal.

17. D&D re-injection dispose on-site was a rough estimate by ARWWP Engineering for removal of re-injection tank and pumps, soils, and above-ground piping.

18. D&D re-injection dispose off-site was a rough estimate by ARWWP Engineering for removal of re-injection tank and pumps, soils, and above-ground piping (considering the added expense of off-site disposal).

19. Wells pumping Alternatives 1 and 2 was based on an additional 600 gpm pumping rate (6,600 gpm) compared to #3. In reviewing cost data it was calculated to cost about $19k for each 100 gpm pumped for the variable costs (electricity and maintenance). That factor was used to revise well operating costs at varying pumping rates.

20. Wells pumping Alternatives 3, 4, and 5, pre-2011 are based on the lower costs of 4700 gpm and no re-injection compared to element #19.

21. Wells pumping Alternatives 3, 4, and 5, post-2011 are based on element #20 with the expectation of staffing needs with shut down of treatment, continuation of pumping.

22. Wells pumping Alternative 6 is based on 5000 gpm pumping, staffing as in element #21.

23. Wells pumping Alternative 7 is based on 5800 gpm pumping, 800 gpm re-injection, (with mobile system treatment operating at 800 gpm).

24. Wells pumping Alternative 2A is based on being the same as cost element #21.

25. AWWT Phase III at 800 gpm is based on lower electricity cost and less replacement of ion exchange resin compared to cost element #5.

26. OSDF temporary cap install was from guidance provided by SDFP management.

27. OSDF permanent cap install was from guidance provided by SDFP management.

28. OSDF temporary cap remove was from guidance provided by SDFP management.

29. Annual monitoring/reporting was from the baseline.

30. Cost of analysis/reporting required by the EPA every 5 years.

The following are descriptions of each alternative consistent with how the cost estimates were prepared.

Alternative 1

Alternative 1 provides for continued site wastewater/groundwater treatment at the AWWT. The IAWWT and SPIT treatment systems will be shut down in March 2005 allowing for D&D and placement of debris and soil in the ODSF. The AWWT Phase I system will be shut down in 2005 after the need to treat stormwater is greatly diminished. The AWWT Phase II system will treat remaining stormwater flows and OSDF leachate through at least March 2006 when the last OSDF cell is capped and all stormwater flow can be free released without treatment. Leachate flow from the finished OSDF cells will be greatly diminished. It's expected that a greatly downsized activated carbon treatment train (nominal capacity of 10 gpm) would be an economically justified expense. Treatment of the OSDF leachate at a Metropolitan Sewer District wastewater treatment is another potential cost savings option (compared to operating AWWT Phase II).

AWWT Phase III will continue to be operated to treat groundwater. Normal operating rate will be 1900 gpm. Ion exchange resin will be replaced when it reaches exhaustion. The groundwater re-injection system will be operated a normal operating rate of 1,400 gpm. Groundwater pumping will be at a normal rate of 6,600 gpm.

This scenario is based on continuing to operate the AWWT Phase III treatment system and the re-injection system to complete the aquifer restoration in the shortest time frame. It's anticipated that treatment of groundwater to meet the 30 μg/L monthly, 600 pound/year uranium discharge limits will no longer be needed in 2013 based on extraction well uranium concentration decline curves at the 95% confidence level. The 600-pound/year parameter is the limiting factor as untreated groundwater concentrations at that time are predicted to be at around 20 ppb by the model. Pumping, treating, and re-injecting groundwater is expected to continue at until 2021. AWWT D&D and disposal off site would occur at that time.

Alternative 2

Alternative 2 has a same operating plan as Alternative 1. The difference is that Alternative 2 relies on on-site disposal of the AWWT and underlying soils by reopening an OSDF cell. Estimated costs for AWWT D&D and disposal are $7.4 million for on-site disposal compared to $38.8 million for off site disposal. These are based on an expected $40/cu-yd for excavation and certification, $10/cu-yd for on-site disposal, $400/cu-yd for off-site disposal, $1.5 million to reopen and recap an OSDF cell, 70,000 cu-yd of soil and 15,000 cu-yd of debris, and a cost of $2.2 million to D&D AWWT. These expected costs suggest a savings of $31.4 million if reopening the cell can be negotiated with the EPA.

Yearly costs and cumulative costs for Alternatives 1 and 2 are graphed in Figures B-1 and B-2.

Alternatives 3 and 3B

Alternative 3 is to use IAWWT/SPIT as the treatment plant for wastewater and groundwater. This allows for the D&D of AWWT, excavation of underlying soils, and placement of debris and soil in the OSDF. As in Alternative 2, this alternative takes advantage of the lower costs of on-site compared to off-site disposal.

A number of actions will need to be completed before site closure to allow this to be a viable solution. AWWT will need to be out of service and ready for D&D by April 2005. Activated carbon treatment of OSDF leachate sized for 200 gpm will need to be provided between April 2005 and closure of the last OSDF cell in March 2006. A 200 gpm activated carbon train would need to be installed at IAWWT/SPIT, piped to be fed from the leachate transmission system. Currently the wells are monitored and controlled at the AWWT central control room. That will continue to be justified and the controller and operator stations will need to be relocated. Timely laboratory analytical results have been needed to manage the 30 μg/L uranium discharge limit. That will continue to be needed and uranium analytical

instrumentation will be relocated. Heated space for storage of spare parts and ion exchange resin and additional room for maintenance personnel, work benches, etc. will be required. A system to allow treatment of backwash water will be required. It's anticipated that would be a low water use, self or manually cleaned filtration device, allowing for removal of solid waste and reuse of backwash water. These changes to IAWWT/SPIT will need to be completed before AWWT can be shut down. Current operating rate of IAWWT and SPIT is a combined 550 gpm. An additional 250 gpm treatment capacity will be provided. This will assure adequate treatment capacity for stormwater during the interim time period between April and December 2005 and will help assure meeting outfall limits. The estimated cost of these revisions is $2.2 million, based on preliminary engineering.

It's expected that the aquifer pumping rate in 2006 will be limited to 4700 gpm (compared to 6600 gpm with 1400 gpm re-injection for Alternatives 1 or 2). Annual operating costs are expected to be $1.1 million less than Alternatives 1 or 2 (lower electrical consumption, less well maintenance, less ion exchange resin replacement, and lower heating costs compared to Building 51) with the lower rate of groundwater pumping and lower treatment rate. It's expected that this groundwater treatment system will need to be operated until early 2011 to meet the 30 μg/L monthly, 600 pounds/year uranium discharge limits based on extraction well uranium concentration decline curves at the 95% confidence level. Alternative 3B assumes a more rapid aquifer clean up with treatment shut down in 2007. D&D, soil excavation, and off-site disposal of debris could than be completed. Groundwater pumping is expected to continue until 2026 in this alternative.

Alternatives 4 and 4B

Alternatives 4 and 4B have the same operating plan as Alternatives 3 and 3B. The difference is that Alternatives 4 and 4B rely on on-site disposal of the IAWWT/SPIT system and underlying soils by reopening an OSDF cell. Estimated costs for IAWWT/SPIT D&D and disposal are $1.8 million for on-site disposal compared to $2.3 million for off-site disposal. These are based on an expected $40/cu-yd for excavation and certification, $10/cu-yd for on-site disposal, $400/cu-yd for off-site disposal, $1.5 million to reopen and recap an On Site Disposal Facility cell, 5,000 cu-yd of soil and debris, and a cost of $0.1 million to D&D IAWWT/SPIT. These expected costs suggest an estimated savings of $0.5 million, if reopening the cell can be negotiated with the EPA. A more timely assessment of costs would need to be made for the future D&D of IAWWT/SPIT.

Alternatives 5 and 5B

Alternatives 5 and 5B are to procure a mobile system to replace AWWT, IAWWT, and SPIT. This would allow for D&D, soil excavation, and placement in the ODSF of these wastewater treatment facilities within the current site closure schedule. Alternative 5 would have the same requirements as those in the second paragraph describing Alternative 3. It needs to be operating by April 2005. In addition to 800 gpm groundwater/wastewater treatment, Alternative 5 includes a 200 gpm activated carbon train for leachate treatment, a central control station for relocated well monitoring and control, space for relocated uranium analytical equipment, heated storage for maintenance parts and ion exchange resin, office/break room space, maintenance work space, and backwash water treatment. Annual operating costs and strategy (well operation and treatment performance) are expected to be the same for this scenario as those of Alternatives 3 or 4. Total installed cost of this system is estimated to be $6.5 million compared to $2.4 million to upgrade IAWWT/SPIT. Total savings (pre closure on-site versus post closure off-site disposal of IAWWT/SPIT) is $2.0 million compared to Alternative 3. There may be salvage value or possible reuse of some of the equipment in this alternative, but it's expected that any salvage value would be equaled or exceeded by D&D and disposal costs. It's likely to be more costly than Alternatives 3 or 4.

Alternative 5 has the same treatment and aquifer pumping strategy and timeline as Alternatives 3 and 4. Treatment is expected to be needed until 2011 to meet current effluent discharge limitations and aquifer pumping is expected to last until 2026. Alternative 5B assumes a more rapid aquifer clean up with treatment shut down in 2007.

Yearly costs and cumulative costs for Alternatives 3, 3B, 4, 4B, 5, and 5B are graphed in Figures B-3 through B-6.

Alternative 6

Alternative 6 is based on a relaxation of effluent discharge limits such that no wastewater or groundwater treatment would be necessary. This alternative allows for D&D and on-site disposal of all wastewater treatment systems and underlying soils before site closure. Aquifer pumping rate would be limited only by the aquifer recharge rate. It's expected that pumping rate would be 5,000 gpm in 2006. Aquifer pumping is expected to be needed until 2024.

If relief from leachate treatment cannot be negotiated with the EPA, a 200 gpm activated carbon system would need to be provided at an expected installed cost of $0.8 million and an expected annual operating cost of $0.1 million.

This is obviously the least cost alternative of the 7 analyzed, but it's the one most likely to be opposed by regulators and the local community.

Alternative 7

Alternative 7 is combination of Alternatives 5 and 6. Although a relaxed effluent limit would not require groundwater treatment, a mobile unit as in Alternative 5 would be installed to provide clean water for re-injection. This alternative would cost $0.1 million more to install than Alternative 5 to provide an aeration tank to pretreat groundwater to remove iron (a needed process for re-injection water) and to pipe treated water to the re-injection tank. Alternative 7 would have a higher annual operating cost than Alternative 5 by $0.4 million (electrical and maintenance costs associated with running the aeration tank, the re-injection system and a higher well pumping rate).

It's expected that the aquifer pumping rate until April 2007 would be 5800 gpm with 800 gpm re-injected. The South Plume would be expected to be adequately remediated at this time and pumping rate could be decreased to 5000 gpm. Groundwater pumping, treatment, and re-injection are expected to continue until 2022 in this alternative.

Yearly costs and cumulative costs for Alternatives 6 and 7 are graphed in Figures B-7 and B-8.

Alternatives 2A and 2B

As costs and groundwater modeling results were being assembled it became clear that the additional operating expenses of Alternatives 1 or 2 would make them more costly than the others. The higher aquifer pumping rate, higher treatment rate, and use of the re-injection system in Alternatives 1 and 2 did decrease the predicted end date to 2021 compared to 2026 for Alternatives 3, 4, and 5. Of the additional expenses ($1.1 million per year) most were primarily associated the higher pumping and treatment volumes (more electricity for pumping, more well maintenance, and more ion exchange resin replacement). The higher cost to heat Building 51 ($0.1 million per year) was the only cost difference associated solely with the option to continue to use AWWT. It was decided to estimate the costs of a new alternative (operating AWWT using the treatment and well pumping strategy of Alternatives 3, 4, or 5).

This alternative's estimated life cycle cost was similar to Alternatives 3, 4, and 5. Alternatives 1 and 2 had the shortest duration aquifer restoration including 6,600 gpm pumping and 1,400 gpm re-injection. Alternative 2A had a 5 year longer aquifer restoration with 4,500 gpm pumping and no re-injection but had more than $30 million lower life cycle costs than Alternative 2. This suggests that the added expenses of higher aquifer pumping rates and re-injection of treated water would not provide a life cycle cost economic benefit. Alternative 2A assumes treatment is needed until 2011 and Alternative 2B assumes treatment is needed until 2007.

Yearly costs and cumulative costs for Alternatives 2A and 2B are graphed in Figures B-3 through B-6.

TABLE B-1

ANNUAL AND LIFE CYCLE COSTS FOR ALL ALTERNATIVES

YEARLY COSTS MILLION $

	Alt 1	Alt 2	Alt 2A	Alt 2B	Alt 3	Alt 3B	Alt 4	Alt 4B	Alt 5	Alt 5B	Alt 6	Alt 7
2004	10.3	10.3	10.3	10.3	12.1	12.1	12.1	12.1	16.2	16.2	10.3	16.3
2005	9.5	9.5	9.0	9.0	13.3	13.3	13.3	13.3	14.0	14.0	10.5	14.2
2006	10.8	7.8	7.0	7.0	9.9	9.9	6.9	6.9	9.9	9.9	7.5	10.2
2007	6.5	6.5	5.5	13.6	5.4	5.4	5.4	7.9	5.4	3.1	3.2	5.8
2008	6.5	6.5	5.5	3.1	5.4	3.1	5.4	3.1	5.4	3.1	3.2	5.8
2009	6.5	6.5	5.5	3.1	5.4	3.1	5.4	3.1	5.4	3.1	3.2	5.8
2010	6.5	6.5	5.5	3.1	5.4	3.1	5.4	3.1	5.4	3.1	3.2	5.8
2011	6.8	6.8	4.0	3.4	4.0	3.4	4.0	3.4	3.7	3.4	3.5	6.1
2012	6.5	6.5	13.5	3.1	5.4	3.1	7.9	3.1	3.1	3.1	3.2	5.8
2013	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2014	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2015	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2016	6.8	6.8	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.5	6.1
2017	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2018	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2019	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2020	6.5	6.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	5.8
2021	45.6	17.2	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.5	6.1
2022			3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	6.8
2023			3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.2	
2024			2.9	3.1	2.9	3.1	2.9	3.1	2.9	3.1	3.0	
2025			2.9	3.1	2.9	3.1	2.9	3.1	2.9	3.1		
2026			3.2	3.4	3.2	3.4	3.2	3.4	3.2	3.4		
Cost Total thru Jun-06	27.2	24.2	23.3	23.3	32.4	32.4	29.4	29.4	37.1	37.1	26.5	37.6
Life Cycle Cost Total	167.8	136.4	109.4	100.0	110.0	100.8	109.5	100.3	112.2	103.3	86.6	135.4

Estimated Costs

1. AWWT annual operating	5.7	16. D&D AWWT off-site	33.8
2. IAWWT/SPIT annual operating	1.5	17. D&D reinjection on-site	0.2
3. Wells annual operating	1.8	18. D&D reinjection off-site	1.0
4. Reinjection annual operating	0.1	19. Wells Alt 1 and 2	1.9
5. AWWT Phase III 1900 gpm	3.3	20. Wells Alt 3, 4, or 5 pre 2011	1.2
6. 200 gpm activated carbon	0.6	21. Wells Alt 3, 4, or 5 post 2011	1.9
7. Mobile system contract	4.7	22. Wells Alt 6	2.0
8. Mobile system Fluor Fernald	1.2	23. Wells Alt 7	1.5
9. Upgrade IAWWT contract	1.2	24. Wells Alt 2A	1.7
10. Upgrade IAWWT Fluor	0.6	25. AWWT Phase III 800 gpm	3.1
11. IAWWT/SPIT yearly future	3.0	26. OSDF cap temp cap install	1.0
12. Mobile system yearly future	3.0	27. OSDF permanent cap install	4.0
13. D&D IAWWT/SPIT on-site	0.3	28. OSDF temporary cap remove	0.5
14. D&D IAWWT/SPIT off-site	2.3	29. Monitoring/reporting annual	1.2
15. D&D AWWT on-site	5.8	30. 5 year reporting	0.3

Figure B-1. Yearly Costs, Alternatives 1 & 2

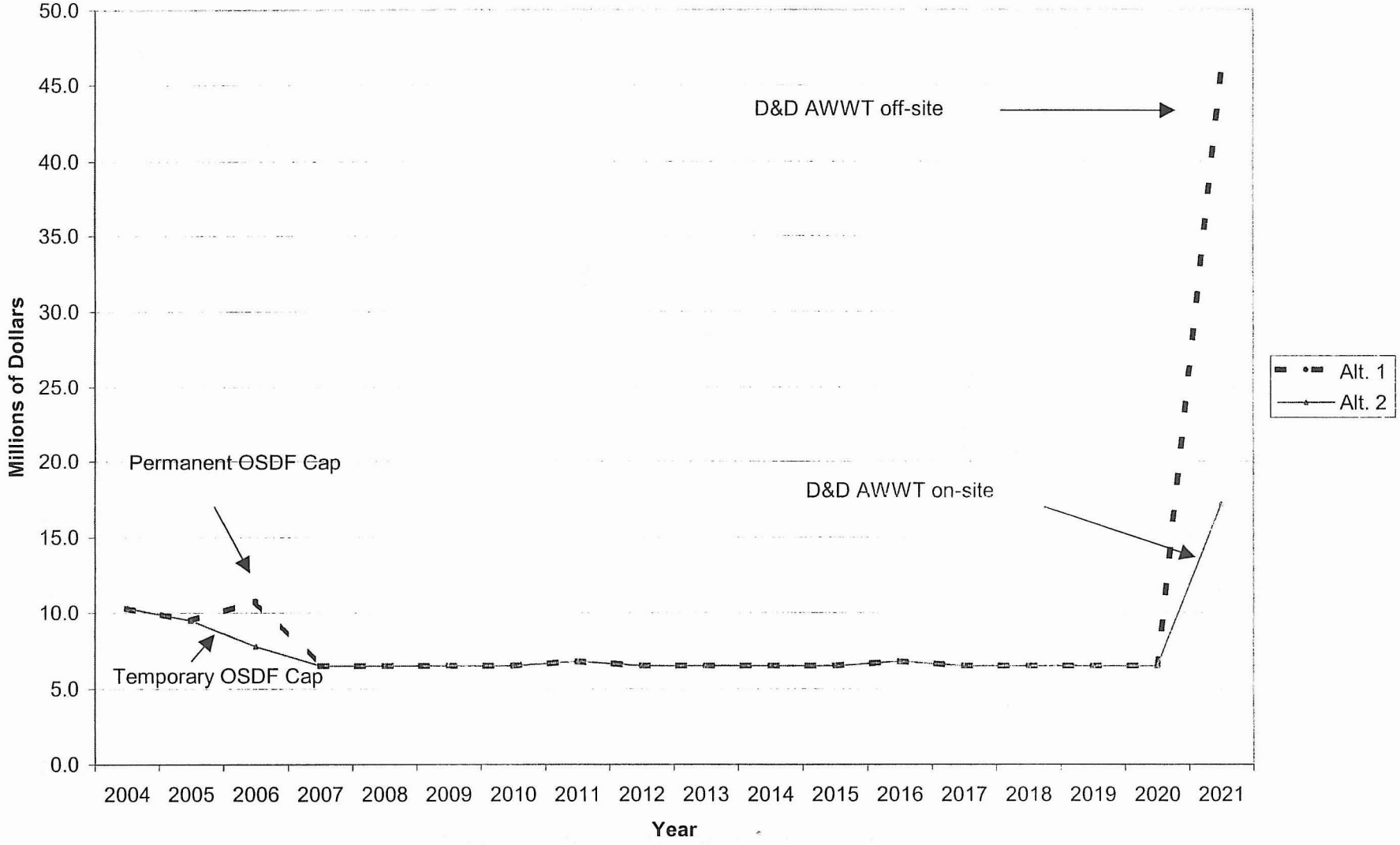


Figure B-2. Cumulative Costs, Alternatives 1 & 2

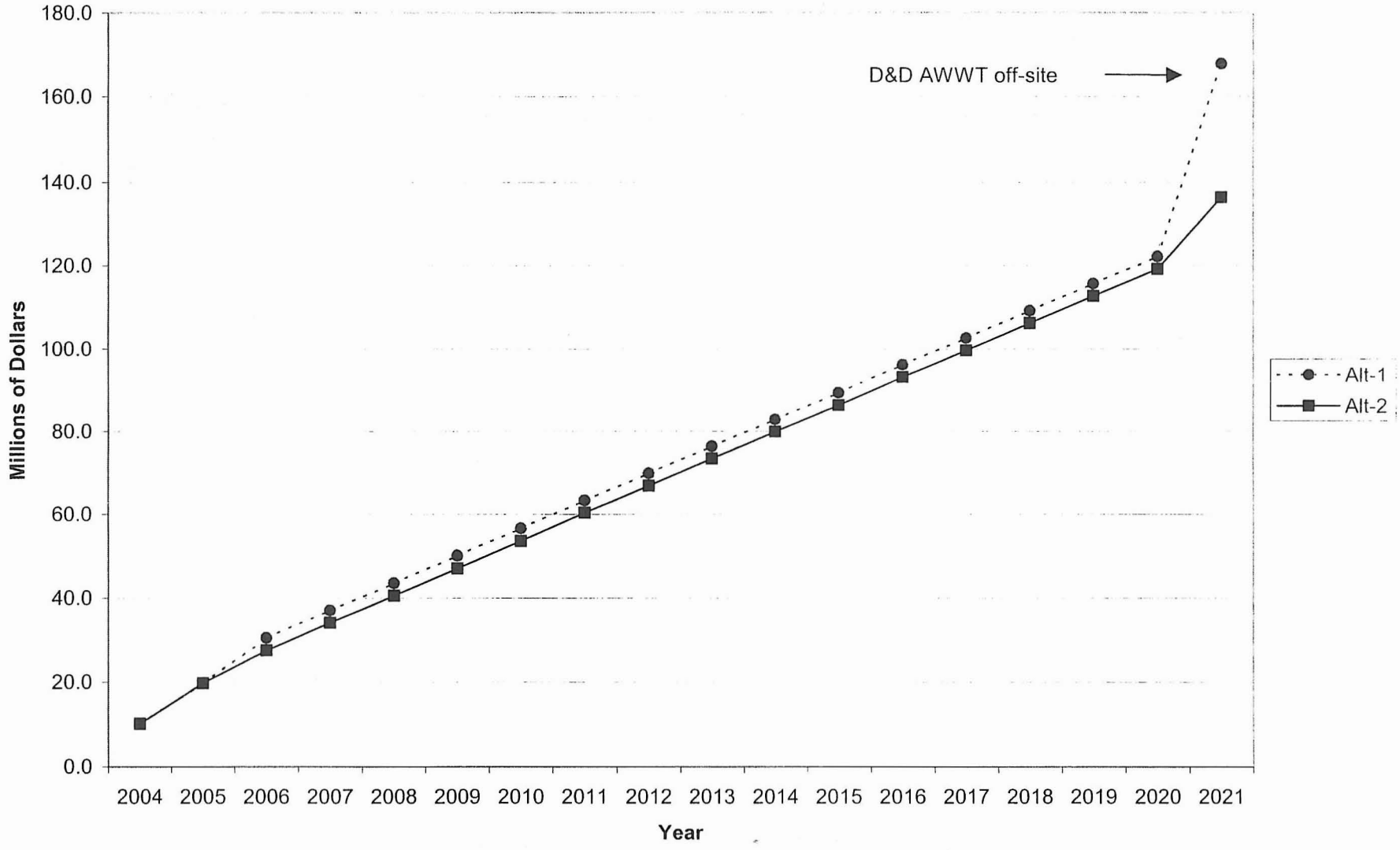


Figure B-3. Yearly Costs, Alternatives 2a, 3, 4, 5

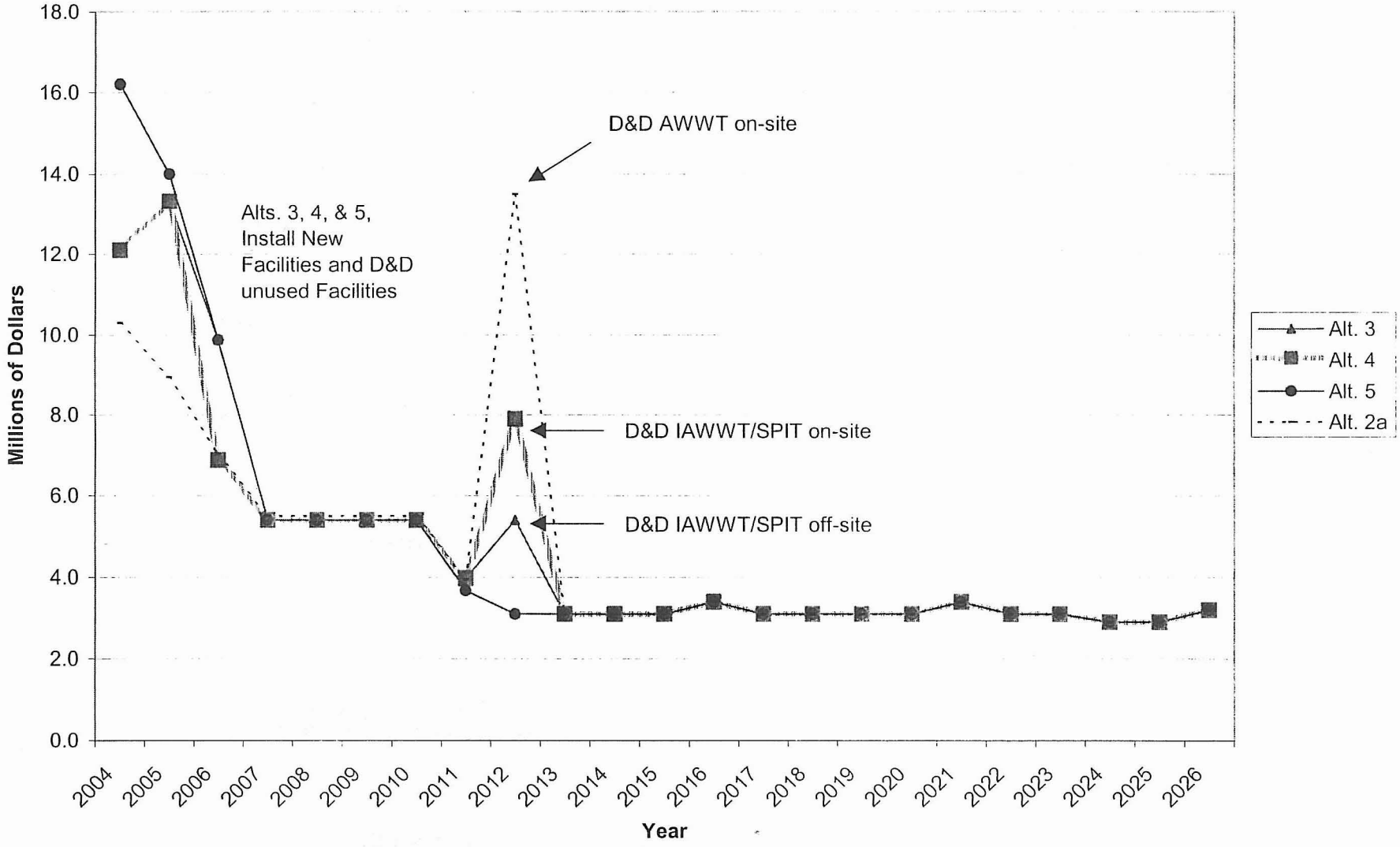


Figure B-4. Yearly Costs, Alternatives 2B, 3B, 4B, and 5B

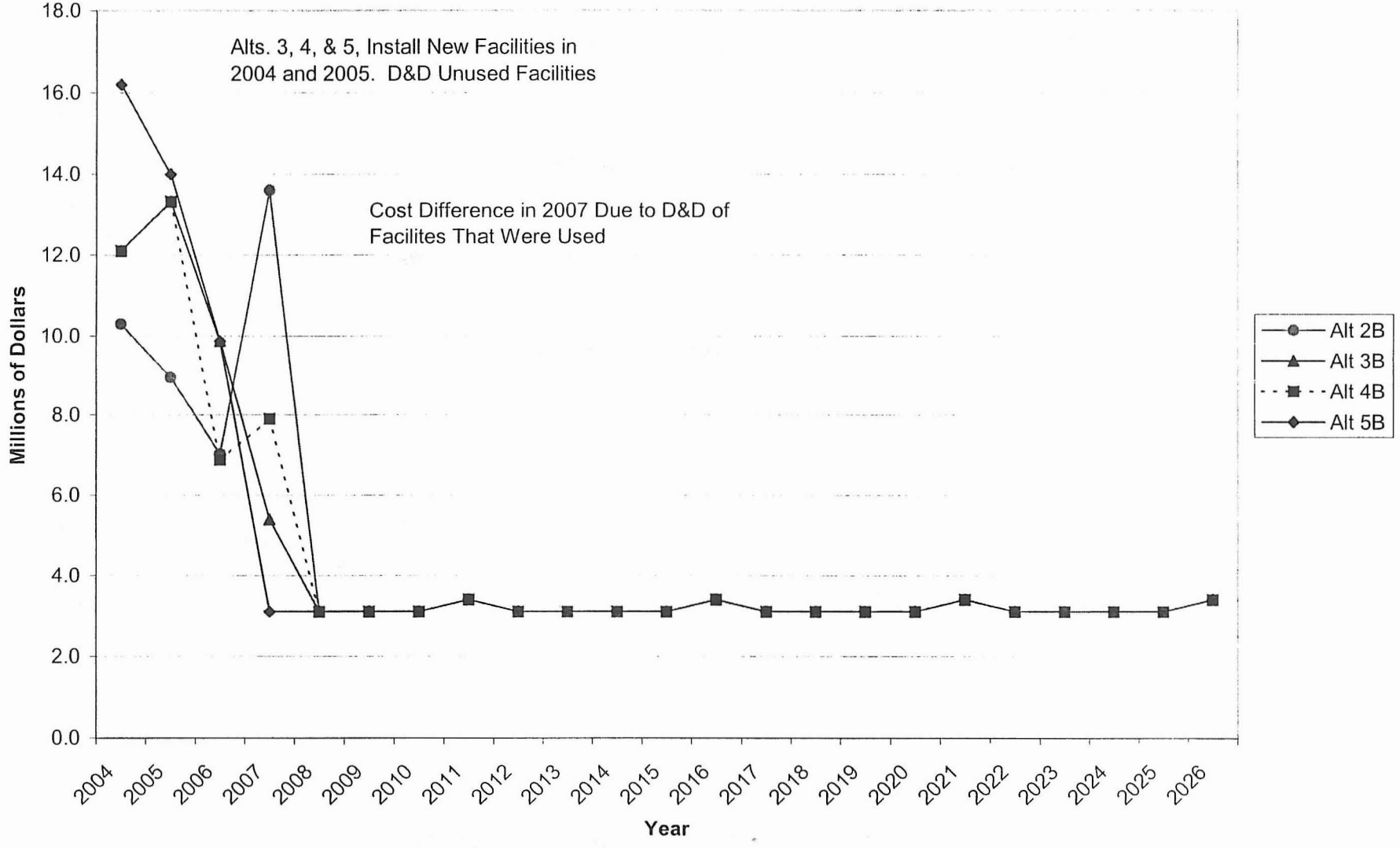


Figure B-5. Cumulative Costs, Alternatives 2a, 3, 4, 5

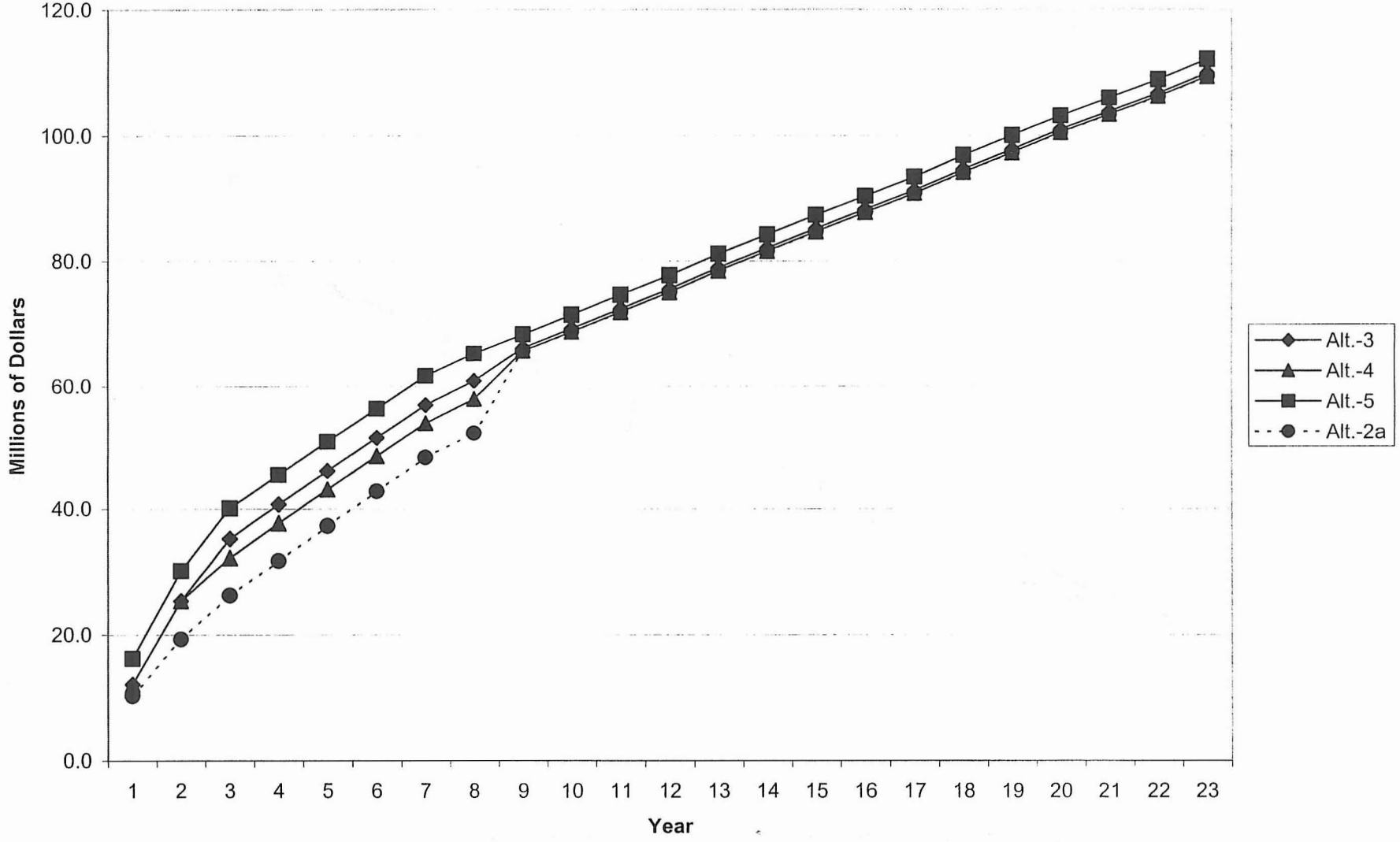


Figure B-6. Cumulative Costs, Alternatives 2B, 3B, 4B, and 5B

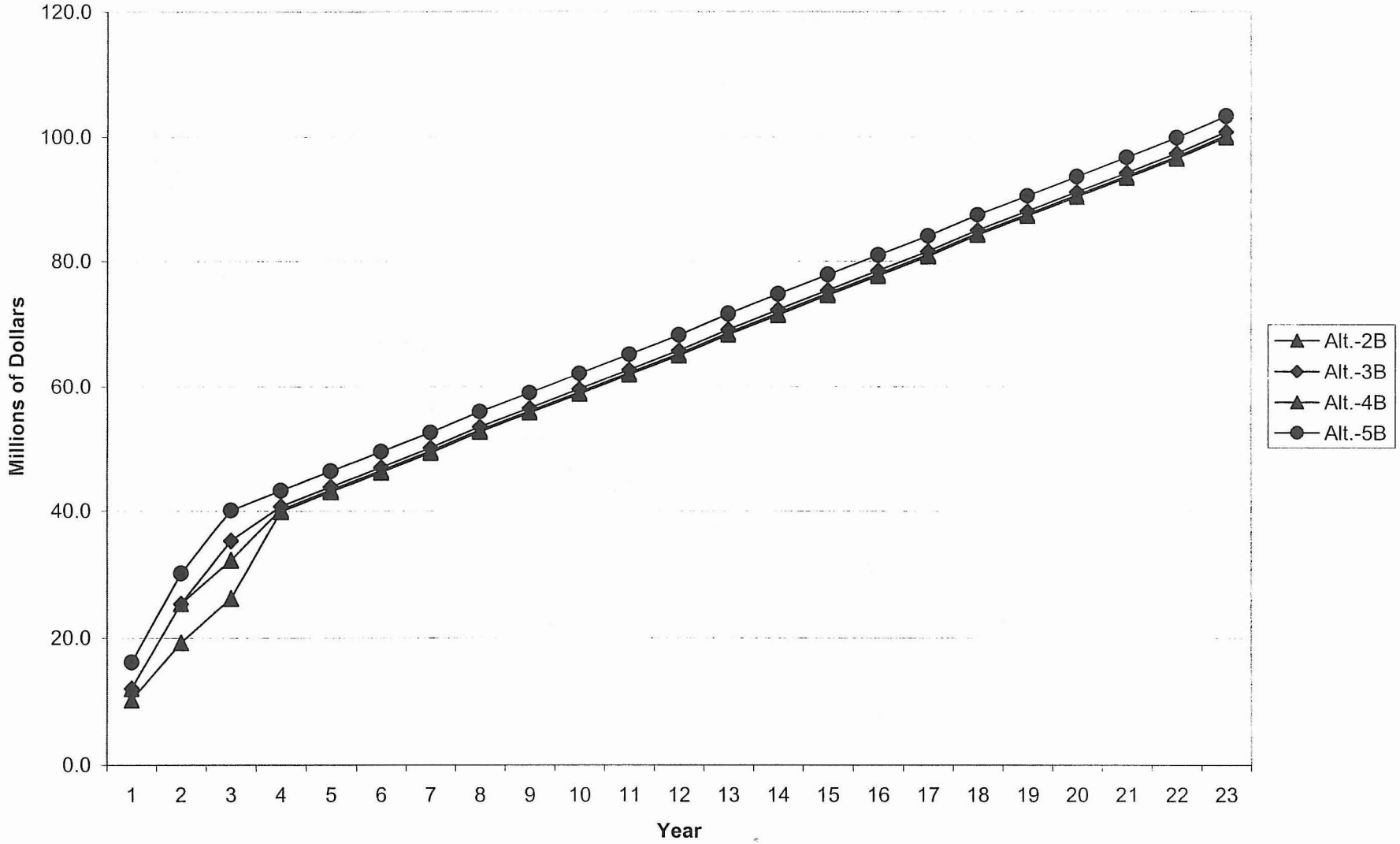


Figure B-7. Yearly Costs, Alternatives 6 & 7

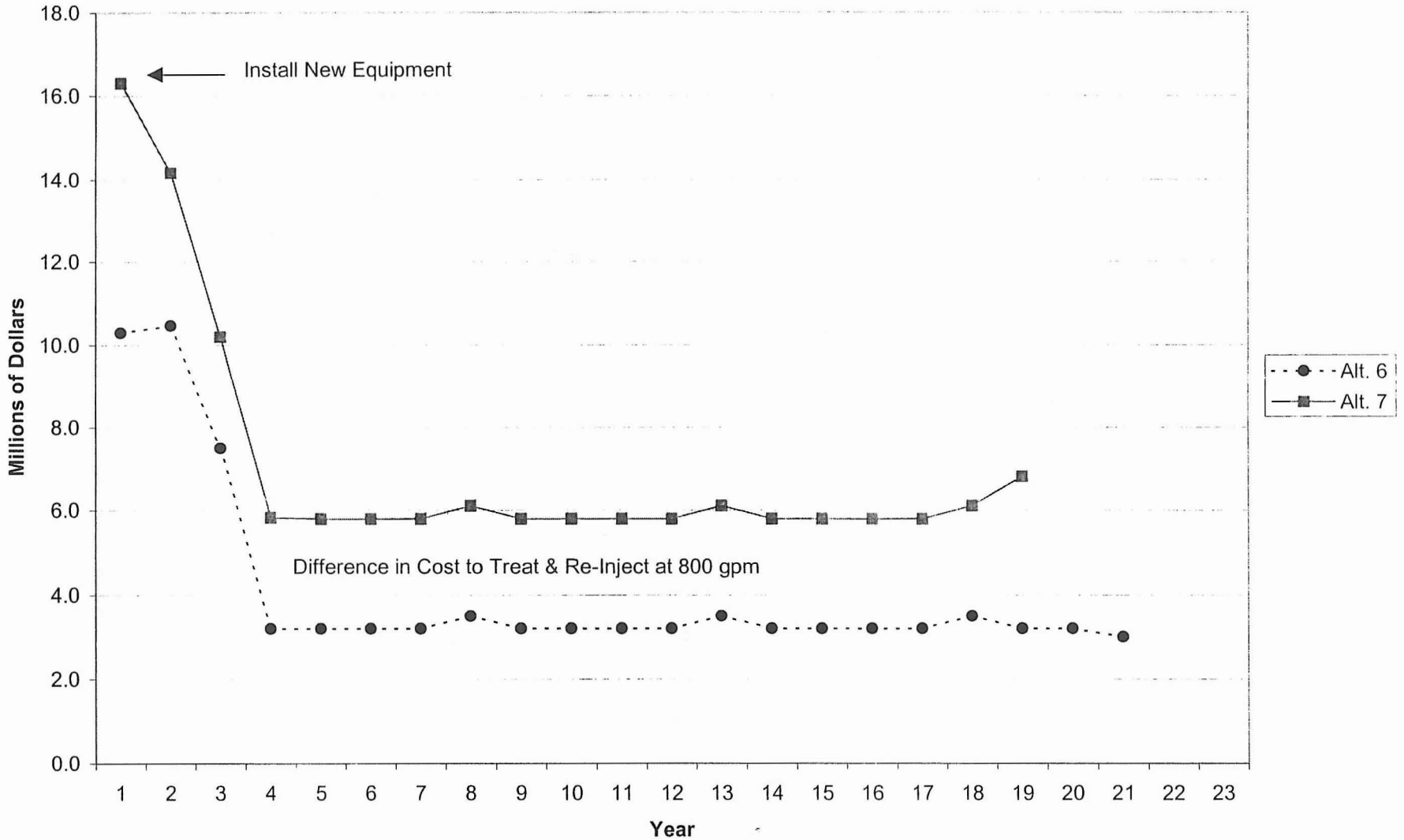
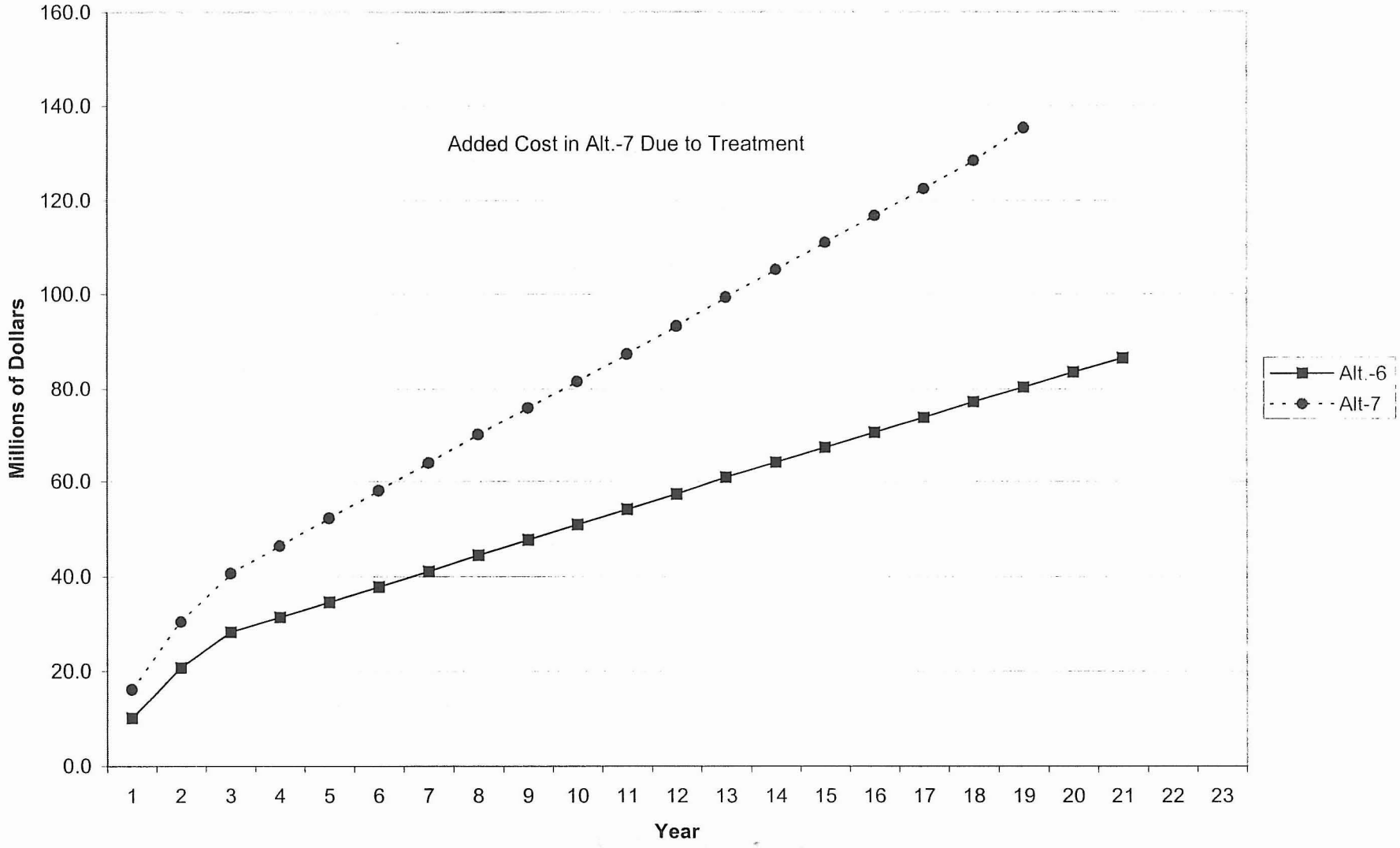



Figure B-8. Cumulative Costs, Alternatives 6 & 7