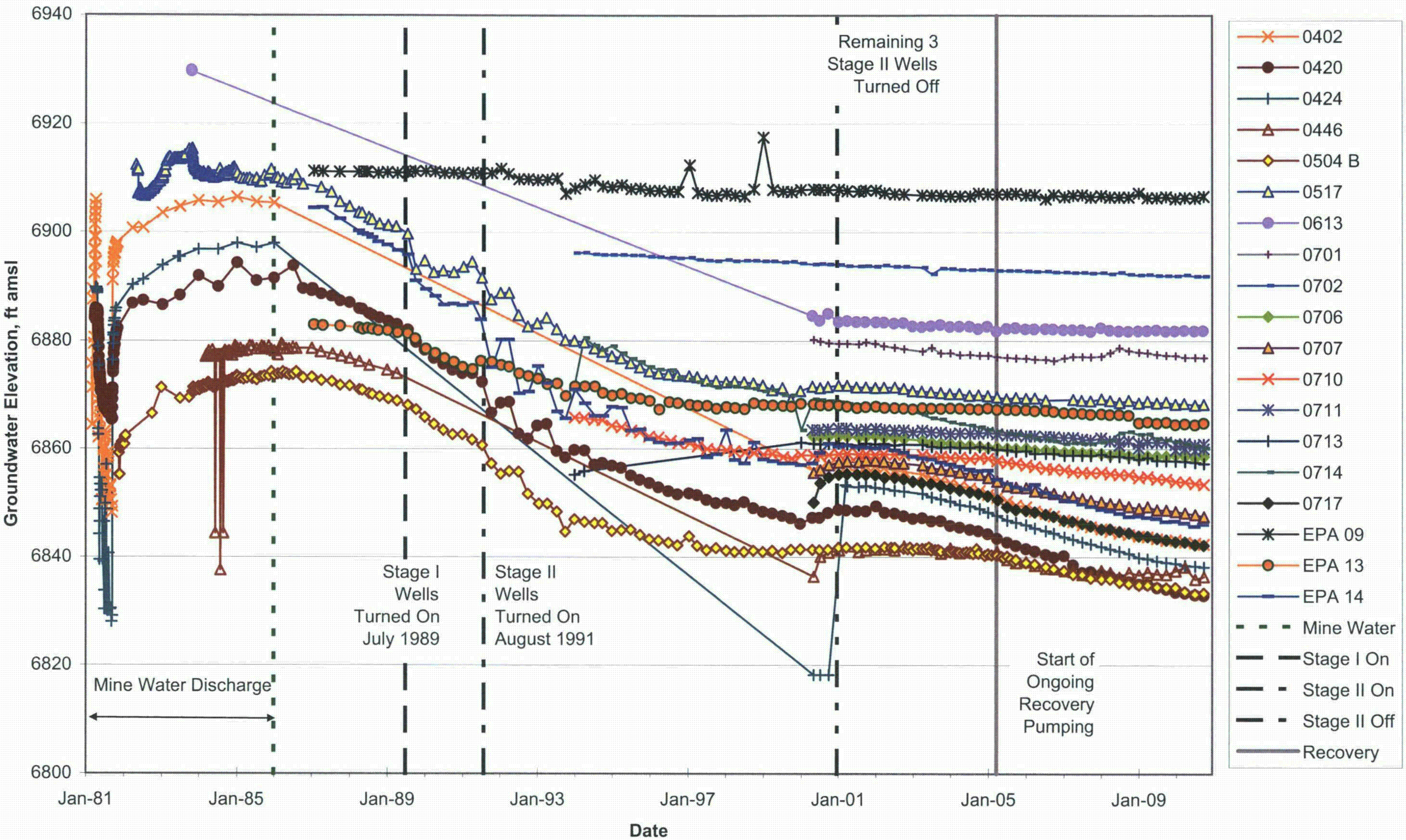
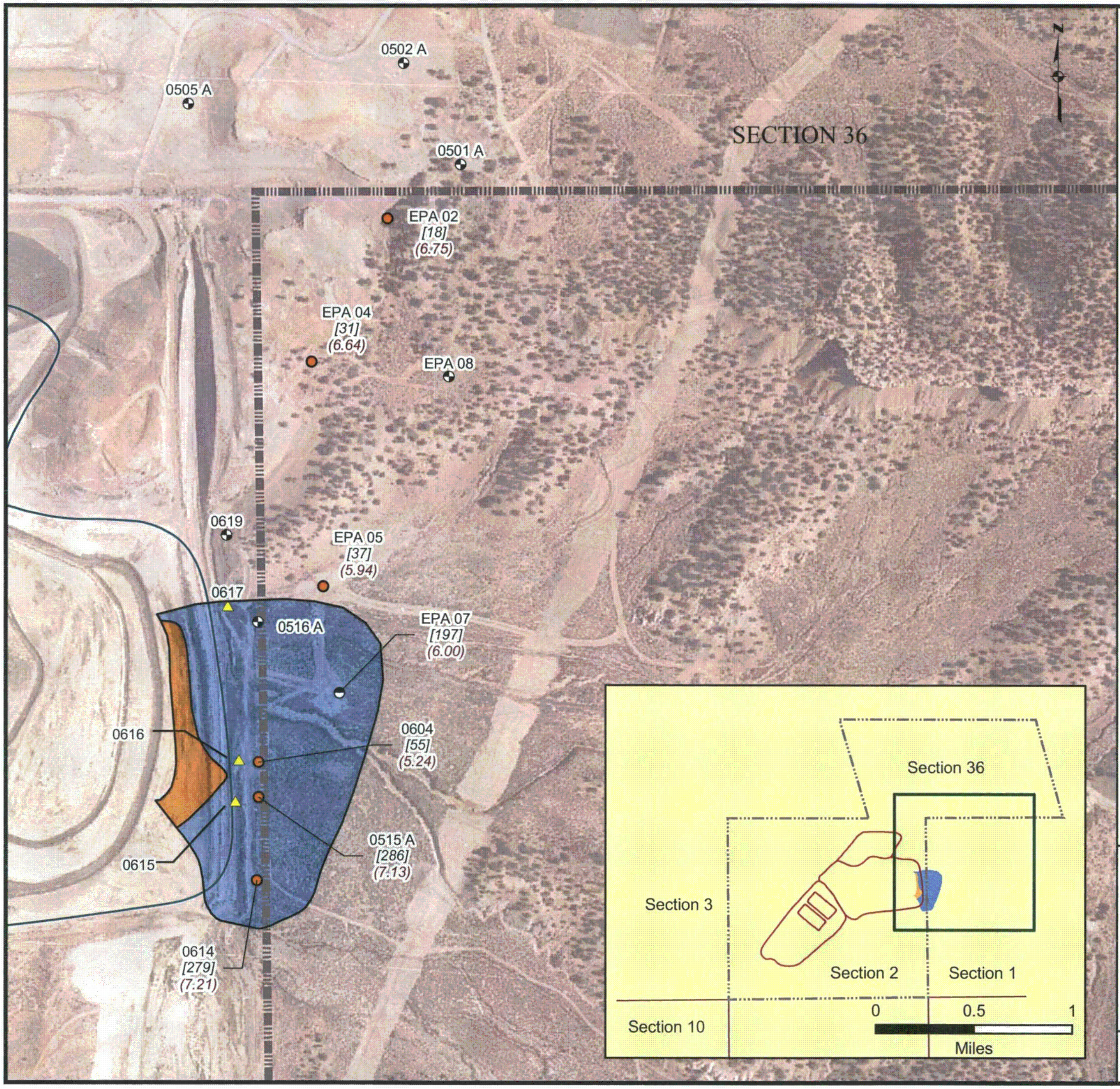
FIGURE 13
Effects of Past and Current Pumping to Dewater Zone 3
United Nuclear Corporation, Church Rock Site, Church Rock, New Mexico



11-6209-SC-111

Chester Engineers



Legend

Well Type

- Water Quality and Water Level Monitoring
- Water Level Monitoring
- Decomissioned East Pump Back
- Revised East Pump Back (Inactive)
- Cell Boundary
- Property Boundary
- Approximate Extent of Zone 1 Seepage Impact
- Approximate Extent of Zone 1 pH Less Than 4.0

[71] Chloride result in mg/L

(6.03) Field-measured pH in SU

Notes:

1. Seepage impacts delineated by chloride detections greater than 50 mg/L.
2. Aerial photo taken on August 1, 1996.

0 250 500 1,000

Feet

FIGURE 14

Zone 1 Extent of Seepage Impacts, October 2010

United Nuclear Corporation Church Rock Site, Church Rock, New Mexico

CHESTER ENGINEERS

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Legend

- Zone 1 Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Cell Boundary
- Property Boundary

Notes:

1. Groundwater elevation values are displayed in feet above mean sea level.
2. Well names are displayed with black text.
3. Groundwater elevations are shown with blue text and enclosed in parentheses.
4. Aerial photo taken on August 1, 1996.

FIGURE 15

Zone 1 Potentiometric Surface Map
October 2010

United Nuclear Corporation Church Rock Site,
Church Rock, New Mexico

CHESTER ENGINEERS

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N

Legend

- Zone 1 Monitoring Well
- Cell Boundary
- Property Boundary
- Saturated Thickness Contour
- Inferred Saturated Thickness Contour
- (3.6) Measured Saturated Thickness

Notes:
1. Well names are displayed with black text.
2. Saturated thickness values are shown in green text and enclosed in parentheses.
3. Saturated thickness values are displayed in feet.
4. Aerial photo taken on August 1, 1996.

0 250 500 1,000
Feet

FIGURE 16

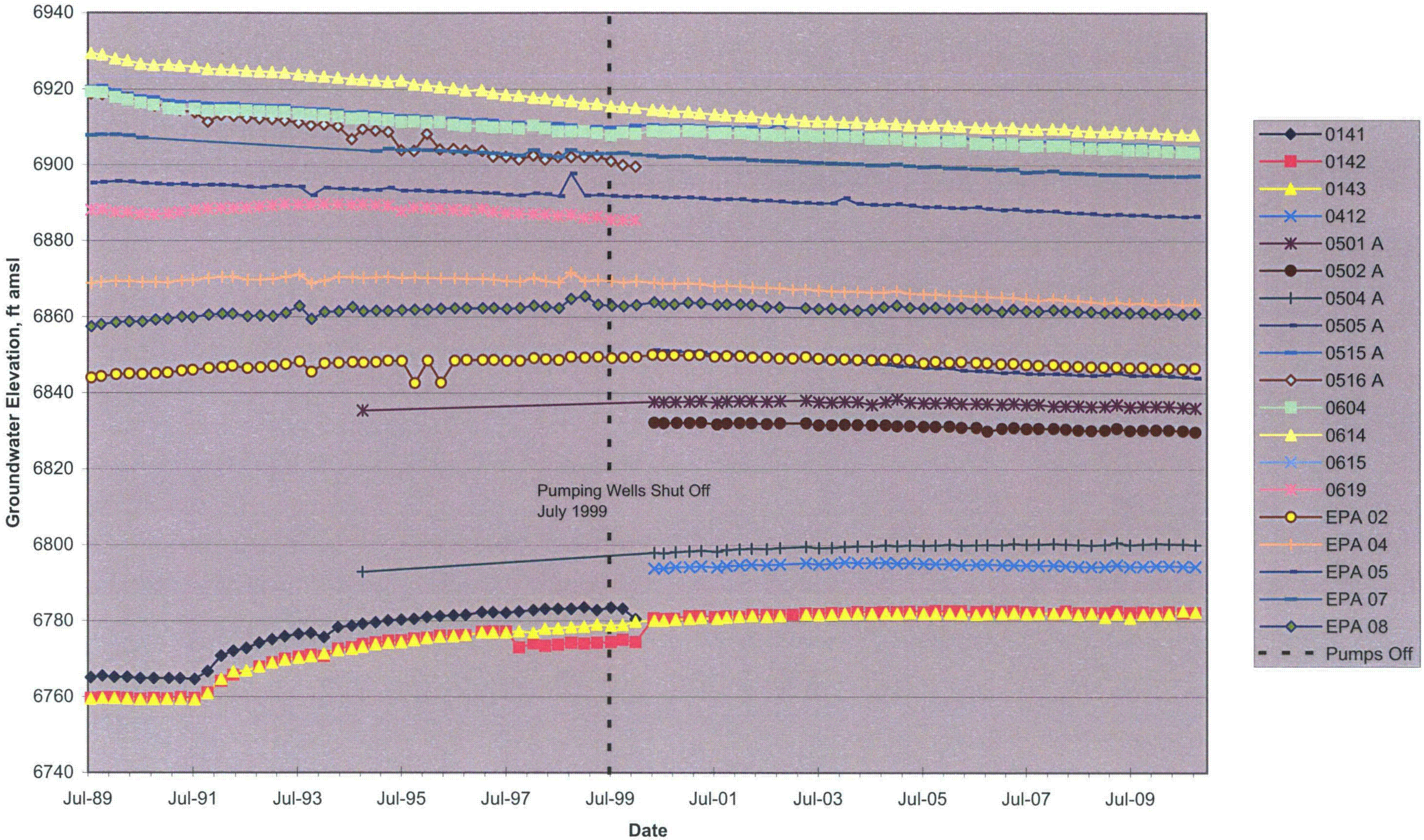
Zone 1 Saturated Thickness Map
October 2010

United Nuclear Corporation Church Rock Site,
Church Rock, New Mexico

CHESTER ENGINEERS

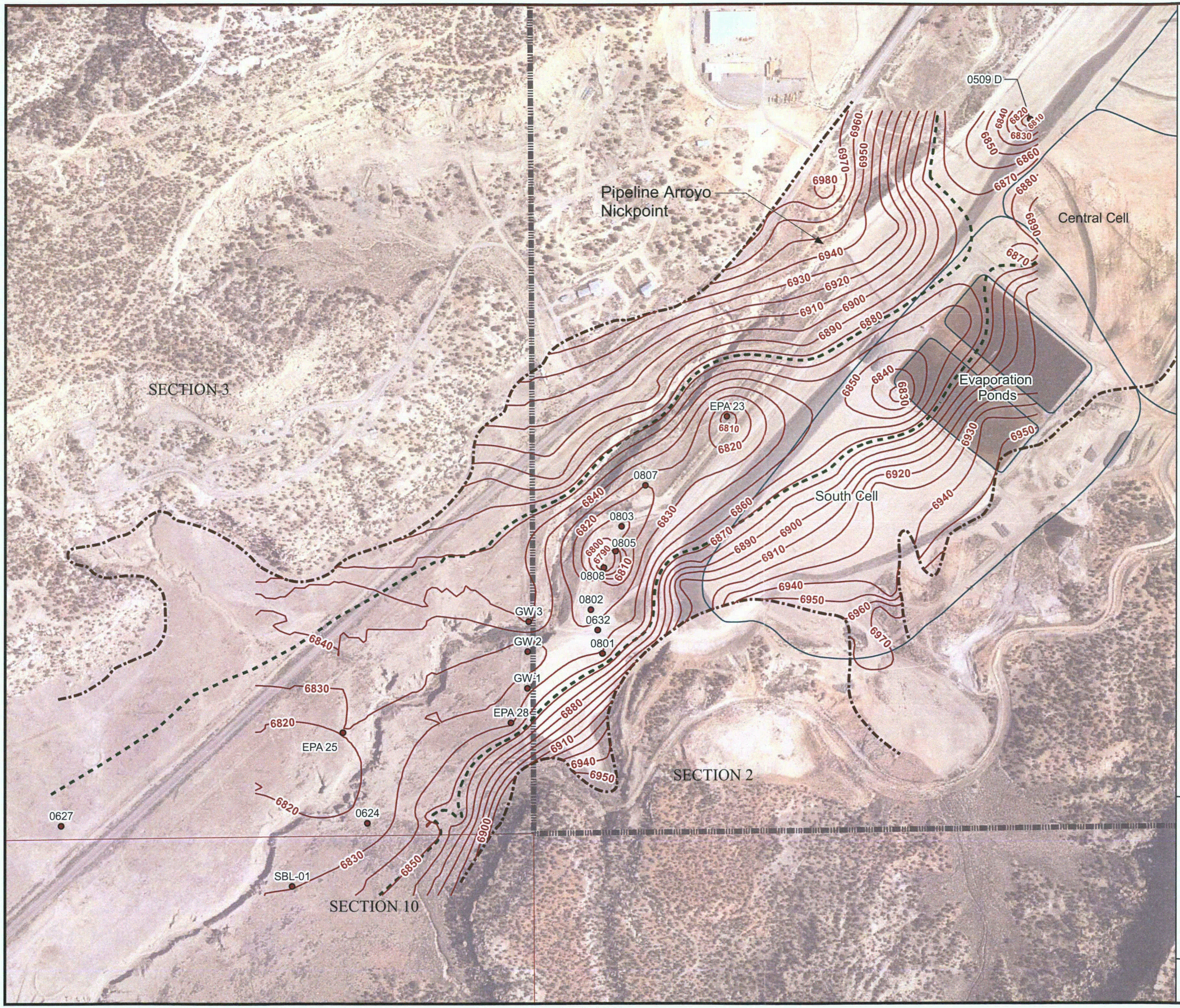
Z:\databases\6209_GE_CR\GISDATA\arcmap_doc\2011\f01_z1_sat_thick.mxd; March 30, 2011

FIGURE 17
Zone 1 Water Levels Over Time
United Nuclear Corporation, Church Rock Site, Church Rock, New Mexico



11-6209-SC-111

Chester Engineers



Legend

- Southwest Alluvium Monitoring Well
- Approximate Extent of Alluvium
- Approximate Extent of Saturated Alluvium
- Property Boundary
- Section Boundary
- Cell Boundary
- Bedrock Surface Elevation

Notes:

1. Well names are displayed with black text.
2. Bedrock surface elevation contours are in feet above mean sea level.
3. Aerial photo taken on August 1, 1996.

0 250 500 1,000
Feet

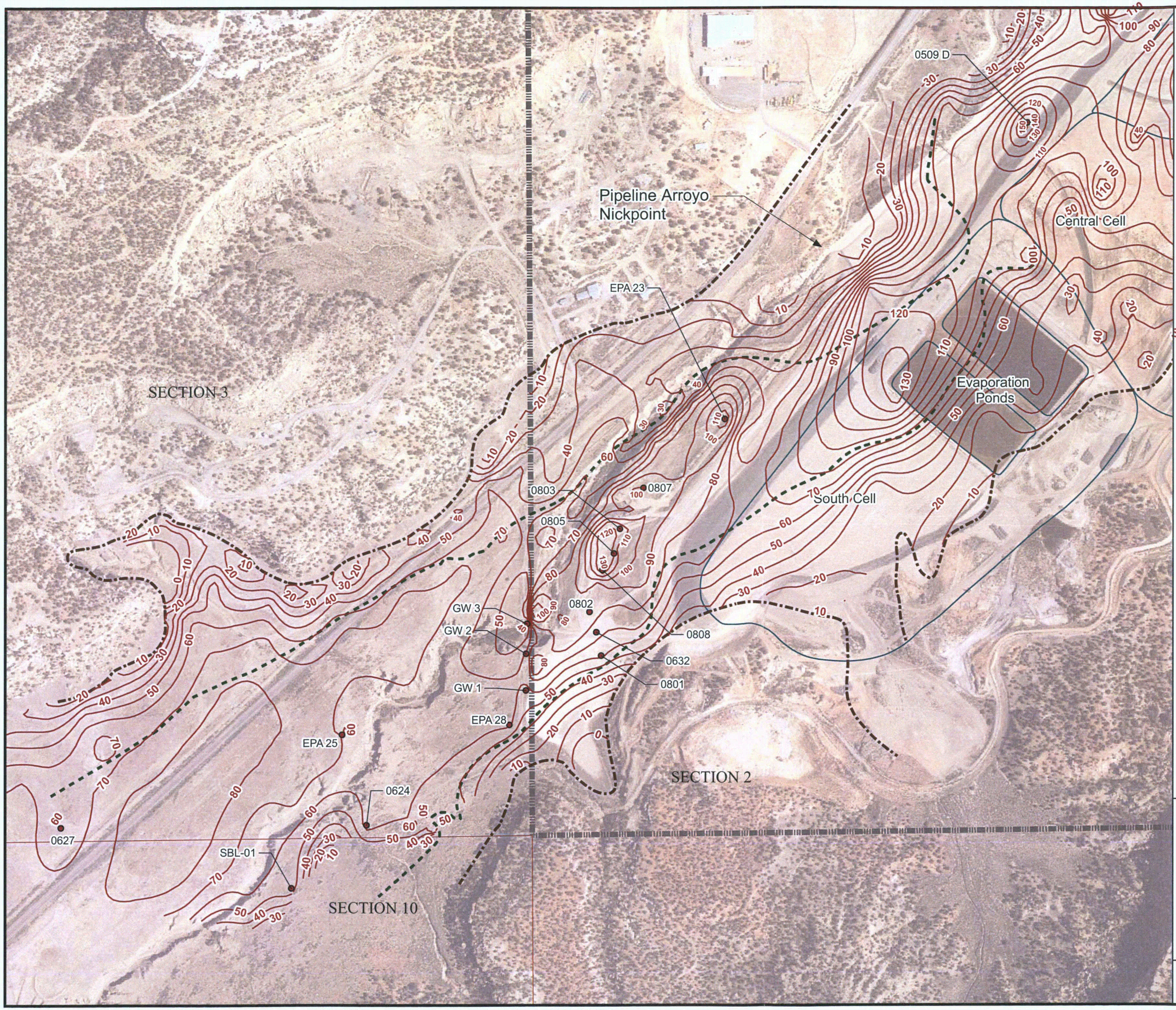
FIGURE 18

Southwest Alluvium
Bedrock Surface Elevation Map

United Nuclear Corporation Church Rock Site,
Church Rock, New Mexico

CHESTER ENGINEERS

Z:\databases\6209_GE_CR\GISDATA\arcmap_doc\2011\f02_swa_top_rock_elev.mxd; March 30, 2011



Legend

- Southwest Alluvium Monitoring Well
- Approximate Extent of Alluvium
- Approximate Extent of Saturated Alluvium
- Property Boundary
- Section Boundary
- Cell Boundary
- Depth to Bedrock Contour

Notes:

1. Well names are displayed with black text.
2. Depth to bedrock contours are shown in feet below ground surface.
3. Aerial photo taken on August 1, 1996.

0 250 500 1,000
Feet

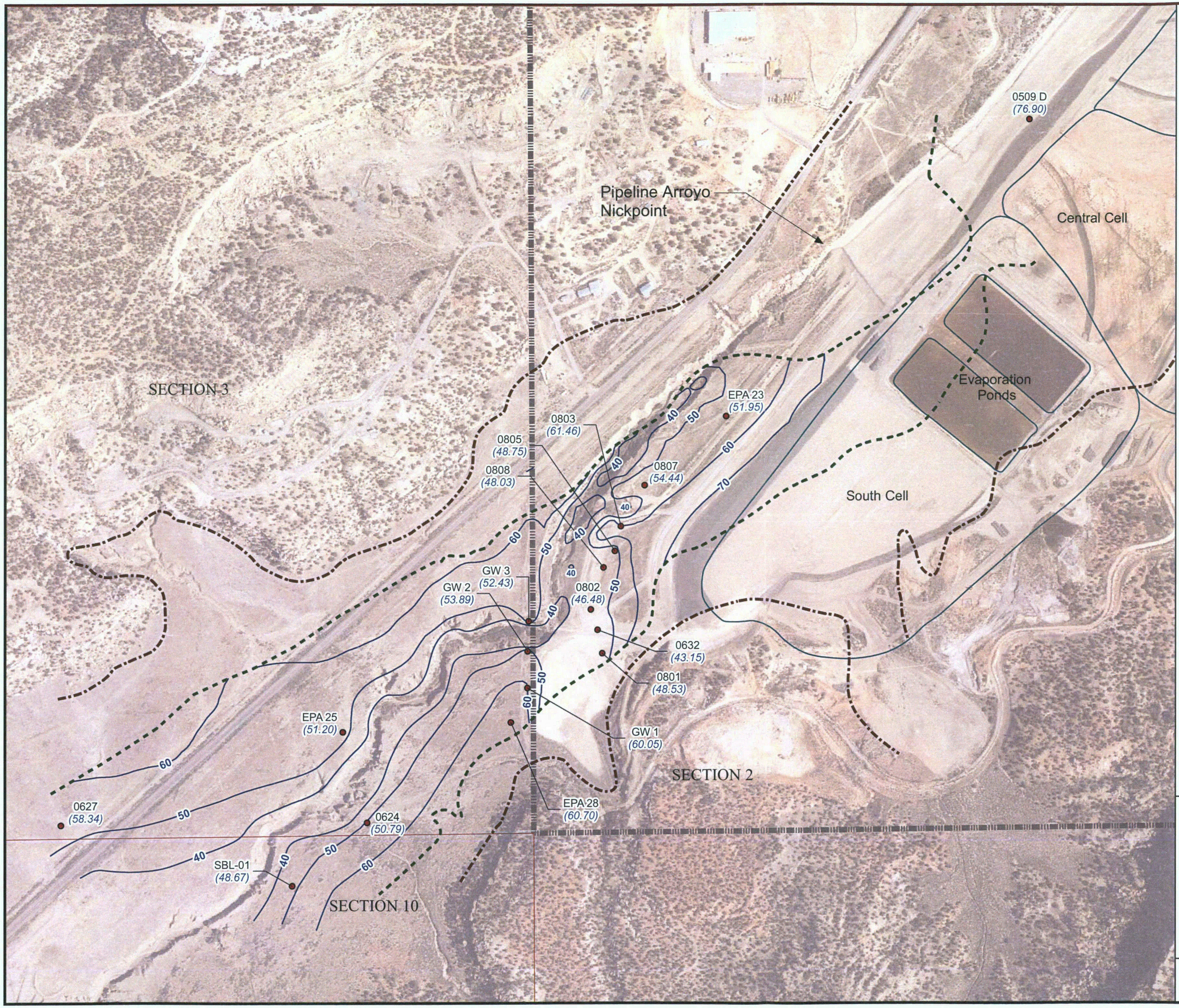
FIGURE 19

Southwest Alluvium
Depth to Bedrock Map

United Nuclear Corporation Church Rock Site,
Church Rock, New Mexico

CHESTER ENGINEERS

Z:\databases\6209_GE_CR\GISDATA\arcmap_doc\2011\f04_swa_depth_to_rock.mxd; April 6, 2011



Legend

- Southwest Alluvium Monitoring Well
- Depth to Water Contour
- Approximate Extent of Alluvium
- Approximate Extent of Saturated Alluvium
- Property Boundary
- Section Boundary
- Cell Boundary

Notes:

1. Well names are displayed with black text.
2. Depth to water measurements are displayed in feet below ground surface.
3. Depth to water measurements are shown with blue text and enclosed in parentheses.
4. Aerial photo taken on August 1, 1996.

0 250 500 1,000
Feet

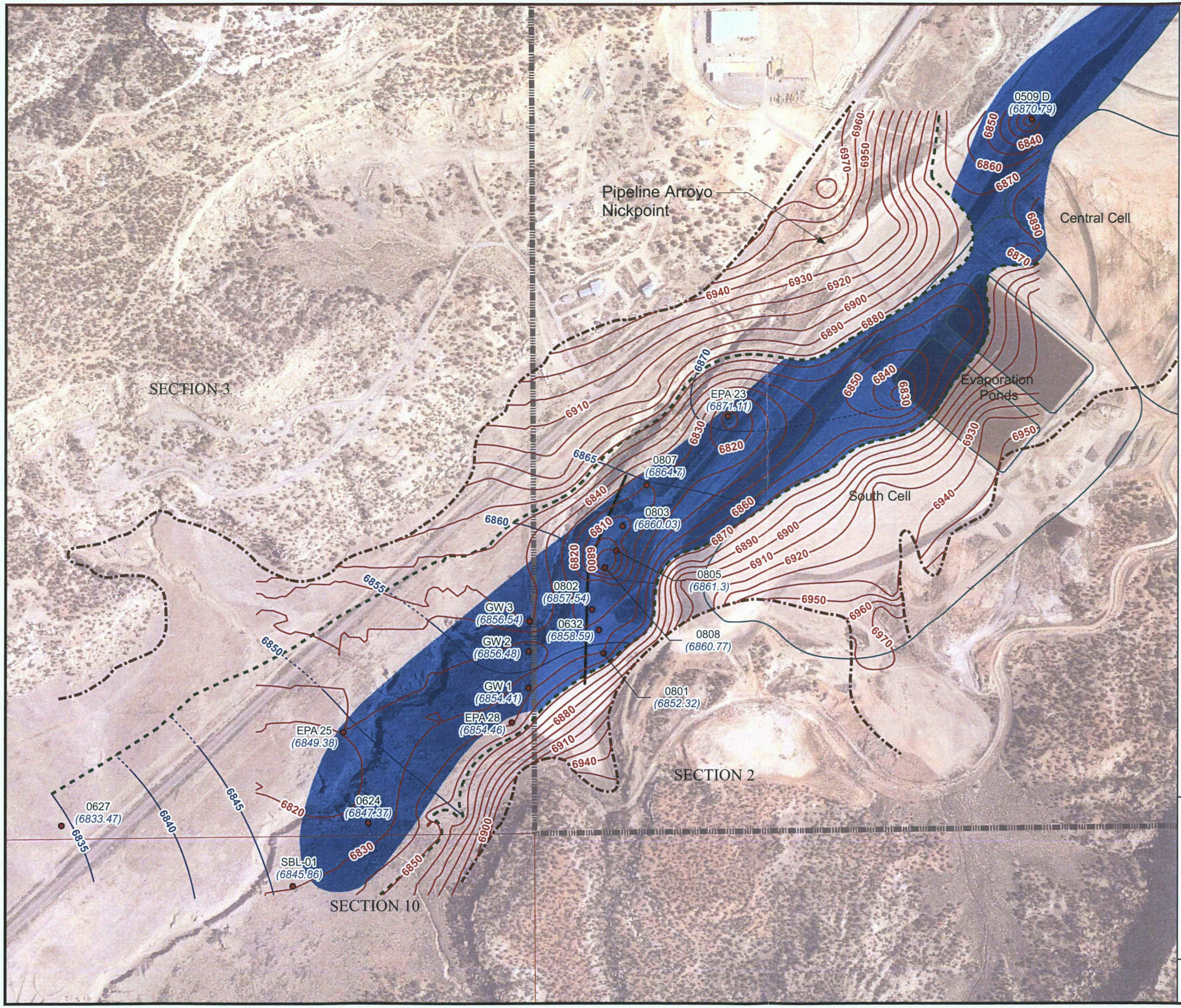
FIGURE 20

Southwest Alluvium
Depth to Water Map
October 2010

United Nuclear Corporation Church Rock Site,
Church Rock, New Mexico

CHESTER ENGINEERS

Z:\databases\6209_GE_CR\GISDATA\arcmap_doc\2011\f03_swa_dtw.mxd; March 31, 2011



Legend

- Southwest Alluvium Monitoring Well
- Groundwater Elevation Contour
- Inferred Groundwater Elevation Contour
- Approximate Extent of Alluvium
- Approximate Extent of Saturated Alluvium
- Property Boundary
- Section Boundary
- Cell Boundary
- Southwest Alluvium Plume
- Grout Curtain
- Bedrock Surface Elevation

Notes:

1. Groundwater elevation values are displayed in feet above mean sea level.
2. Well names are displayed with black text.
3. Groundwater elevations are shown with blue text and enclosed in parentheses.
4. Aerial photo taken on August 1, 1996.

0 250 500 1,000
Feet

FIGURE 21

Southwest Alluvium Potential Grout Curtain Location

United Nuclear Corporation Church Rock Site, Church Rock, New Mexico

CHESTER ENGINEERS

Z:\databases\6209_GE_CR\GISDATA\arcmap_doc\2010_annual_report\f03_swa_piezo.mxd; January 3, 2011

Appendix A

UNC Responses to EPA Comments (November 22, 2006) on the List of Preliminary Assembled Remedial Alternatives
(N.A. Water Systems, September 25, 2006)

APPENDIX A

UNC Responses to EPA Comments (November 22, 2006) on the List of Preliminary Assembled Remedial Alternatives (N.A. Water Systems, September 25, 2006)

A.1 EPA General Comment 1

<u>EPA General Comment 1:</u> *[1] The NAWS letter summarizes two of the three phases of a feasibility study (FS): the development of alternatives and the screening of alternatives. Those alternatives that remain following the screening-out phase, if approved by EPA, are to be carried forward into the detailed analysis of alternatives, the last phase of the Feasibility Study (FS). Overall, the NAWS letter lacks sufficient information to allow EPA to fully assess the merits of the remedial alternatives developed and screened by UNC. It is recognized that UNC proposed to develop the SWSFS as a companion document to the EPA's original 1988 FS, and one that acknowledges and builds on that FS. However, the SWSFS still needs to represent a comprehensive study that is consistent with all relevant and current regulations and guidance on the performance of an FS and supports future EPA decision making.*

<u>UNC Response to General Comment 1:</u> UNC intends to prepare a SWSFS that is consistent with all relevant and current regulations and guidance on the performance of an FS. UNC also understands that the SWSFS will rely on and build upon previous determinations that were already established in the site FS and the ROD. The FS analysis, and the ROD determinations reached from that analysis, remain as valid as they were in 1988, as supported by nearly 20 years of operational and monitoring data that confirm the limitations that were forecast in the prior work. Nonetheless, the SWSFS will present a comprehensive review that is consistent with regulations and guidance and that supports EPA decision-making on the site.

A.2 EPA General Comment 2

<u>EPA General Comment 2:</u> *[1] The NAWS letter appears to be out of sync with the 1988 Record of Decision (ROD) and the National Oil and Hazardous Substances Contingency Plan (NCP), 40 CFR 300 et seq., and it also fails to consult, discuss, or reference several important, relevant EPA Superfund guidance documents.*

[2] First, the statement the NAWS will not second-guess matters in the 1988 FS that are EPA decision making is beside the point. The FS is not a decision-making document, but is instead a developmental document that develops, assembles, and analyzes various remedial alternatives, and it is pre-decisional. It is a foundation-source document, along with the Remedial Investigation (RI), for both the proposed plan and the ROD. The reason that EPA has directed the process now underway is because it wants to look at new potential remedial alternatives (and perhaps some old ones re-examined) for the Site in the light of several years of additional Site-related data that have been gathered during Site remediation and in light of possible additions to the body of scientific and engineering knowledge, as well as changes in potentially applicable or relevant and

appropriate requirements (ARARs). In fact, this process arose out of the EPA's determination in the mandatory CERCLA five-year review of 2003 to engage in a Supplemental Feasibility Study (SFS), and it is consistent with the recognition in the 1988 ROD that it might be technically impracticable to clean up the ground water to meet all ARAR contaminant levels for ground water. See Appendix A to the 1988 ROD.

[3] The NAWS letter adopts an operable unit approach to UNC alternatives development, based on hydro-geologic strata, even though the EPA has never adopted this approach to Site ground-water remediation and has not directed it. While under the 1988 Memorandum of Understanding, the U.S. Nuclear Regulatory Commission (NRC) is responsible for remediation of the licensed facility or source control, EPA has handled the ground-water remediation problem as a single operable unit. See the selected alternative from the 1988 ROD. The SWSFS must look at the full range of comprehensive alternatives, individually or in combination, for a single ground-water remedy. The EPA recognizes that while it may be appropriate to examine and analyze different remedial approaches and technologies with respect to different saturated zones or geologic strata, remedial alternatives should be developed that deal comprehensively with the Site, including the no-action alternative.

[4] Further, the NAWS screening letter has missed the requirements of the NCP for the development and screening of remedial alternatives as a necessary precursor to the process of screening them. The NCP mandates development and analysis of preliminary remediation goals (PRGs), along with identification of potential ARARs, and analysis of systemic toxicants and known or suspected carcinogens, including contaminant risk pathways and receptors, as required underpinnings to the development, analysis, and screening of remedial alternatives. See 400 C.F.R. 300.430(e)(2). While it is true that PRGs from the original FS, as well as the remediation goals and remedial action objectives (RAOs) from the 1988 ROD, may still be valid (as UNC indicated in its July 27, 2006 letter to EPA), these issues need to be visited in the SFS process per the NCP. This has not been done even though for example, the five-year review identified at least nine compounds that should be examined for potential ARAR changes in light of regulatory developments since the 1988 ROD. The following list is taken from the 2003 Second Five-Year Review Report at p. 66:

- *a. Arsenic – the arsenic MCL was to have been reduced to 0.010 mg/l, effective January 2006.*
- *b. Antimony – An MCL was promulgated for antimony (0.006 mg/l) in 1992.*
- *c. Beryllium – An MCL was promulgated for beryllium (0.004 mg/L) in 1992.*
- *d. Cadmium – The cadmium MCL was reduced to 0.005 mg/l in 1991.*
- *e. Thallium – An MCL was promulgated for thallium (0.002 mg/L) in 1992.*

f. *Nitrate – The background value for nitrate was changed by the NRC to 190 mg/l on the basis of additional background studies it conducted in 1996. No decision has yet been made by the EPA on this change.*

g. *Sulfate – The background value for nitrate was changed by the NRC to 2,215 mg/l on the basis of additional background studies it conducted in 1996. No decision has yet been made by the EPA on this change.*

h. *TDS – The background value for TDS was changed by the NRC to 4800 mg/l on the basis of additional background studies it conducted in 1996. No decision has yet been made by the EPA on this change.*

i. *Uranium – The uranium MCL was reduced to 0.030 mg/l, effective December 2003.*

[5] It is noted that the New Mexico Environment Department (NMED) supported the NRC's changes of the post-mining, pre-milling background levels for nitrate, sulfate and TDS in a letter to EPA, dated January 6, 1998. In its review of the referenced document, the NMED has indicated to EPA that it would reexamine the Site data (both the pre-1998 data submitted in support of the background revisions, as well as data that have been collected since 1998) before supporting the formal request for such background level revisions in the SWSFS. Additionally, as stated in NMED's January 6, 1998 letter, "UNC would also need to apply for a variance from applicable state ground water standards for the non-compliant constituents through the New Mexico Water Quality Control Commission (NMWQCC)." The NMED informed the EPA that it is not aware that this has yet been done.

[6] It is also noted that in revisiting the merits of existing RAOs and PRGs, including those health-based cleanup levels selected by EPA in the ROD, it may be necessary to reassess the risk at the Site based on current Site conditions. If this is deemed necessary, EPA will perform any reassessment of the risk, as appropriate.

UNC Response to General Comment 2 Paragraphs [1] and [2]: UNC is following the NCP and EPA Superfund guidance. We are building upon the FS and ROD to evaluate remedial alternatives in light of site data and technology changes. We have also tabulated (Table 1) potential changes to ARARs.

The ROD is the current reference point by which any modifications to the remedy must be made. In as much as the remedy may be modified, such as through a ROD amendment, it is understood by UNC that the underlying site history, site characteristics, cleanup target areas and goals that were established in the ROD have not changed. In particular, where the more than 20 years of remedial action and monitoring support the fundamental findings of the 1988 ROD, we have taken care to preserve those findings. Appendix A of the ROD (EPA, 1988c) (Hydrologic Impact of Selected Remedy) contains one such fundamental finding which is consistent with the NCP and site data. It states the following under the section Contingencies for Selected Remedy:

> The goal of the selected remedy is to restore groundwater outside the tailings disposal area to concentrations dictated by Federal and State standards, or background, to the maximum extent practicable and to the extent necessary to adequately protect public health and the environment. A program of regular performance evaluations, required as part of the selected remedy, will provide a measure of how well this remedial alternative meets modeling and design expectations. The performance evaluation program may indicate that the response objectives have been met and the remedy is complete. However, operational results may demonstrate that it is technically impractical to achieve all cleanup levels in a reasonable time period, and a waiver to meeting certain contaminant-specific applicable or relevant and appropriate requirements (ARARs) may require re-evaluation as a result. Operational results may also demonstrate significant declines in pumping rates with time due to insufficient natural recharge of aquifers. The probability of significant reductions in the saturated thickness of aquifers at the site must be considered during performance evaluations since much of the water underlying the tailings disposal area is the result of mine water and tailings discharge, both of which no longer occur. In the event that saturated thicknesses cease to support pumping, remedial activity would be discontinued or adjusted to appropriate levels.

Since the issuance of the original EPA FS (1988b) and ROD (EPA, 1988c), quarterly groundwater monitoring has occurred for 20 years to date. Such monitoring has developed a very large body of site-wide water-quality and water-level data that are relevant to multiple issues to be addressed by the SWSFS. UNC discusses the meaning of these data in numerous reports (Earth Tech, 2000, 2002; GE, 2006; N.A. Water Systems, 2005, 2008d; Chester Engineers, 2009) that all point to a firm conclusion that it is technically impracticable to clean up the groundwater to meet all current ARAR contaminant levels for groundwater regardless of the technology applied.

UNC Response to General Comment 2 Paragraph [3]: UNC is treating groundwater as one operable unit in this document. As noted in EPA's comment, for this site it is appropriate to examine and analyze different remedial approaches and technologies with respect to different geologic strata. However, the remedial approaches are being developed in a way that will deal comprehensively with the site. In this document, UNC presents Figure 4, the assembled remedial alternatives, as a matrix similar to Table 8-1 (Combined Remedial Alternatives) in EPA's original FS (1988b). The original FS matrix, as is the one used in the SWSFS, is defined by rows of remedial alternatives and combined remedial alternatives specific to individual site hydrostratigraphic units (i.e., the Southwest Alluvium, Zone 3 and Zone 1), versus columns of the individual components of the combined remedial alternatives specific to individual site hydrostratigraphic units. We will evaluate whether the three different hydrostratigraphic units may require different remedial approaches to be effective.

UNC Response to General Comment 2 Paragraphs [4] and [6]: A compilation of contaminant-specific groundwater cleanup levels and other comparison values (including potential ARARs) has been accepted by EPA (see Table 6 of N.A. Water Systems, 2008b), as part of the revision of SWSFS Part I. This same compilation is provided in the present document as Table 1. All of the specific compounds and elements listed in this EPA comment are included in Table 1.

On February 7, 2007, UNC and EPA held a conference call concerning site risk assessment (EPA included a risk assessment specialist on the call). Key topics discussed included the following:

- Risk Assessment History at the Church Rock Site (including discussion of Chapter 4 of the EPA FS (1988b) – Public Health Assessment (PHA, discussed further below); the Agency for Toxic Substances and Disease Registry (ATSDR) Site Health Assessment (November 21, 1988); and the absence of ecological risk assessments having been completed because this is a groundwater-only site with no ecological receptor exposure)).
- Current Conditions (including discussion of changes in risk assessment methods over time; changes in toxicity factors; and other relevant considerations including the detection of significant radionuclide (e.g., uranium, radium-226, and radium-228) and inorganic constituent (e.g., arsenic, manganese, sulfate, and TDS) concentrations in background wells (e.g., Southwest Alluvium well SBL-1 and Zone 3 well NBL-1)).
- UNC's conclusions that: (1) risks will be similar if based on similar assumptions; (2) background water risk contributions will be significant; and (3) an updated risk assessment is unwarranted.

The following discussion elaborates on some of these issues including contaminant risk pathways and receptors, and a discussion of the key points presented in the original EPA (1988b) PHA.

2.2.1 Human Exposure Potential

For human health the following contaminant risk pathways were evaluated:

- Direct ingestion of groundwater.
- Dermal absorption of groundwater (e.g., through bathing).
- Ingestion of groundwater-irrigated produce.

There is no potential for human exposure to groundwater in the property owned by UNC (Sections 2 and 36), except during the quarterly groundwater sampling conducted by UNC personnel. No groundwater supply wells drawing on any of the three hydrostratigraphic units will be allowed on UNC property, and the same restriction will apply once this property is turned over to the Department of Energy for long-term surveillance monitoring.

EPA stated the following in the ROD about the inaccessibility and unsuitability of Zone 1 for water supply wells: "EPA studies indicate that the physical characteristics of Zone 1 are such that sufficient quantities of water could not be pumped from the sandstone to support volumes required for domestic or livestock purposes. Therefore, Zone 1 would not be a good candidate for locating a domestic or livestock well even if there were no impacts from tailings seepage" (ROD, EPA 1988c, Appendix H (Responsiveness Summary), Response to Comment 9 in Section 2, p. 4).

In the Southwest Alluvium outside the site boundary, there are no exceedances of hazardous constituents for which there are ROD-based standards or NRC License groundwater protection standards. Offsite impacted groundwater in the Southwest Alluvium has quality that is equal to or better than the offsite background water quality; both types of groundwater are unsuitable for human consumption.

In Zone 3, the impacted groundwater is presently restricted to locations within the site property boundary (Sections 2 and 36). Zone 3 in Section 1 is predominantly unsaturated. A new set of Zone 3 extraction wells were brought online during February 2009 in an attempt to contain the northward advance of the impacted water in Section 36 (the approved work plan was presented in N.A. Water Systems, 2008a).

A.2.2 Environmental Exposure Potential

No site groundwater naturally discharges to any bodies of surface water. Current potential effects on the ecology are mainly from the discharge of pumped water from Zone 3, and purged water from quarterly groundwater sampling, into the evaporation ponds on the South Cell. Illegally grazing stock have occasionally consumed water here but site access is restricted according to the NRC License and key parts of the site fencing have recently been physically strengthened, which has decreased the rate of incursions.

A.2.3 Consequences of Exposure

The consequences of human exposure to the most contaminated site groundwater are discussed next. It should be noted that, both within and outside of the site property boundary, the background groundwater quality is not suitable for human consumption.

A.2.4 Original Public Health Assessment

EPA prepared a Public Health Assessment (PHA) of the UNC Church Rock site, which was published as Chapter 4 of the FS (EPA, 1988b). The ROD indicates that although there was no exposure at that time to local residents from ingestion of groundwater in domestic and livestock wells within four miles of the site, EPA concluded that adverse health or environmental hazards could result in the future if no action was taken to prevent exposure to groundwater contaminants found at the site. Since the issuance of the ROD, new or revised toxicity values, and health-based values, have only become more conservative. As a result, if the human health risk assessment were updated, the conclusion reached would remain the same given similar exposure assumptions.

The PHA conclusions are based on the assumed ingestion of groundwater at contaminant concentrations equal to those measured during the 1985 RI sampling events (see Tables 4 and 5 of the ROD), which included a few sampling locations within Section 2 in addition to those in Sections 1, 3, and 36. In the PHA, EPA indicated this assumption was conservative since dilution, dispersion, and natural attenuation were expected to occur if seepage continued to migrate downgradient from the site and would likely further reduce the concentration of contaminants from the concentrations assumed.

The PHA calculated quantitative potential future health risks for carcinogenic effects due to both radionuclides and non-radionuclides and for non-carcinogenic effects.

The PHA assessed exposure to non-carcinogens by comparing the estimated daily intake of four indicator constituents (cadmium, manganese, nickel, and selenium) to the reference dose (RfD) or Acceptable Intake for Chronic Exposure developed at the time of the assessment. The results of the PHA indicated that the potential non-carcinogenic hazard index was greater than one under the future exposure scenario, for both the mean and maximum indicator parameter concentrations for each hydrostratigraphic unit (see Table A.1 below).

Table A.1
PHA Hazard Index Values

(Source: PHA in EPA Feasibility Study, 1988b)

Hydrostratigraphic Unit	Mean Hazard Index Adult	Maximum Hazard Index Adult	Mean Hazard Index Child	Maximum Hazard Index Child
Southwest Alluvium	5.2	16.2	18.2	56.8
Zone 3	5.5	34.5	13.3	120.7
Zone 1	3.2	13.1	4.6	11.5

The PHA concluded that the potential risk associated with the use of groundwater from Zones 1 and 3 exceeded 10^{-6} and the potential hazard quotient exceeded 1.0. If the risk assessment were to be updated using current data and methods, these conclusions would not change, primarily because toxicity values (i.e., reference doses) have become more conservative since the PHA was prepared.

Based on long-term monitoring data and improved understanding of the site, the hazard associated with certain site contaminants likely would be attributable to background conditions.

Table I of the PHA listed constituents comprising "on-site contamination" based on the RI. Table II of the PHA listed constituents comprising "off-site contamination" based on sampling of four domestic wells located within four miles of the UNC site.

Notwithstanding whether an updated risk assessment is necessary, it should be pointed out that there likely is no reasonably anticipated future exposure for the following reasons:

- There is no reasonably anticipated exposure to any of the seepage-impacted waters in Section 2, which will be included in the License and property transfer from UNC to DOE under UMTRCA Title II.
- There is no reasonably anticipated exposure to the portion of the Zone 3 plume that extends off the UNC property into Section 1 because there is currently less than 5 feet of saturation, which is gradually draining. (For example, well EPA-9 had a saturated thickness of 3.55 ft on October 13, 2008 (see Table 10 in Chester Engineers, 2009)). For this reason, NRC (1999) eliminated Section 1 as a point-of-exposure for Zone 3. The Zone 1 sandstone in Section 1 is entirely unsaturated approximately 800 feet to the east of the impacted water.

As stated in the PHA, background groundwater concentrations of certain contaminants (for example, combined radium) represent significant proportions of, or for some data exceed, those in impacted groundwater.

UNC Response to General Comment 2 Paragraph [5]: Regarding background water quality, all of the agency stakeholders have agreed to use the background values calculated in the revised SWSFS Part I (N.A. Water Systems, 2008b). It is noted here that the uranium background values determined solely by reference to statistical parameter estimates are inappropriate for application to the Southwest Alluvium because they do not take into consideration the role that geochemistry plays in influencing the spatial variation in background (GE, 2006).

We believe that UNC would not need to apply for variances through the State administrative process. CERCLA response actions are subject to substantive, not administrative, requirements (see the preamble to the proposed NCP (53 Fed. Reg. 51443)). EPA elaborated in 55 Fed. Reg. 8762 that this interpretation is most consistent with the terms of CERCLA and the goals of the statutes:

> Moreover, Congress made clear in sections 121(d)(2) and (d)(4) that the "standards" or "requirement" of other laws that are ARARs should be applied to actions conducted on-site, and specifically provided in section 121(e)(1) that federal and state permits would not be required for such on-site response actions. These subsections reflect Congress' judgment that CERCLA actions should not be delayed by time-consuming and duplicative administrative requirements such as permitting, although the remedies should achieve the substantive standards of applicable or relevant and appropriate laws. . . . Accordingly, it would be inappropriate

to formally subject CERCLA response actions to the multitude of administrative requirements of other federal and state offices and agencies.

UNC should not have to apply to a state agency for a variance from a CERCLA ARAR. The variance itself is an ARAR that can be applied to the site.

A.3 EPA General Comment 3

<u>EPA General Comment 3:</u> *[1] NAWS fails to note or analyze several relevant EPA guidance documents dealing with the subjects that it raises in its screening analysis. Instead, NAWS largely backs its conclusions with the prior recommendations of UNC counsel and contractors without analysis or support. The NAWS reference list contains only one reference to EPA guidance out of 17 references that are shown. That guidance has undergone important modification noted below that is not mentioned. Also, although Technical Impracticability (TI) Waivers are mentioned in the NAWS letter, there is no mention of the requirements of, nor any reference to, the EPA <u>Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration,</u> September 1993, OSWER Directive 9234.2-25.*

[2] The NAWS letter refers to remedy technologies (GRAs) that cost too much compared to their benefits, yet it does not reference the applicable costing guidance and cost benefit guidance, much less engage in analysis based on them. While the EPA 1988 RF/FS Guidance is referenced overall by NAWS, the section in that guidance dealing with costing is not referenced and has in any event been superseded by two other guidance documents not referenced here. These are: <u>A Guide to Developing and Documenting Cost Estimates During the Feasibility Study</u>, (July 2000 OSWER Directive 9355.0-75, and <u>Scoper's Notes – An RI/FS Costing Guide. Bring in a Quality RI/FS on Time and Within Budget</u>, EPA/540/G-90/002, NTIS: PB90-258369INX. Together, these supersede Section 6.2.3.7 of the Guidance for <u>Conducting Remedial Investigations and Feasibility Studies under CERCLA – Interim Final</u>, October 1988, EPA/540/G-89/004 (cited by NAWS).

[3] Further, there are at least two guidance documents germane to the development and screening of remedial alternatives that also summarize the general RI/FS Guidance requirements. These have not been cited by NAWS and they are: <u>Getting Ready: Scoping the RI/FS (November 1989),</u> OSWER 9355.3-01FS1, NTIS: PB90-274390INX, and <u>The Feasibility Study, Development and Screening of Remedial Action Alternatives (November 1989),</u> OSWER 9355.3-01FS3, NTIS: PB90-274416INX. For analysis farther down the RI/FS process there is <u>The Feasibility Study, Detailed Analysis of Remedial Action Alternatives (March 1990)</u>, OSWER 9355.3-01FSF4, NTIS: PB90-272675INX.

[4] The NAWS letter suggests consideration of Alternate Concentration Limits (ACLs). ACLs are governed by the NCP at 40 C.F.R. 300.430(e)(2)(i)(F) and the statute at 42 U.S.C. §9621(d)(2)(B)(ii). However, the analysis required by those provisions is not

present, nor is a reference to, or explanation of, the provisions of EPA guidance relating to the use of ACLs for Superfund sites. That EPA guidance is: Alternate Concentration Limits (ACL's) in Superfund Cleanups, July 19, 2005, OSWER Directive 9200.4-39, 4 p. That guidance supersedes 1987 Resource Conservation and Recovery Act Interim Final ACL Guidance with respect to Superfund cleanups.

[5] All of these guidance documents are available in PDF file download on the EPA Headquarters web site for Superfund. In addition, under "technology considerations" on the EPA Superfund web site, there are a number of technology documents available as well as links to information sources on both commonly use and innovative technologies for Superfund sites.

UNC Response to General Comment 3 Paragraph [1]: We have reviewed EPA's cited guidance document on TI, as well as the following EPA TI guidance document: EPA Memorandum, January 19, 1995, Consistent Implementation of the FY 1993 Guidance on Technical Impracticability of Ground-Water Restoration at Superfund Sites; OSWER Directive 9200.4-14. These references were used as appropriate in the analysis.

We have also reviewed the following relevant EPA information: EPA Power Point presentation, November 7, 2007, Technical Impracticability (TI) Waivers Usage at Superfund Sites; presented by Matt Charsky, Office of Superfund Remediation and Technology Innovation (OSRTI).

UNC Response to General Comment 3 Paragraphs [2] and [3] and [5]: We have reviewed all of EPA's cited guidance documents and relevant technology issues. These references were used as appropriate in the analysis.

UNC Response to General Comment 3 Paragraph [4]: We have reviewed EPA's cited regulations and guidance document on ACLs, as well as relevant regulations at 40 CFR §264.94(a) and (b). These references were used as appropriate in the analysis.

A.4 EPA General Comment 4

EPA General Comment 4: *[1] In its June 23, 2006 letter to UNC, EPA specified that the analysis and data of UNC's previous TI evaluation shall be carried forward and discussed in the SWSFS if a TI Waiver is to be a component of any alternative. Although the TI Waiver is included in the list of alternatives carried through the development and screening process, the analysis and data supporting the TI Waiver alternative were not, nor was the guidance on evaluating TI in ground-water restoration discussed or referenced (see EPA General Comment No. 2, above). As UNC is aware, the EPA put together a TI Waiver Review Team for evaluating the merits of invoking a TI Waiver for the standards of sulfate, TDS and manganese based on previous Site-related documents submitted by UNC. The SWSFS shall be included in the set of documents that the TI Waiver Review Team will review in performing such evaluation. Therefore, the SWSFS needs to be conducted without an initial bias towards waiving ARARs. The SWSFS needs to include the TI evaluation and analysis and data to support carrying forward the TI*

Waiver into the detailed analysis of alternatives, but the discussion of such issues should follow only upon rigorous analysis of the possible effectiveness of all potential alternatives relative to Site-specific ARARs. This comment also pertains to the inclusion of ACLs as a component of any alternative.

UNC Response to General Comment 4: During a conference call between UNC and EPA on December 19, 2006 (post-dating the EPA comments presently under review here), EPA requested that TI Waivers should be categorically eliminated as remedial alternatives during UNC's revision of SWSFS Part II. EPA suggested that instead, UNC might explain why some site constituents cannot meet ROD cleanup levels, potential ARARs, and other relevant comparison values. UNC has deleted reference to TI Waivers from the lists of remedial alternatives in this revision of SWSFS Part II. The SWSFS will reference and/or include the data and analyses that have previously been used to support former TI evaluations.

A.5 EPA General Comment 5

EPA General Comment 5: *[1] All cost documentation referenced in the MWH Supplemental FS (October 2004) should be included in the SWSFS.*

UNC Response to General Comment 5: This information is provided in Appendix C of the document.

A.6 EPA General Comment 6

EPA General Comment 6: *[1] The passive reactive barrier (PRB) alternative apparently was not evaluated for any of the aquifers. Please include the PRB alternative in the evaluation.*

UNC Response to General Comment 6: UNC has included permeable reactive barriers in the present evaluation (see Table 3 and Figure 1).

A.7 EPA Specific Comment 1

EPA Specific Comment 1: *Page 7, paragraph 6: The document states that "Government parties have agreed that there is no Zone 3 point-of-exposure (POE) in Section 1 (NRC, September 16, 1999)." The NMED does not support the NRC concept of point-of-exposure for the protection of the State of New Mexico's ground-water resources. The NMWQCC regulations and the NMED policy require groundwater to meet established standards throughout the aquifer, including beneath the contaminant source area(s), not only at designated locations such as POE wells. Please delete or revise any statements in the referenced document that refer to POE.*

UNC Response to Specific Comment 1: The compliance concept and phrase "point of exposure" is not used in the body of this revised submittal of SWSFS Part II. Nonetheless, the ROD expressly states that, "the selected remedy for this operable unit is designed to contain, remove, and evaporate contaminated groundwater resulting from tailings seepage *outside of the tailings disposal area thus preventing further migration of seepage into the environment*" (italics added). It should be noted that NMED policy is not an ARAR. The state's policy is clearly in conflict with both the objectives of the CERCLA action and the NRC Source Materials License, which has established points of compliance for meeting the groundwater protection standards.

A.8 EPA Specific Comment 2

EPA Specific Comment 2: *Figure 1: The eleven process options referenced in the EPA's 1988 FS should be listed in the table.*

UNC Response to Specific Comment 2: The relevant figure in EPA's 1988 FS is Figure 5-3 (Technical Implementability Screening of Process Options). Under the category Remedial Technology of Vertical Barriers in that figure, there are seven (not eleven) process options shown. These seven process options are now shown in the present document's Figure 1; an additional process option, deep soil mixing, is also shown.

A.9 EPA Specific Comment 3

EPA Specific Comment 3: *Table 2, Southwest Alluvium Alternatives: This table lists alternatives that are retained after the initial screening process. Please retain the following remedial technologies in this table from Figure 1:*

a. *Barriers – physical barriers were screened out from Figure 1 based on the fact that pumping to avoid spillover is required. Please retain the physical barrier with pumping alternative.*

b. *Hydraulic flushing – this alternative was not screened out from Figure 1, yet was not retained as an alternative; please add it to Table 2.*

UNC Response to Specific Comment 3: In the attached revised Figure 1, we have retained the physical barrier with pumping alternative for the Southwest Alluvium. In the attached revised Table 4 (Summary of Potential Remedial Alternatives for the Southwest Alluvium [revised version of former Table 2]) we have included the hydraulic flushing alternative.

Appendix B

Revised Submittal – Calculation of Background Statistics with Comparison Values, UNC Church Rock Mill & Tailings Site, Church Rock, New Mexico
(N.A. Water Systems, October 17, 2008)

NOTE – THIS REPORT IS ONLY PROVIDED ON THE CD

Appendix C

Revised Submittal -- Estimated UCL95 Statistics and EPCS in Impacted Groundwater (N.A. Water System, December 5, 2008)

NOTE – THIS REPORT IS ONLY PROVIDED ON THE CD

Appendix D

Select Permeable Reactive Barriers Case Studies

APPENDIX D
Select Permeable Reactive Barriers Case Studies

EPA (2000b) and the RTDF website summarized the following case studies at former uranium mill and tailings sites:

- Former mill site, Monticello, Utah – Full-scale PRB installed 1999; reactive medium zero-valent iron (Fe^0); contaminants: uranium, arsenic, manganese, selenium, and vanadium – physical installation involved driving sheet piling into uppermost bedrock (depth not stated) forming a rectangular box; the native soils within the box were then replaced with Fe^0 and gravel. The influent groundwater concentrations for the target contaminants were as follows: uranium (700 ug/L); selenium (40 ug/L); vanadium (400 ug/L); and arsenic (10 ug/L). Measurements of groundwater quality within the PRB showed non-detects for all these contaminants.
- Bodo Canyon Disposal Cell Mill Tailings Site, Durango, Colorado – Four pilot-scale PRBs installed from 1995 to 1999; four gates with reactive media of iron foam (Fe^0), iron with copper catalyst, granular iron, and steel wool; contaminants: uranium, arsenic, selenium, zinc, radium-226, molybdenum, and manganese – physical installation collected ground seepage from a tailings disposal cell and piped it to a retention pond; PRBs were constructed to ~7 feet below ground in unconsolidated materials, in proximity to the retention pond – some pond fluids piped to holding tanks for testing of refined configurations of the reactive media. The influent concentrations of all the target contaminants were several orders higher than those associated with the Southwest Alluvium at the Church Rock site.
- Fry Canyon Uranium Mine Mill Tailings Site, Utah – Three pilot-scale PRBs installed 1997 – three gates with reactive media of amorphous ferric oxide, bone-char phosphate, and Fe^0; contaminant: uranium – gates within an alluvial to colluvial aquifer (poorly sorted fine- and medium-grained sand) less than 10 feet thick. The influent concentration of uranium was not stated in the case study reviewed; however, that study does say that the phosphate and Fe^0 barriers removed more than 99% of the uranium.

The RTDF website also summarized the following two full-scale case studies involving treatment for radionuclides at two other sites (these are not former mill and tailings sites):

- Y-12 Site, Oak Ridge National Laboratory, Oak Ridge, Tennessee – Liquid wastes stored in disposal ponds – one full-scale PRB installed 1997 and one full-scale continuous treatment trench installed 1997 – PRB gate reactive medium Fe^0; continuous trench contains 5 separate reaction vessels – contaminants: nitric acid, uranium, and technetium – gate and trench within clay and regolith from 10 to 20 ft thick. The case study reviewed did not provide information on specific contaminant concentration reductions achieved by the PRBs.

- Rocky Flats Environmental Technology Site (Solar Ponds Plume), Golden, Colorado – Liquid wastes stored in a former pond have contaminated groundwater – one full-scale PRB installed 1999 – treatment via two reaction vessels with reactive media of Fe^0 and wood chips – contaminants: nitrate and uranium -- the groundwater collection system intercepting the groundwater contaminant plume extends approximately 1,100 ft; to install the collection system, an excavation was dug at a variable depth of approximately 20-30 ft below ground and approximately 10 ft into claystone. The influent concentration of uranium was 20-28 pCi/L; the PRB effluent concentration was <1 pCi/L.

All the above case examples involve PRBs configured as either funnel-and-gates or continuous treatment walls (or trenches), emplaced within unconsolidated materials at depths of 30 ft below ground or less.

The RTDF website describes the following case studies of PRBs targeting non-radionuclide inorganic constituents:

- Nickel Rim Mine Site, Sudbury, Ontario, Canada – Inactive mine tailings impoundment has contaminated groundwater (tailings have been undergoing oxidation for ~ 40 years) – one full-scale continuous PRB installed 1995 – reactive medium organic carbon – contaminants: nickel, iron, and sulfate – contaminated aquifer is 10-26 ft thick and composed of glacio-fluvial sand confined to a narrow valley bounded on both sides and below by bedrock; barrier formed by trenching spans the valley and is 50 ft long and 14 ft deep. The influent concentrations for the target contaminants were as follows: sulfate (2400-3800 mg/L); iron (740-1000 mg/L), and up to 10 mg/L of nickel. Treatment in the PRB caused a decrease in sulfate concentrations to 110-1900 mg/L; iron concentrations decreased to <1-91 mg/L; and dissolved nickel decreased to <0.1 mg/L.

Tonolli Superfund Site, Nesquehoning, Pennsylvania – Former battery recycling and secondary lead smelting plant plus acid mine drainage from coal mine spoil – one full-scale continuous PRB installed 1998 – reactive medium limestone – contaminants: lead, cadmium, arsenic, zinc, and copper – contamination in coal mine spoil from 0-19 ft and in alluvium from 74-113 ft; PRB constructed by digging a trench 1,100 ft long and 20 ft deep (groundwater is apparently very shallow). The case study reviewed indicated that the results of the PRB treatment were pending.

Appendix E

MWH (2004) Zone 3 Cost Documentation

Prepared for:

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SUPPLEMENTAL FEASIBILITY STUDY
ZONE 3 HYDROSTRATIGRAPHIC UNIT
CHURCH ROCK URANIUM MILL TAILING SITE

October 2004

Prepared by:

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APPENDIX C
COST EVALUATION DATA

Costing Approach

Capital cost estimates were developed for five dewatering alternatives as follows:

- Alternative 3 Tunnel
- Alternative 4 Open Pit
- Alternative 5 Enhanced Well Field
- Alternative 6 Cut-off/Containment Well
- Alternative 7 Large Diameter Hole with Radial Horizontal Collection Fan (1-3 Wells)
- Alternative 8 Directionally-drilled (horizontal) well

The following describes how each cost alternative was developed and assumptions made:

- Alternative 3 Tunnel: An 8 ft by 8 ft drift was assumed for construction. This size drift was used in case radial drainage holes would be installed at a later date to improve drainage to the drift. A concrete floor was assumed since it would be in use for a long period of time. A ventilation system was also assumed since there would be personnel needing access during construction and the operational life. A vertical shaft was also assessed with the associated costs for a headframe and elevator system. Costs for these options were developed by the Cowin Company and Redpath who both are specialty tunneling contractors.

- Alternative 4 Open Pit: This option assumed that an open pit would be developed downgradient of the existing plume and would act as a sump to collect any contamination. A conceptual pit plan was developed which estimated that approximately 500,000 cubic yards of material would have to be excavated. Costs were used from other open pit mining operations that we have been involved with on various projects. It was assumed that a 1/2 mile haul would be required to stockpile material that was excavated from the pit.

- Alternative 5 Well Field: This option assumed between 70 and 140 vertical dewatering wells would be installed in the location of the plume. The cost of hydraulic fracturing these wells was also included. These wells and the associated pumping and piping systems would be similar to the existing dewatering wells previously installed at the site. Extracted water would be routed to the existing evaporation system. Development costs for this option were obtained from Larry Bush of UNC who has installed the existing wells at the site.

- Alternative 6 Cut-off/Containment Wells: This alternative includes up to 32 wells to capture the seepage-impacted groundwater as it moves downgradient. The cost of hydraulic fracturing these wells was also included. These wells and the associated pumping and piping systems would be similar to the existing dewatering wells previously installed at the site. Extracted water would be routed to the existing evaporation system.

- Alternative 7 Large Diameter Hole with Radial Horizontal Collection Fan (Ranney-type Well): This option assumed that between one and three 15 foot diameter vertical shafts would be sunk to a depth of approximately 175 feet which would be at the base of the contamination plume. A total of 1,500 feet of radial drainage wells drilled out horizontally from the shafts were assumed for this project. The cost estimate for the Large Diameter Hole with Radial Collection Fan (Ranney-type Well) was developed for one installation. It was hoped that this cost could be developed with assistance from Layne Drilling, Ranney-type Well Division; however, this application is not suited to their normal installation methods (in unconsolidated sediments) and therefore they did not provide costing information. Therefore, the cost estimate for this alternative was developed based on shaft construction costing information developed during costing of the tunnel alternative.

- Alternative 8 Directionally-drilled (horizontal) well: A directional drillhole was assumed to be drilled approximately parallel down the middle of the current plume geometry. This drillhole would be started at the surface and decline to the bottom of the plume to intercept contamination. A 4,000 foot long drillhole was estimated to be required to intercept the current plume geometry. Costs from other jobs that MWH has completed were used to determine project development costs.

SUMMARY OF CAPITAL COSTS FOR ALTERNATIVES				
	Quantity	Units	Unit Cost	Subtotal
Alternative 3 Tunnel				
Item				
Decline and Drift	4,000	ft	$800	$3,200,000
Steel Sets	1	ls	$500,000	$500,000
Gunnite	1	ls	$300,000	$300,000
Fan System	1	ls	$110,000	$110,000
Concrete Floor	4,000	ft	$350	$1,400,000
Procure and Install Dewatering Pumps	3	each	$5,000.00	$15,000
Engineering (10% of Direct Cost)				$552,500
CQA (5% of Direct Cost)				$276,250
			Total	*$6,353,750*
Alternative 4 Open Pit				
Item	Quantity	Units	Unit Cost	Subtotal
Excavate and Load Material	500,000	yd^3	$2.20	$1,100,000
Haul Material ½ mile and Dump	500,000	yd^3	$0.40	$200,000
Doze Dumped Material	500,000	yd^3	$0.20	$100,000
Procure and Install Dewatering Pumps	3	each	$5,000.00	$15,000
Revegetate Waste Stockpile	28,000	yd^2	$ 0.60	$16,800
Mob/Demob (20% of Direct Cost)				$286,360
Engineering (10% of Direct Cost)				$143,180
CQA (5% of Direct Cost)				$71,590
Contractor OH&P (30% of Direct Cost)				$429,540
			Total	*$2,362,470*
Alternative 5 Well Field (70 Wells)				
Item	Quantity	Units	Unit Cost	Subtotal
Extraction Wells with Pumps	70	ea	$6,300	$441,000
Hydraulic Fracturing of Extraction Wells	70	ea	$12,000	$840,000
Extraction Wells (with Pumps) in Alluvium	15	ea	$6,300	$94,500
Collection System	1	ea	$50,000	$50,000
Engineering (10% of Direct Cost)				$58,550
			Total	*$1,484,050*
Alternative 5 Well Field (140 Wells)				
Item	Quantity	Units	Unit Cost	Subtotal
Extraction Wells with Pumps	140	ea	$6,300	$882,000
Hydraulic Fracturing of Extraction Wells	140	ea	$12,000	$1,680,000
Extraction Wells (with Pumps) in Alluvium	15	ea	$6,300	$94,500
Collection System	1	ea	$75,000	$75,000
Engineering (10% of Direct Cost)				$58,550
			Total	*$2,790,050*

SUMMARY OF CAPITAL COSTS FOR ALTERNATIVES				
	Quantity	Units	Unit Cost	Subtotal
Alternative 6 Cut-off/Containment Wells				
Item	Quantity	Units	Unit Cost	Subtotal
Extraction Wells with Pumps	32	ea	$6,300	$201,600
Hydraulic Fracturing	32	ea	$12,000	$384,000
Collection System	1	ea	$50,000	$50,000
Engineering (10% of Direct Cost)				$58,550
			Total	*$694,150*
Alternative 7 Large Diameter Hole with Radial Horizontal Collection Fan (One Ranney-type Well)				
Item	Quantity	Units	Unit Cost	Subtotal
Shaft Excavation	175	ft	$1,200	$210,000
Headframe	1	ea	$1,500,000	$1,500,000
Radial Drillholes	1500	ft	$30	$45,000
Procure and Install Pump	1	each	$10,000.00	$10,000
Engineering (10% of Direct Cost)				$176,500
CQA (5% of Direct Cost)				$88,250
			Total	*$2,029,750*
Alternative 8 Directionally-drilled (horizontal) well				
Item	Quantity	Units	Unit Cost	Subtotal
Directional Drilling	4,000	ft	$300.00	$1,200,000
Procure and Install Pump	3	each	$5,000.00	$15,000
Mob/Demob (20% of Direct Cost)				$243,000
Engineering (10% of Direct Cost)				$121,500
CQA (5% of Direct Cost)				$60,750
Contractor OH&P (30% of Direct Cost)				$364,500
			Total	*$2,004,750*
(Unit Rates Include Other Indirect Costs)				

Appendix F

Applicable Water Treatment Technologies If Enhanced Extraction Exceeds the Capacity of Site Evaporation Ponds

APPENDIX F
Applicable Water Treatment Technologies If Enhanced Extraction Exceeds the Capacity of Site Evaporation Ponds
United Nuclear Corporation Church Rock Site, New Mexico

General Response Actions	Remedial Technology	Process Option	Technical and Administrative Implementability Screening Comments
Treatment of Groundwater Pumped for Hydraulic Containment or Enhanced Extraction	Ex-Situ Physical/Chemical Treatment	Distillation/Evaporation	Distillation/evaporation is a chemical separation process in which the components of a liquid solution are separated vaporization, leaving behind a brine that must be disposed of. Potentially applicable.
		Filtration/Ultrafiltration/Microfiltration/Reverse Osmosis	Potentially applicable. Filtration is the physical process of mechanical separation based on particle size whereby particles suspended in a fluid are separated by forcing the fluid through a porous medium. Ultrafiltration, mircrofiltration, or reverse osmosis use a semi-permeable membrane to produce a clean water stream and a smaller volume of a concentrated solution of contaminants.
		Chemical oxidation/reduction	Potentially applicable for certain species. Chemical redox treatment is implemented by mixing treatment chemicals with the water stream to promote a redox reaction. Potentially applicable for certain species. The process may not be cost-effective for high contaminant concentrations because of the large amounts of redox agent required. Also redox chemicals may be consumed by non-contaminant species or treatment may form undesirable by-products.
		Precipitation/Coagulation/Flocculation	Potentially applicable. Precipitation may be selected for use in treating groundwater containing heavy metals, including radioactive isotopes. In ground water treatment applications, the precipitation process may be used as pretreatment for other treatment technologies (such as chemical oxidation or air stripping).
		Ion Exchange	Potentially applicable. Ion exchange is an ex situ water treatment process for removing ions from solution by exchanging cations or anions between the dissolved phase and counter ions on a resin matrix Different resins are needed to remove cations and anions.
	Ex-Situ Biological Treatment	Anaerobic Biological Reduction	Uses microorganisms in anoxic environment to reduce nitrates to nitrogen gas. Potentially applicable for nitrate removal. Not typically used for other inorganics, but may effect some removal of uranium or other inorganics.

Appendix G
Cost Documentation of Potential Remedial Alternatives

APPENDIX G
Remedial Alternative Preliminary Cost Estimate Summary
For SWA See Table 35; for Zone 1 see Table 36; for Zone 3 see Table 37

Hydrostratigraphic Unit and Alternative	Remedial Alternative Description	Capital Cost	Annual O&M Cost	Comments
SWA - Alternative 1	No Further Action (except for Long-Term Stewardship by DOE)	$0	$0	Assume no Capital or O&M costs required.
SWA - Alternative 2	Enhanced Extraction	$1,580,857	$1,393,054	Assumes installation of 60 wells and basic wastewater treatment (precip./floc./coag.). Includes cost to design/build 300 gpm WWTP capacity for chemical precipitation/ coagulation/flocculation.
SWA - Alternative 3	Hydraulic Containment Using Vertical Pumping Wells	$160,724	$86,046	Assumes pumping from four new wells and four existing wells. Estimate does not include cost to pre-treat injection water, if necessary; unable to quantify costs until ARARs are established.
SWA - Alternative 4	Passive Treatment Wells	$640,000	$54,840	Assumes 30 new passive treatment wells. Assumes media changed in 20% of wells each year. Does not include any additional groundwater quality monitoring associated with the treatment.
SWA - Alternative 5	Vertical Physical Barrier	$2,284,224	$86,046	Jet-grouted vertical barrier installed from bedrock surface to top of saturated zone (i.e., does not extend to ground surface). Barrier approximately 1100 ft long and 50,000 sq. ft @ $30 per vertical sq ft. (1997 dollars) (L. Pearlman, March 1999, indicates a range of $15 to $30 per vertical sq ft). Includes quarterly groundwater monitoring, but no additional water level monitoring labor or equipment or evaluate barrier effectiveness. Assumes no inspection or maintenance of barrier required.
SWA - Alternative 6	Hydraulic Barrier from Injection Wells	$255,724	$100,046	Assume 8 new wells to be used (4 injection at 5 gpm, 4 extraction at 5 gpm). Estimate does not include installation of a new injection water source well from deeper aquifer (e.g., Westwater Canyon) or cost of additional distribution line, if current mill well capacity is insufficient or unavailable ($100-200K). Estimate does not include cost to pre-treat injection water, if necessary; unable to quantify costs until ARARs are established.
SWA - Alternative 7 (+)	Permeable Reactive Barriers (+)	$3,255,121	$322,265	Funnel and gate style permeable reactive barrier. Approximately 1,030 ft long and 78,800 sq. ft with 200-ft long x 5-ft wide gate. Iron filings used for reactive media gate and sheet piling for funnel. O&M costs included in estimate are (1) media replacement at approximately five year interval (shown @ 20% replacement cost per year), (2) groundwater monitoring for remedy effectiveness.
SWA - Alternative 8	Hydraulic Flushing	$200,724	$104,898	Assume 10 wells to be used (6 existing, 4 new) 5 injection at 5 gpm, 5 extraction at 5 gpm. Estimate does not include installation of a new injection water source well from deeper aquifer (e.g., Westwater Canyon) or cost of additional distribution line, if current mill well capacity is insufficient or unavailable ($100-200K). Estimate does not include cost to pre-treat injection water, if necessary; unable to quantify costs until ARARs are established.
Zone 1 - Alternative 1	No Further Action (Except for Long-Term Stewardship by DOE)	$0	$0	Assume no Capital or O&M costs required.
Zone 1 - Alternative 2	Institutional Controls	$100,000	$20,000	Groundwater modeling/consulting and legal services to establish IC Zone and conditions. Includes $20 O&M to oversee and enforce the IC, but no additional monitoring, reporting, or inspection requirements.
Zone 1 - Alternative 3	Hydraulic Containment with Extraction and Evaporation	$253,319	$55,216	Assumes installation and pumping of 10 wells at 1.5 gpm with discharge to evaporation ponds.
Zone 1 - Alternative 4	Enhanced Extraction	$761,616	$115,161	Assumes installation of 35 wells and basic wastewater treatment (precip./floc./coag.). Does not include design/build WWTP.
Zone 3 - Alternative 1	No Further Action (Except for Long-Term Stewardship by DOE)	$0	$0	Assume no Capital or O&M costs required.
Zone 3 - Alternative 2	Institutional Controls (ICs) for Section 36 if Needed	$100,000	$20,000	Groundwater modeling/consulting and legal services to establish IC Zone and conditions. Includes $20 O&M to oversee and enforce the IC, but no additional monitoring, reporting, or inspection requirements.
Zone 3 - Alternative 3	Passive Treatment Wells	$630,000	$52,600	Assumes 20 new wells. Assumes media changed in 20% of wells each year. Does not include any additional groundwater quality monitoring associated with the treatment.
Zone 3 - Alternative 4	Hydraulic Containment with Extraction and Evaporation	$0	$53,869	This is the current remedy in Zone 3. No additional capital costs. Does not include cost of pending injection of alkalinity-adjusted water.
Zone 3 - Alternative 5	Enhanced Extraction	$2,031,803	$834,561	Assumes installation of 80 wells and basic wastewater treatment (precip./floc./coag.). Includes estimated cost to design/build 100 gpm WWTP capacity for chemical precipitation/ coagulation/flocculation.
Zone 3 - Alternative 6	Hydraulic Barrier from Injection Wells for Containment.	$90,420	$54,017	Assume 6 wells to be used (3 injection at 2 gpm, 3 extraction at 2 gpm). Estimated cost does not include connection to injection water source or cost of pumping water from deeper aquifer (e.g., Westwater Canyon) or cost of distribution line from existing water source, which are already installed. Estimate does not include cost to pre-treat injection water, if necessary.

Notes:
SWA = Southwest Alluvium.
(+) PRB costs are highly site-specific; the estimate presented here is poorly constrained.
Shading indicates that the remedial alternative has been screened out.
For groundwater pumping options, sludge disposal costs (~$0.5/1000 gal treated) are not included.

SOUTHWEST ALLUVIUM
ALTERNATIVE 2 **Enhanced Extraction**

CAPITAL COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	15,000	1.000	15,000	Estimate
Well installation	60	each	10,000	1.000	600,000	Previous site work
Groundwater pumps with controls (4-in submersible, 1.5 hp, 241'<head<300', 15-20 gpm)	60	each	2,212	1.212	160,857	Means, 2002
Piping system	1	LS	80,000	1.000	80,000	Estimate
Engineering	1	LS	75,000	1.000	75,000	Modeling to select well locations, pumping and pipeline system design.
WWTP Design Engineering	1	LS	50,000	1.000	50,000	Estimated for basic chemical precipitation and coagulation/flocculation additional specialized treatment may be required as well).
Construct WWTP (chemical precipitation and coagulation/flocculation)	1	LS	600,000	1.000	600,000	Estimated (Means, 2002), traditional metals treatment at ~300 gpm (additional specialized treatment may be required as well).
				Total	$1,580,857	

O&M COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Annual pumping costs	653,496	kwh	0.085	1.000	55,547	60 wells x 1.5 hp pump x 0.746 kw/HP x 8760 hrs (assumes 90 percent efficiency).
Annual rehabilitation/replacement costs	1	LS	75,000	1.000	75,000	Estimate
Annual inspection labor costs	416	hr	30	1.000	12,480	8 hours/week
Annual maintenance labor costs	312	hr	30	1.000	9,360	6 hours/week
Treatment (precip/floc/coag)	157,680	1000 gal	4.00	1.920	1,210,667	Avg. volume = 60 wells x 5 gpm. Cost - Army COE Design Manual November 2001 (based on 1987 costs - escalates to $7.68/1000 gal).
Groundwater monitoring	1	LS	30,000	1.000	30,000	Assumed proportion of current costs for SWA.
				Total	$1,393,054	

SOUTHWEST ALLUVIUM
ALTERNATIVE 3 Hydraulic Containment Using Vertical Pumping Wells

CAPITAL COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	5,000	1.000	5,000	Estimate
Well installation	4	each	10,000	1.000	40,000	Previous site work. Assume 4 new and 4 existing wells to be used. Assume higher unit price than Alt 2 (fewer wells).
Groundwater pumps with controls (4-in submersible, 1.5 hp, 241'<head<300', 15-20 gpm)	4	each	2,212	1.212	10,724	Means, 2002. Assume existing wells have pumping equipment.
Piping	1	LS	15,000	1.000	15,000	Estimate, assume hook into previously existing system.
Evaporation mister/cannon system	1	LS	40,000	1.000	40,000	Estimate to make mister system operational.
Engineering	1	LS	50,000	1.000	50,000	Modeling to select well locations, pumping and pipeline system design.
				Total	$160,724	

O&M COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Annual pumping costs	87,133	kwh	0.085	1.000	7,406	8 wells x 0.75 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual rehabilitation/replacement costs	1	LS	8,000	1.000	8,000	Estimate
Annual inspection labor costs	104	hr	30	1.000	3,120	2 hours/week
Annual maintenance labor costs	104	hr	30	1.000	3,120	2 hours/week
Treatment (evaporation using mister/cannon system)	480	hr	30	1.000	14,400	Evaporate extraction from 8 wells x 5 gpm. Discharge to evaporation ponds. Would require labor for mister system operation equal to 3 man-months.
Treatment power costs (evaporation using mister/cannon system)	1	LS	20,000	1.000	20,000	Annual power costs for mister/cannon system.
Groundwater monitoring	1	LS	30,000	1.000	30,000	Assumed proportion of current costs for SWA.
				Total	$86,046	

Supporting Pumping Calculations		
Number of extraction wells	8	wells
Pumping rate (average)	5	gpm
Pump HP	1.50	HP
Power usage per well	10,892	kwh
Power usage total	**87,133**	kwh
Volume pumped per well per year	2,628,000	gallons
Total volume pumped per year	**21,024,000**	gallons

SOUTHWEST ALLUVIUM
ALTERNATIVE 4 **Passive Treatment Wells**

CAPITAL COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	10,000	1.000	10,000	Estimate
Treatment well installation	30	each	20,000	1.000	600,000	Individual well cost estimate ($10K) based on previous site work + $10K per well for special construction for passive treatment wells (including media).
Engineering	1	LS	30,000	1.000	30,000	Modeling to determine well locations.
Reactive media	-	-	-	-	-	Assume included in +$10K per well.
				Total	$640,000	

O&M COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Annual inspection labor costs	104	hr	30	1.000	3,120	2 hours/week
Annual maintenance labor costs	24	hr	30	1.000	720	Replace media in 20% of wells/year. Assume 4 man-hours hours per well to replace media with no equipment required.
Annual media replacement	6	well	1,000	1.000	6,000	Assume 5 years for replacement of reactive media in PRBs and passive treatment wells (i.e., 20% replaced each year). For proprietary media changeout assume $1000 per well.
Groundwater monitoring	1	LS	45,000	1.000	45,000	Assumed 38% of current monitoring costs for SWA ($30K), increased to $45K to account for increased frequency and/or parameters.
				Total	$54,840	

SOUTHWEST ALLUVIUM
ALTERNATIVE 5 **Vertical Physical Barrier**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Exploratory geotechnical investigation to map top of bedrock	1	LS	30,000	1.000	30,000	Estimate
Well installation	4	each	10,000	1.000	40,000	Previous site work. Assume 4 new and 4 existing wells to be used. Assume higher unit price than Alt 2 (fewer wells).
Groundwater pumps with controls (4-in submersible, 1.5 hp, 241'<head<300', 15-20 gpm)	4	each	2,212	1.212	10,724	Means, 2002. Assume existing wells have pumping equipment.
Piping	1	LS	15,000	1.000	15,000	Estimate, assume hook into previously existing system.
Mobilization of equipment and crew	1	LS	50,000	1.000	50,000	Estimate
Install jet grouted barrier	50,000	sq. ft	30	1.359	2,038,500	Approximately 1100 ft long jet-grouted vertical barrier installed from bedrock surface to top of saturated zone (i.e., not to ground surface). Based on range of $15 to $30 per sq ft (1997) cited by L. Pearlman, Subsurface Containment and Monitoring Systems: Barriers and Beyond (Overview Report) March 1999.
Evaporation mister/cannon system	1	LS	40,000	1.000	40,000	Estimate to make mister system operational.
Engineering	1	LS	60,000	1.000	60,000	Modeling to determine optimum barrier location, engineering design.
				Total	$2,284,224	

O&M COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Annual pumping costs	87,133	kwh	0.085	1.000	7,406	8 wells x 1.5 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual rehabilitation/replacement costs	1	LS	8,000	1.000	8,000	Estimate
Annual inspection labor costs	104	hr	30	1.000	3,120	2 hours/week. Assumes no inspection or maintenance of vertical barrier required.
Annual maintenance labor costs	104	hr	30	1.000	3,120	2 hours/week
Treatment (evaporation using mister/cannon system)	480	hr	30	1.000	14,400	Evaporate extraction from 8 wells x 5 gpm. Discharge to evaporation ponds. Would require labor for mister system operation equal to 3 man-months.
Treatment power costs (evaporation using mister/cannon system)	1	LS	20,000	1.000	20,000	Annual power costs for mister/cannon system.
Groundwater monitoring	1	LS	30,000	1.000	30,000	Assumed 38% of current monitoring costs for SWA.
				Total	$86,046	

Does not include water level monitoring to evaluate barrier effectiveness.

Supporting Pumping Calculations		
Number of extraction wells	8	wells
Pumping rate (average)	5	gpm
Pump HP	1.50	HP
Power usage per well	10,892	kwh
Power usage total	**87,133**	kwh
Volume pumped per well per year	2,628,000	gallons
Total volume pumped per year	**21,024,000**	gallons

SOUTHWEST ALLUVIUM
ALTERNATIVE 6 **Hydraulic Barrier from Injection Wells**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	10,000	1.000	10,000	Estimate
Well installation	8	each	10,000	1.000	80,000	Previous site work. Assume 8 new wells to be used, 4 injection at 5 gpm, 4 extraction at 5 gpm.
Groundwater pumps with controls (4-in submersible, 1.5 hp, 241'<head<300', 15-20 gpm)	4	each	2,212	1.212	10,724	Means, 2002. Assume existing wells have pumping equipment. Assume higher unit price then Alt 2 (fewer wells).
Piping (extraction)	1	LS	15,000	1.000	15,000	Estimate
Engineering	1	LS	60,000	1.000	60,000	Modeling to select well locations, pumping and pipeline system design.
Injection System (tank, pumps, influent line, valve, transducers)	1	LS	30,000	1.000	30,000	Estimate does not include installation of a new injection water source well from deeper aquifer (e.g., Westwater Canyon) or cost of additional distribution line, if current mill well capacity is insufficient or unavailable.
Permitting of injection system	1	LS	10,000	1.000	10,000	Assume permit cost permitting process is relatively straightforward.
Evaporation mister/cannon system	1	LS	40,000	1.000	40,000	Estimate to make mister system operational.
				Total	$255,724	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	
Annual extraction pumping costs	43,566	kwh	0.085	1.000	3,703	4 wells x 1.5 hp pump x 0.746kw/HP x 8760 hrs (assumes 90 percent efficiency).
Annual injection pumping costs	43,566	kwh	0.085	1.000	3,703	Assumed power costs associated with injection equal to extraction.
Annual rehabilitation/replacement costs @ 20% of pumping and injection system	1	LS	22,000	1.000	22,000	Estimate
Annual inspection labor costs	104	hr	30	1.000	3,120	2 hours/week
Annual maintenance labor costs	104	hr	30	1.000	3,120	2 hours/week
Treatment (evaporation using mister/cannon system)	480	hr	30	1.000	14,400	4 wells x 5 gpm. Discharge of pumped water to evaporation ponds. Would require labor for mister system operation equal to 3 man-months.
Treatment power costs (evaporation using mister/cannon system)	1	LS	20,000	1.000	20,000	Annual power costs for mister/cannon system.
Treatment of injection water	-	1000 gal	0	1.000	-	If necessary, not estimated
Groundwater monitoring	1	LS	30,000	1.000	30,000	Assumed 38% of current monitoring costs for SWA.
				Total	$100,046	

Supporting Pumping Calculations		
Number of extraction wells	4	wells
Pumping rate (average)	5	gpm
Pump HP	1.50	HP
Power usage per well	10,892	kwh
Power usage total	**43,566**	kwh
Volume pumped per well per year	2,628,000	gallons
Total volume pumped per year	**10,512,000**	gallons

SOUTHWEST ALLUVIUM
ALTERNATIVE 7 **Permeable Reactive Barrier**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Exploratory geotechnical investigation to map top of bedrock	1	LS	30,000	1.000	30,000	Estimate
Mobilization of rig and crew	1	LS	50,000	1.000	50,000	Estimate
Temporary heavy wall sheet piling	15,000	sq ft	23.35	1.210	423,803	Means 2002
Permanent heavy wall sheet piling	63,800	sq ft	23.35	1.210	1,802,573	Means 2002
Excavation and gate installation 75 - 120 ft (normal soil)	2,778	cy	10.57	1.210	35,527	Means 2002
Iron Filings	1,630	cy	425	1.210	837,662	Means 2002
Backfill with excavated material	1,148	cy	3.30	1.210	4,585	Means 2002
Key-in treatment wall (3 ft)	104	cy	87.44	1.210	10,972	Means 2002
Engineering	1	LS	60,000	1.000	60,000	Modeling to determine optimum barrier location, engineering design.
				Total	$3,255,121	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Annual inspection labor costs	40	hr	30	1.000	1,200	
Annual maintenance labor costs	25	hr	30	1.000	750	Labor for media replacement
Annual media replacement	1	LS	270,315	1.000	270,315	Media replacement (assumed 100% at five years) accounted for as 20% replacement per year. Replacement costs include sheet piling, excavation, iron filings, and backfill.
Groundwater monitoring	1	LS	50,000	1.000	50,000	Assumed 38% of current monitoring costs plus additional $20K for additional paramters or higher sampling frequency at beginning of remedy.
				Total	$322,265	

Length of Entire PRB wall	1,025	ft
Length of Gate	200	ft
Average Total Depth	77	ft
Vertical Area of PRB wall	78,800	sq. ft
Vertical Area of PRB gate	15,000	sq. ft
Vertical Area of Funnel	**63,800**	sq. ft
Thickess of PRB gate	5	ft
Volume of PRB gate zone	**2,778**	cy
Depth to BR at gate southern end	68	ft
Depth to BR at gate northern end	82	ft
Gate excavation volume total	**2,778**	cy
Vertical Area of Reactive Media	**8,800**	sq. ft
Volume of Reactive Media	**1,630**	cy
Backfill volume	**1,148**	cy

SOUTHWEST ALLUVIUM
ALTERNATIVE 8 **Hydraulic Flushing**

CAPITAL COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	5,000	1.000	5,000	Estimate
Well installation	4	each	10,000	1.000	40,000	Previous site work. Assume 4 new and 6 existing wells to be used. Assumed higher unit price for fewer wells.
Groundwater pumps with controls (4-in submersible, 1.5 hp, 241'<head<300', 15-20 gpm)	4	each	2,212	1.212	10,724	Means, 2002. Assume existing wells have pumping equipment. Assume higher unit price then Alt 2 (fewer wells).
Piping (extraction system)	1	LS	15,000	1.000	15,000	Estimate, assume hook into previously existing system.
Engineering	1	LS	50,000	1.000	50,000	Modeling to select well locations, pumping and pipeline system design.
Injection System (tank, pumps, influent line, valve, transducers)	1	LS	30,000	1.000	30,000	Estimate does not include installation of a new injection water source well from deeper aquifer (e.g., Westwater Canyon) or cost of additional distribution line, if current mill well capacity is insufficient or unavailable.
Permitting of injection system	1	LS	10,000	1.000	10,000	Assume permit cost permitting process is relatively straightforward.
Evaporation mister/cannon system	1	LS	40,000	1.000	40,000	Estimate to make mister system operational.
				Total	$200,724	

O&M COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Annual pumping costs	54,458	kwh	0.085	1.000	4,629	5 wells x 1.5 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual injection pumping costs	54,458	kwh	0.085	1.000	4,629	Assumed injection costs equal to extraction.
Annual rehabilitation/replacement costs @ 5%	1	LS	5,000	1.000	5,000	Estimate
Annual inspection labor costs	104	hr	30	1.000	3,120	2 hours/week
Annual maintenance labor costs	104	hr	30	1.000	3,120	2 hours/week
Treatment (evaporation using mister/cannon system)	480	hr	30	1.000	14,400	5 wells x 5 gpm. Discharge to evaporation ponds. Would require labor for mister system operation equal to 3 man-months.
Treatment power costs (evaporation using mister/cannon system)	1	LS	20,000	1.000	20,000	Annual power costs for mister/cannon system.
Treatment of injection water	13,140	1000 gal	-	-	-	Not estimated, unable to quantify until ARARs are established.
Amendment of injecion water	13,140	1000 gal	-	-	-	Not estimated
Groundwater monitoring	1	LS	50,000	1.000	50,000	Assumed 38% of current monitoring costs plus additional $20K for additional paramters or higher sampling frequency at beginning of remedy.
				Total	$104,898	

Supporting Pumping Calculations		
Number of extraction wells	5	wells
Pumping rate (average)	5	gpm
Pump HP	1.50	HP
Power usage per well	10,892	kwh
Power usage total	**54,458**	kwh
Volume pumped per well per year	2,628,000	gallons
Total volume pumped per year	**13,140,000**	gallons

ZONE 1
ALTERNATIVE 2 **Institutional Controls**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Engineering/Consulting	1	LS	50,000	1.000	50,000	Modeling/consulting to establish IC Zone and conditions.
Legal	1	LS	50,000	1.000	50,000	Tribal resolution, Right-of-Way.
				Total	$100,000	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Maintenance					20,000	Oversight and enforcement.
				Total	$20,000	

ZONE 1
ALTERNATIVE 3 **Hydraulic Containment with Extraction and Evaporation**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	10,000	1.000	10,000	Estimate
Well installation	10	each	15,000	1.000	150,000	Previous site work
Groundwater pumps with controls (4 in submersible, 1/2 hp, 141'<head<240', 0.3-7 gpm)	10	each	1,924	1.212	23,319	Means, 2002
Piping	1	LS	20,000	1.000	20,000	Estimate
Engineering	1	LS	50,000	1.000	50,000	Modeling to select well locations, pumping and pipeline system design.
				Totals	$253,319	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Annual pumping costs	32,193	kwh	0.085	1.000	2,736	10 wells x 0.5 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual rehabilitation/replacement costs	1	LS	20,000	1.000	20,000	Estimate
Annual inspection labor costs	208	hr	30	1.000	6,240	4 hours/week
Annual maintenance labor costs	208	hr	30	1.000	6,240	4 hours/week
Treatment (evap)	2,628	1000 gal	0.000	1.000	0	10 wells x 0.5 gpm. Discharge to evaporation ponds.
Groundwater monitoring	1	LS	20,000	1.000	20,000	Assumed 25% of current monitoring costs for Zone 1.
				Totals	$55,216	

Supporting Pumping Calculations		
Number of extraction wells	10	wells
Pumping rate (average)	0.5	gpm
Pump HP	0.50	HP
Power usage per well	3,631	kwh
Power usage total	**36,305**	kwh
Volume pumped per well per year	262,800	gallons
Total volume pumped per year	**2,628,000**	gallons

ZONE 1
ALTERNATIVE 4 **Enhanced Extraction**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	15,000	1.000	15,000	Estimate
Well installation	35	each	15,000	1.000	525,000	Previous site work
Groundwater pumps with controls (4-in submersible, 1/2 hp, 141'<head<240', 0.3-7 gpm)	35	each	1,924	1.212	81,616	Means, 2002
Piping	1	LS	50,000	1.000	50,000	Estimate
Engineering	1	LS	50,000	1.000	50,000	Modeling to select well locations, pumping and pipeline system design.
Evaporation mister/cannon system	1	LS	40,000	1.000	40,000	Estimate to make mister system operational
				Totals	$761,616	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Annual pumping costs	127,069	kwh	0.085	1.000	10,801	35 wells x 0.5 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual rehabilitation/replacement costs	1	LS	25,000	1.000	25,000	Estimate
Annual inspection labor costs	416	hr	30	1.000	12,480	8 hours/week
Annual maintenance labor costs	416	hr	30	1.000	12,480	8 hours/week
Treatment (evaporation using mister/cannon system)	480	hr	30	1.000	14,400	10 wells x 0.5 gpm. Discharge to evaporation ponds. Would require labor for mister system operation equal to 3 man-months.
Treatment power costs (evaporation using mister/cannon system)	1	LS	20,000	1.000	20,000	Annual power costs for mister/cannon system.
Groundwater monitoring	1	LS	20,000	1.000	20,000	Assumed 25% of current monitoring costs for Zone 1.
				Totals	$115,161	

Supporting Pumping Calculations		
Number of extraction wells	35	wells
Pumping rate (average)	0.5	gpm
Pump HP	0.50	HP
Power usage per well	3,631	kwh
Power usage total	**127,069**	kwh
Volume pumped per well per year	262,800	gallons
Total volume pumped per year	**9,198,000**	gallons

ZONE 3
ALTERNATIVE 2 **Institutional Controls**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Engineering/Consulting	1	LS	50,000	1.000	50,000	Modeling/consulting to establish IC Zone and conditions.
Legal	1	LS	50,000	1.000	50,000	Tribal resolution, Right-of-Way.
				Total	$100,000	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Maintenance	1	LS	50,000	1.000	20,000	Oversight and enforcement.
				Total	$20,000	

ZONE 3
ALTERNATIVE 3 **Passive Treatment Wells**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	10,000	1.000	10,000	Estimate
Treatment well installation	20	each	25,000	1.000	500,000	Individual well cost estimate ($15K) based on previous site work + $10K per well for special construction for passive treatment wells (including media).
Monitoring well installation (incl. development)	6	each	15,000	1.000	90,000	Based on previous site work. Need 6 additional monitoring wells to monitor effectiveness of PTWs.
Engineering	1	LS	30,000	1.000	30,000	Modeling to determine well locations.
Reactive media	-	-	-	-	-	Assume included in +$10K per well.
				Total	$630,000	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Annual inspection labor costs	104	hr	30	1.000	3,120	2 hours/week
Annual maintenance labor costs	16	hr	30	1.000	480	Replace media in 20% of wells/year (i.e., 4 wells/year). Assume 4 man-hours hours per well to replace media with no equipment required.
Annual media replacement	4	well	1,000	1.000	4,000	Replace media in 20% of wells/year. For proprietary media changeout assume $1000 per well.
Groundwater monitoring	1	LS	45,000	1.000	45,000	Assumed 38% of current monitoring costs for Zone 3 ($30K), increased to $45K to account for increased frequency and/or parameters.
				Total	$52,600	

ZONE 3
ALTERNATIVE 4 **Hydraulic Containment Using Vertical Pumping Wells**

CAPITAL COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
						This is the current remedy in Zone 3. Assumes no additional capital costs. Costs do not reflect alkalinity adjustment.
				Total	$0	

O&M COSTS

Item	Quantity	Unit	Unit Price	Escalation	Total Cost	Comment
Annual pumping costs	16,337	kwh	0.085	1.000	1,389	3 wells x 0.75 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual rehabilitation/replacement costs	1	LS	10,000	1.000	10,000	Estimate
Annual inspection labor costs	208	hr	30	1.000	6,240	4 hours/week
Annual maintenance labor costs	208	hr	30	1.000	6,240	4 hours/week
Treatment (evap)	3,154	1000 gal	0.000	1.000	0	3 wells x 2 gpm. Discharge to evaporation ponds.
Groundwater monitoring	1	LS	30,000	1.000	30,000	Assumed 38% of current monitoring costs for Zone 3.
				Total	$53,869	

ZONE 3
ALTERNATIVE 5 **Enhanced Extraction**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	15,000	1.000	15,000	Estimate
Well installation	80	each	15,000	1.000	1,200,000	Previous site work
Groundwater pumps with controls (4 in submersible, 3/4 hp, 241'<head<340', 0.3-7 gpm)	80	each	2,236	1.212	216,803	Means, 2002.
Piping	1	LS	100,000	1.000	100,000	Estimate
Engineering	1	LS	50,000	1.000	50,000	Modeling to select well locations, pumping and pipeline system design.
WWTP Design Engineering	1	LS	50,000	1.000	50,000	Estimated for basic chemical precipitation and coagulation/flocculation additional specialized treatment may be required as well).
Construct WWTP (chemical precipitation and coagulation/floculation)	1	LS	400,000	1.000	400,000	Estimated (Means, 2002), traditional metals treatment at 100 gpm (additional specialized treatment may be required as well).
				Total	$2,031,803	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Annual pumping costs	435,664	kwh	0.085	1.000	37,031	80 wells x 0.75 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual rehabilitation/replacement costs	1	LS	100,000	1.000	100,000	Estimate
Annual inspection labor costs	416	hr	30	1.000	12,480	8 hours/week
Annual maintenance labor costs	312	hr	30	1.000	9,360	6 hours/week
Treatment (precip/floc/coag)	84,096	1000 gal	4.00	1.920	645,689	80 wells x 2 gpm. Cost - Army COE Design Manual November 2001 (based on 1987 costs).
Groundwater monitoring	1	LS	30,000	1.000	30,000	Assumed 38% of current monitoring costs for Zone 3.
				Total	$834,561	

ZONE 3

ALTERNATIVE 6 **Hydraulic Barrier from Injection Wells**

CAPITAL COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	Comment
Mobilization of drill rig and crew	1	LS	5,000	1.000	5,000	Estimate
Well installation	2	each	15,000	1.000	30,000	Previous site work. Assume 3 new wells to be used, 3 injection at 2 gpm, 3 extraction at 2 gpm.
Groundwater pumps with controls (4-in submersible, 3/4 hp, 241'<head<340', 0.3-7 gpm)	2	each	2,236	1.212	5,420	Means, 2002. Assume existing extraction wells have pumping equipment.
Piping	1	LS	10,000	1.000	10,000	Estimate
Engineering	1	LS	30,000	1.000	30,000	Modeling to select well locations, pumping and pipeline system design.
Injection System (tank, pumps, influent line, valve, transducers)	0	LS	30,000	1.000	0	Assumes that current injection system will be sufficient for additional capacity.
Permitting for injection system	1	LS	10,000	1.000	10,000	If required, at injection rates greater than 2000 gpd. Assume permitting process is relatively straightforward.
				Total	$90,420	

O&M COSTS

Item	Quantity	Unit	Unit Cost	Escalation	Total Cost	
Annual extraction pumping costs	16,337	kwh	0.085	1.000	1,389	3 wells x 0.75 hp pump x 0.746 kw/hp x 8760 hrs (assumes 90 percent efficiency).
Annual injection pumping costs	16,337	kwh	0.085	1.000	1,389	Assumed equal to extraction.
Annual rehabilitation/replacement costs	1	LS	15,000	1.000	15,000	Estimate
Annual inspection labor costs	104	hr	30	1.000	3,120	2 hours/week
Annual maintenance labor costs	104	hr	30	1.000	3,120	2 hours/week
Treatment of extraction water (evap)	3,153,600	1000 gal	0.000	1.000	0	3 wells x 2 gpm. Discharge of pumped water to evaporation ponds.
Treatment of injection water		1000 gal	0.000	1.000	0	If necessary, not estimated.
Groundwater monitoring	1	LS	30,000	1.000	30,000	Assumed 38% of current monitoring costs for Zone 3.
				Total	$54,017	