SEQUOYAH FUELS
A GENERAL ATOMICS COMPANY

RE: 1033-N

August 18, 2010

**FedEx**
**Tracking No. 7989 5573 1236**

Ken Kalman, Project Manager
Fuel Cycle Facilities Branch
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety
U.S. Nuclear Regulatory Commission
Two White Flint North, Mail Stop T8F5
Rockville, MD 20852-2738

RE: License No. SUB-1010, Docket No. 040-08027
License Condition 47, Final Groundwater Corrective Action Plan (CAP)

Dear Mr. Kalman:

Enclosed please find five (5) copies of Sequoyah Fuels Corporation's Final Groundwater Corrective Action Plan (CAP). Also enclosed with each copy is a CD containing the CAP with Attachments 1 and 2.

If you have any questions please give me a call at 918-489-5511, ext. 226.

Sincerely,

John H. Ellis

John H. Ellis, President
Sequoyah Fuels Corporation

Enclosures as Stated

# CORRECTIVE ACTION PLAN REPORT

*Prepared For:*
**Sequoyah Fuels Corporation**
I-40 & Highway 10
Gore, Oklahoma 74435

*Prepared By:*
**MFG, Inc.**
3801 Automation Way, Suite 100
Fort Collins, Colorado 80525

*Final Revisions Prepared By:*
**Sequoyah Fuels Corporation**
I-40 & Highway 10
Gore, Oklahoma 74435

**June 14, 2010**

M
F
G
consulting
scientists and
engineers

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES



## APPENDICES

## ATTACHMENTS

| | | |
|---|---|---|
| Attachment 1 | Response to Request for Additional Information GWCAP, dated March 2005 |
| Attachment 2 | Response to Request for Additional Information GWCAP, dated December 2005 |
| Attachment 3 | Hydrological and Geochemical Site Characterization Report Volumes I and II, dated June 30, 2009 |

## 1.0 INTRODUCTION

Sequoyah Fuel Corporation (SFC) conducted uranium conversion operations at its Gore, Oklahoma facility (Facility) from 1970 to 1993. In August of 1990, SFC notified the Nuclear Regulatory Commission (NRC) that uranium had been discovered in soils during excavation of underground storage tanks within the restricted boundary of its Facility. The NRC initiated an investigation and SFC began an initial characterization of the area surrounding the contaminated soils. In late 1990, SFC expanded the characterization investigation to include the Main Process Building (MPB) and began development of a comprehensive Facility Environmental Investigation (FEI) plan, which included an extensive soil and groundwater monitoring well installation program. Details of the investigation, its findings, and corrective action taken as a result of the findings are reported in the SFC Facility Environmental Investigation Findings Report (RSA, 1991).

In February 1993, SFC notified the NRC of its intent to discontinue production and submitted a preliminary plan for completion of decommissioning (PPCD) for the Facility to the NRC. In August of 1993, SFC signed a Resource Conservation Recovery Act (RCRA) Section 3008 (h) Administrative Order on Consent (AOC) with the Environmental Protection Agency (EPA). As a result, SFC was required to conduct an RCRA Facility Investigation (RFI) to establish the amount and location of hazardous wastes and constituents at or from the Facility and to gather information necessary for the Corrective Measures Study (CMS). The RFI, published in 1997, includes detailed information on Facility description and history, local geology and hydrogeology, monitoring activities, extent and concentration of Facility contamination, and the effects of contamination on the surrounding area and its inhabitants (SFC, 1997a). The Corrective Measures Study developed and evaluated corrective measures alternatives for the Facility (SFC, 1997b).

In December of 1998, SFC completed a Site Characterization Report (SCR) (SFC, 1998a). Activities for the SCR were designed to obtain information to characterize the source(s) of contamination, establish the level of contamination in the environment where releases had occurred, and finalize environmental setting characterization to support decommissioning planning.

Additional site characterization provided during the SCR allowed for the update of decommissioning alternatives. These alternatives, including corrective action measures and conceptual design of a disposal cell, were presented in the Final Decommissioning Alternatives Study Report (SFC, 1998b).

By February 2001, SFC determined that the site hydrogeologic model was inadequate, and retained Shepherd Miller, Inc. ([SMI], now MFG, Inc. [MFG]) to re-evaluate the conceptual model to assess its deficiencies. Characterization efforts by SMI, which occurred in May 2001, included hydrogeologic, geochemical, and geophysical investigations. The data and analysis obtained in this study supported the development of a groundwater flow and transport model, allowing for the delineation of the impact of key constituents on the environment, both in the present and in the future. The findings for this site characterization were submitted by SFC in the Hydrogeological and Geochemical Site Characterization Report (SMI, 2001).

Subsequent to releasing this site characterization report, several issues regarding site conditions characterizations and groundwater modeling were identified as requiring further study. Supplemental data collection occurred in February 2002. In October 2002, the Sequoyah Fuels Corporation (SFC) submitted the revised Hydrogeological and Geochemical Site Characterization Report (HGSCR) (MFG, 2002a). This site characterization included the results and findings of the site characterization performed by Shepherd Miller in 2001 and the Supplemental Data Collection effort of 2002.

The additional site characterization by MFG, Inc. and modifications to the disposal cell construction design and strategy has resulted in the Preliminary Design Report for the Disposal Cell at the Sequoyah Fuels Corporation Facility (MFG, 2002b).

## 1.1 Scope of Report

Information from the various reports discussed above has been reviewed, evaluated, and summarized in this report with the objective of developing a groundwater Corrective Action Plan (CAP) for the Site. The groundwater CAP is intended to reduce the concentration of hazardous constituents in the Point of Compliance (POC) wells to levels that are less than maximum concentration limits (MCLs) or background, which ever is greater.

This report summarizes the site hydrogeological and geochemical conditions, develops and evaluates a series of CAP alternatives and presents the selected CAP from the alternatives. During the course of agency review of the original GWCAP Report, several Requests for Additional Information were received. SFC's responses are contained in to volumes, dated March 2005 and December 2005, respectively. These responses are incorporated into this report as Attachments 1 and 2. Additionally, the Hydrogeological and Geochemical Site Characterization Report, originally prepared in 2001 and revised in 2002, required major revision as a result of the numerous RAI's. The final version of this report, submitted June 30, 2009, is incorporated into this report as Attachment 3.

## 2.0 SUMMARY OF SITE CHARACTERIZATION

This section provides a summary of the facility description, site history, groundwater and surface water hydrology, and characterization of geochemical conditions and water quality. Detailed information concerning these topics can be found in the RFI (SFC, 1997a), SCR (SFC, 1998a) and the HGSCR (MFG, 2002a).

### 2.1 Facility Description and Site History

The SFC facility is a 600-acre site and contains the Process Area and Industrial Area. The Facility is located in Sequoyah County in mid-eastern Oklahoma about 150 miles east of Oklahoma City. Figure 2-1 shows the location of the Facility. The facility is bounded on the north by private property, on the east by State Highway 10, on the south by Interstate 40 (I-40) and on the west by U.S. Government-owned land (managed by the U.S. Army Corps of Engineers) adjacent to the Illinois and Arkansas River tributaries of the Robert S. Kerr Reservoir (Figure 2-2).

Most of the uranium processing operations were conducted on the 85-acre portion of the Facility commonly referred to as the Process Area. SFC uses an additional 115 acres to manage storm water and store by-product materials. The Process Area and additional management areas are collectively referred to as the Industrial Area (Figure 2-3). Most of the land outside of the industrial area is either used for grazing cattle or forage production, or is forested.

The Industrial Area contains a series of process buildings, storage areas, disposal ponds, and open space utilized during site processing operations, the majority of which were conducted within the Process Area. The Facility Environmental Investigation Finding Report (RSA, 1991) and the Site Characterization Report (SFC, 1998a) provide a thorough description of most of these features. The Site Characterization Report identified these features as representing specific processing areas or facilities on the site and referred to them as site characterization units (SCUs). A general Facility layout with SCUs is presented in Figure 2-4. Table 2.1 lists the SCUs evaluated as sources of contamination in the HGSCR (MFG, 2002a).

The Decorative Pond and the Storm Water Reservoir are the only non-process surface impoundments within the Facility downgradient of the Process Area. The Decorative Pond is located south of the MPB and was used for aesthetic purposes only. The pond was fed by a pipeline from the Facility's raw water supply and does not receive storm water runoff or process discharges. The Storm Water Reservoir receives storm water runoff from non-process areas.

The majority of processing operations were conducted within the Process Area. The conversion of uranium ore concentrates into uranium hexafluoride ($UF_6$) was conducted in the MPB, the Miscellaneous Digestion Building, and the Solvent Extraction (SX) Building. The reduction of depleted uranium hexafluoride ($DUF_6$) to depleted uranium tetrafluoride ($DUF_4$) was conducted in the $DUF_4$ building. Feed material for processing was stored on the yellowcake storage pad. Additional facilities at the Facility included bulk storage of chemicals such as ammonia ($NH_4$), hydrofluoric acid (HF), nitric acid ($HNO_3$) and sulfuric acid ($H_2SO_4$), a facility for electrolytic production of fluorine from HF, treatment systems and storage ponds for liquid waste streams, and a land-treatment program utilizing ammonium nitrate by-product solution as fertilizer on SFC property.

Processing operations at the SFC Facility utilized yellowcake ($U_3O_8$) in the stepwise production of $UF_6$. Intermediate solid compounds such as $UO_2(NO_3)_2$, $UO_3$, $UO_2$, and $UF_4$, were produced. Various chemicals, such as $H_2SO_4$, $HNO_3$, HF, $NH_3$, $BaCl_2$, CaO, and limestone were stored on-site and used in the process. Major by-products of the operation were $NH_4NO_3$, $CaF_2$, and raffinate sludge. During the operative years, known releases of $UO_2(NO_3)_2$, $HNO_3$, $NH_4NO_3$, and arsenic occurred from corrosion of storage containers, from overflows, from on-site burial of wastes, and from leakage from unlined ditches and storage ponds. Neutralization of scrubber water with limestone was another source of aqueous fluoride, uranium, calcium and magnesium. The uranium, arsenic, fluoride, and nitrate released were predominantly in their oxidized, mobile forms and a portion of these constituents migrated into shale units of the terrace and shallow bedrock groundwater system beneath the Facility.

## 2.2 Facility Operational History

### 2.2.1 NRC License History

The Kerr McGee Corporation was issued License SUB-1010, Docket No. 40-8026, for storage only of uranium ore concentrate. This license was amended on February 20, 1970, authorizing the operation of a Uranium Hexafluoride ($UF_6$) Conversion Plant. The license was amended again on February 23, 1987, authorizing the Kerr McGee Corporation to operate a $UF_6$ Reduction Plant ($DUF_4$ Building). The license was last renewed on September 20, 1985 and remained in effect since. On February 16, 1993 and July 7, 1993, pursuant to 10 CFR 40.42, SFC notified the NRC of its intent to terminate licensed activities at the Facility and requested termination of License SUB-1010. The license remains in effect pursuant to 10 CFR 40.42 (c) until site decommissioning is completed and the NRC approves termination of the license.

### 2.2.2 1986 $UF_6$ Release

In 1986, a shipping container containing heated $UF_6$ ruptured, releasing several tons of gaseous $UF_6$ into the air (SFC, 1998a). The gaseous $UF_6$ reacted with water vapor in the air, forming a uranyl fluoride precipitate that quickly settled to the ground. Building surfaces, including the MPB, and several acres of ground were contaminated with uranium by this release. Some of the contamination was cleaned up immediately following the accident; however impacts still exist in some areas between the MPB and the Facility Boundary near Highway 10. A significant amount of uranyl fluoride precipitate washed into the North Ditch and Emergency Basin. Most of this material remains there (SFC, 1998a).

## 2.3 Physical Characteristics of the Facility

The facility is located on gentle rolling terrain, with elevations on or near the Facility ranging from approximately 460 feet above mean sea level (amsl) to about 585 feet amsl near the northeast corner of the property (Figure 2-2). The Facility is located on the east bank of the Illinois River tributary of the Robert S. Kerr Reservoir. The Process Area is located on an upland area approximately 100 feet higher than the surface elevation of the Robert S. Kerr Reservoir. The land surface drops steeply to the north, west, and southwest of the Process Area. Slopes on upland area are generally less than 7 percent. Relatively steep (40 percent average) surface gradients occur between the Process Area and the Robert S. Kerr Reservoir or between the floodplain area in the southwest portion of the SFC property. Several small, intermittent streams flow outward from the Process Area to the Robert S. Kerr Reservoir, including the 001, 004, 005, 007, 008, and 009 streams (Figure 2-5), and drainage associated with the Storm Water Reservoir. Most of the stream that flow westward from the Industrial Area are relatively short and incise deep ravines before reaching the Robert S. Kerr Reservoir. One small, unnamed stream drains the area south of the Fertilizer Ponds. This relatively shallow stream trends southward from the Ponds eventually bending northwestward and follows the southwest floodplain area (Agland) before joining with water from the Storm Water Reservoir drainage.

A facility inspection on August 27, 2001, conducted by Craig Harlin and Scott Munson of SFC identified and located three seeps in the drainage areas of the Facility. These seeps were identified by a seep and associated pool in both the 005 and 008 outfalls, and with a pool in the 007 Outfall. The location of these seeps is presented in Figure 2-5.
Sequoyah County has a warm, temperate, continental climate. The mean annual temperature is 61.5° F. The monthly average ranges from 40° F in January to 82° F in July. The mean annual precipitation ranges from 42.9 inches in the town of Sallisaw, to approximately 44.1 inches in the northeastern part of Sequoyah County. The seasonal distribution of rainfall is fairly even, with the most rainfall (31 percent) occurring in the spring. The average amount of snowfall from November through April is about 5.2 inches. Lake evaporation averages about 47.5 inches annually. Of this, 72 percent occurs from May through October. Based on the precipitation and lake evaporation values, there is a net annual evaporation rate of about 4 inches in the SFC area. The most severe storms occur in the spring, although thunderstorms are also frequent during the summer months. Strong winds, heavy precipitation, and intense lightning may be associated with these storms.

## 2.4 Hydrogeologic Conditions

Extensive geologic and hydrogeologic characterization of the Facility was performed during both the RFI (SFC, 1997a) and the HGSCR (MFG, 2002a). These characterizations used data collected from several hundred boreholes, surface reconnaissance, and geophysical methods to develop an understanding of the local geology. Well pump and slug tests provided information of the subsurface hydrologic conditions. Details of the hydrogeologic conditions at the Facility can be found in Section 3 of the RFI (SFC, 1997a) and Section 6 of the HGSCR (MFG, 2002a). The following section provides a summary of the hydrogeologic conditions at the Facility.

The bedrock immediately underlying the site includes alternating layers of shale and sandstone. These bedrock units are part of the Pennsylvanian Atoka Formation and are locally identified in descending order as Unit 1 Shale, Unit 1 Sandstone, Unit 2 Shale, Unit 2 Sandstone, Unit 3

Shale, Unit 3 Sandstone, Unit 4 Shale, Unit 4 Sandstone, Unit 5 Shale, and Unit 5 Sandstone. The bedrock units are overlain by Quaternary-age unconsolidated sediments, including terrace deposits, which occur primarily in the Process Area, colluvium on the slopes extending outward from the Process Area, and alluvial deposits adjacent to the Arkansas River. Soils are ubiquitous throughout the site, consisting mostly of loams and silty loams up to about six feet thick. Imported granular fill material (sand and gravel) is present in various areas, mostly in the Process Area and as surface impoundment material south of the Process Area.
Soils, terrace deposits, alluvium deposits, colluvium deposits, and the sand of the fill material are similar lithologically, consisting mostly of clays and silts. Detailed description of Facility soils and fill material is given in the RFI (SFC, 1997a). Detailed descriptions of terrace, alluvium, and colluvium deposits are provided in the HGSCR (MFG, 2002a).

Soils on the site consist mostly of loams and silty loams. Soil thickness range from zero to approximately six feet, and are commonly about one to two feet thick. Granular fill materials are found in various locations on the Facility (SFC, 1997a). Fill material within the Process Area is found in buried utility line trenches, in surface impoundment dikes, as landfill around building footings, and as a sub-base to concrete floors, concrete and asphalt roads, and concrete storage pads.

Unconsolidated deposits overlying Unit 1 Shale, which is found primarily under the Process Area, are identified as terrace deposits. Quaternary-age terrace deposits consist mostly of clay and silts. Terrace deposits range from 0 to 16.5 feet thick, averaging about 8 feet thick throughout the Process Area.

Alluvium deposits are Recent fluvial deposits found primarily in the southwest portions of the site, adjacent to the Illinois/Arkansas River. Alluvium thickness ranges from 0 feet to greater than 35 feet thick, with the greatest thickness found near the westernmost extent of the site boundaries. The alluvium ranges from about 15 to about 25 feet thick in the Agland area west and southwest of the Fertilizer Pond Area. Colluvium deposits include all unconsolidated sediment in the site not identified as either terrace or alluvium deposits. These deposits are found mostly on the slopes surrounding the Process Area, in outfall drainages, and in-situ deposits formed by breakdown of older rocks by weathering and erosion. Colluvium thickness ranges from 0 to over 20 feet; most colluvium deposits are less than 6 feet thick. Alluvium and colluvium deposits typically consist of silts, clays, and/or sands with varying amounts of gravel.

The bedrock units that directly underlie the Facility are a series of alternating shale and sandstone units of the Atoka Formation. The shales are typically are grayish black to dark grayish brown, soft, and fissile. Unit 1, 2 and 3 Shale tends to be highly weathered, weathering to a brownish or reddish yellow clay or silty clay with remnants of laminated, gray shale. The sandstones typically are pale brown to dark gray, consist largely of medium grained, subrounded quartz, are very hard and are well cemented.

The lateral extent of the various bedrock units is shown on Figure 2-6. Cross sectional views of the geology underlying the Facility is shown on Figures 2-7 to 2-13. Unit 1 Shale, where present, is typically about six feet thick, however near the Emergency Pond and the Yellowcake Storage Pad Unit 1 Shale is greater than 10 feet thick. The Unit 1 Sandstone, Unit 2 Shale, Unit 2 Sandstone, Unit 3 Shale, and Unit 3 Sandstone are relatively thin, generally less than three feet thick, and are not laterally extensive under the Facility. The Unit 3 Shale frequently pinches out entirely, and the other stratigraphically upper units commonly thin to less than one foot thick. In contrast, the deeper units (Unit 4 Shale, Unit 4 Sandstone, and Unit 5 Shale) are laterally extensive under the Facility, and typically have thicknesses greater than 10 feet.

Bedrock units tend to dip southwest at a dip of one to four degrees. The most prominent structural feature in the immediate area of the Facility is the Carlile School Fault (CSF), which trends northeast to southwest and is located approximately 5,000 feet southeast of the MPB. The CSF is a nearly vertical normal fault, downdropped to the south. The fault is estimated to be less than one mile in length, and has a displacement of less than 100 feet. The fault lies hydrologically upgradient and geologically up-dip from the Process Area.

Regional groundwater flow in the area of the Facility is generally westward towards the Illinois or Arkansas Rivers. Groundwater in the region occurs principally in alluvium along the Arkansas and Illinois rivers and some terrace deposits along the Arkansas River. The only major bedrock aquifer in the region occurs approximately 10 miles northeast of the Facility in the Mississippian-age Keokuk and Reed Springs Formations. Groundwater under the Facility originates primarily from precipitation that infiltrates through the Quaternary surface cover.

Once precipitation has entered the subsurface it migrates downward through the bedrock units and flows radially away from the potentiometric high that corresponds to the topographic high in the pastureland east of Highway 10. Subsurface flow discharges to the surface waters that surround the watershed including Robert S. Kerr Reservoir to the west, Salt Branch to the north, and the Salt Branch tributary that parallels the Carlile School Fault to the east. June 2001 potentiometric surface maps for the hydrologic units are presented in Figures 2-14 through 2-18. A conceptualized schematic of the site hydrogeology is displayed in Figure 2-19.

Underlying the Facility, groundwater flow is generally to the west, and primarily occurs through the fissile shale units. The transmissivity of the shale units is highly heterogeneous due to large variations in unit thickness and hydraulic conductivity, and in some locations, possibly due to the effects of historic leaks and spills of acidic solutions. Acidic water can react with carbonate compounds in the rock, increasing the porosity. Slug testing results indicate that the hydraulic conductivity varies from two to three orders of magnitude in individual shale units (Appendix J and Table 4-9, MFG, 2002a). Groundwater in the shale units discharge laterally to streams that flow to the Robert S. Kerr Reservoir, hillside colluvium, and/or to Arkansas/Illinois River alluvium; additionally the hydrostratigraphic model indicates that Unit 5 Shale discharges directly to the Robert S. Kerr Reservoir adjacent to the northern portion of the Facility. The horizontal hydraulic gradient in the terrace/Unit 1 Shale in the MPB area is approximately 0.008 ft/ft. In the deeper shale units, the horizontal gradient ranges from 0.01 to 0.04 ft/ft across the Facility. Groundwater in the colluvium and alluvium also discharges to the Robert S. Kerr Reservoir and its tributaries. The horizontal hydraulic gradient in the alluvium ranges from 0.0059 to 0.0081 ft/ft. Minor flow also occurs in the terrace deposits in areas where it is partially saturated.

Except where affected by acidic leaks and spills from the facility processes, the sandstone units are highly cemented and transmit insignificant volumes of groundwater relative to the shale units. Estimates of horizontal hydraulic conductivity of Unit 4 Sandstone range from $2.25 \times 10^{-5}$ ft/d to $4.75 \times 10^{-5}$ ft/day (SFC, 1998a) and are several orders of magnitude smaller than observed in the shale units.

A downward vertical gradient persists between all of the bedrock units over the majority of the Facility. The observed downward gradient ranges between 0.08 and 0.35 ft/ft. The vertical flow component is significantly smaller than the horizontal component due to the extremely low vertical conductivity of the sandstone units. Some vertical groundwater flow is also believed to occur through boreholes drilled in the late 1960's during site geotechnical exploration. Records indicated that these boreholes, which number between 80 and 100, were not plugged. None of these boreholes penetrate the Unit 4 Sandstone. Another pathway for vertical groundwater flow are the monitoring wells that are screened across multiple shale units, thus penetrating the inter-lying aquitards. None of the wells that are screened across multiple shale units penetrate Unit 4 Sandstone. These features act as vertical conduits that hydraulically connect shale units that would be naturally buffered by the sandstone units. They are distributed over the entire Facility, excluding the Agland, but have the greatest density in the vicinity of the Process Area, Solid Waste Burial Areas, the Fertilizer Pond Area, and the Pond 2 area.

In general, the shale units are the primary water bearing units in the area of the Facility, while the sandstone units act as aquicludes or aquitards, with little horizontal or vertical hydraulic transmissivity. An evaluation of the potential yield of individual geologic units is presented in the HGSCR, Appendix K (MFG, 2002a). The evaluation indicates that Unit 1, 2, and 3 shales have essentially no ability to yield sufficient quantities of water to reasonably be considered as a potential source of drinking water. The evaluation also indicates that although the Unit 4 Shale may have very limited potential to yield groundwater slightly greater than the 0.1 gpm, the background water quality of this unit is of such poor quality that it would not reasonably be used for any domestic purpose. Background water quality of Unit 4 Shale includes sulfate concentration of 1,750 mg/L and total dissolved solids concentrations of over 3,100 mg/L (Appendix K, MFG, 2002a). These concentrations exceed the current Class III criteria of the Oklahoma State Water Resources Board guidelines for suitability of water for livestock and irrigation uses.

## 2.5 Existing Groundwater Quality and Extent of Contamination

### 2.5.1 Hazardous Constituents and Constituents of Concern

Hazardous constituents at the Facility were identified during the RCRA Facility Investigation (SCF, 1997a) and during surface water, groundwater, and soil monitoring programs that have been ongoing since 1991. As of January 2003, the following constituents exceed the EPA National Drinking Water Standards (MCLs) in Facility groundwater: arsenic, fluoride, nitrate, and uranium. A comprehensive evaluation of the potential hazardous constituents in the source material was not done, historically; however, recent dewatering studies for the raffinate sludge gives an opportunity to quantify hazardous constituents in the sludge. The following constituents exceed MCLs in a Facility Raffinate Liquor sample: antimony, arsenic, cadmium, chromium, lead, nitrate, selenium, thallium, and uranium. Table 2.2 compares constituent concentrations from a filtered raffinate liquor sample collected in January 2003 to MCLs.

Of these constituents, the key mobile constituents that affect groundwater are arsenic, nitrate, and uranium. Antimony, cadmium, chromium, lead, selenium, and thallium have not had an impact on groundwater, and are therefore not considered as CAP constituents of concern. Fluoride concentrations only slightly exceed the MCL in very limited, small areas of shale units in the Industrial Area. Fluoride also behaves conservatively and is relatively mobile in groundwater; therefore the fluoride derived from any available higher concentration source will tend to be readily diluted with groundwater concentrations below the MCL. From the sources available, fluoride will not impact any surface water exposure point with concentrations above the MCL, therefore fluoride will not be considered further as a CAP constituent of concern. All constituents that exceed MCLs in facility groundwater or raffinate liquor, however, will be monitored for in the SFC Groundwater Monitoring Program.

### 2.5.2 Existing Groundwater Quality and Extent of Contamination

Existing groundwater quality and extent of contamination was determined using data from the 2002 groundwater sampling events. Figures 2-20 through 2-25 shows the COC concentration in wells sampled during 2002. Terrace groundwater includes data from wells screened in the Terrace sediments and Unit 1 Shale. Shallow Bedrock groundwater includes data from well screened in the Unit 2 Shale, Unit 3 Shale, and/or Unit 4 Shales. Site-derived constituents have been identified in Terrace sediment, and Unit 1 through 4 Shales at concentrations that could pose potential hazard to human health and the environment. Site-derived constituents have not migrated past Unit 4 Shale into the underlying shale (i.e. Unit Shale 5), and are blocked from doing so by a laterally pervasive, thick massive sandstone aquiclude (Unit 4 Sandstone).

Figure 2-20 shows nitrate concentrations in Terrace/Unit 1 Shale wells during 2002. In the terrace and Unit 1 Shales nitrate impacts to the groundwater are found mostly around the MPB, Clarifier Basins, and Pond 2 area. The nitrate levels found in the Terrace/Unit 1 Shale system varied from 0.5 mg/L to 820 mg/L. The high of 820 mg/L occurred in well MW025 located north of the SX Building. Terrace/Unit 1 Shale wells with nitrate levels above the MCL of 10 mg/L were 2302A, MW008, MW012, MW014, MW015, MW024, MW025, MW035, MW036, MW040, MW045, MW054, MW066, MW103, MW107, MW108, and MW120.

Figure 2-21 shows nitrate concentrations in Unit 2 through Unit 4 shale wells during 2002. In the Unit 2 through Unit 4 shales nitrate impacts to groundwater occurs adjacent of and west of Pond 2, west of the Pond 1 Spoils Pile, in the SX Building area, west of the MPB, the North Ditch and Emergency Basin, the Fertilizer Pond area, and the Agland Fertilizer Application Area. The nitrate levels found in the Unit 2 through Unit 4 Shales varied from <0.2 mg/L to 8,230 mg/L. The high of 8,230 mg/L occurred in well MW057A located at the southwest corner of Pond 2. Unit 2 through Unit 4 shale wells with nitrate levels above the MCL of 10 mg/L were 2301B, 2302B, 2303A, 2322A, 2340A, 2341, 2342, 2443, 2344, 2346, 2348, 2349, 2351, 2352, 2353, 2354, 2355, 2356, MW012A, MW013A, MW014A, MW024A, MW025A, MW035A, MW036A, MW039A, MW040A, MW041A, MW042A, MW046A, MW047A, MW049A, MW050A, MW051A, MW052A, MW053A, MW057A, MW058A, MW059A, MW065A, MW066A, MW075A, MW076A, MW082A, MW093A, MW095A, MW102A, and MW116A.

Figure 2-22 shows uranium concentrations in Terrace/Unit 1 Shale wells during 2002. In the Terrace/Unit 1 Shale system uranium impacts to groundwater are found southwest, west, and northwest of the MPB, north and west of the SX Building, north and west of the Emergency Basin, in the Clarifier Basin areas and in the Solid Waste Burial Areas. The uranium levels found in Terrace/Unit 1 Shale groundwater varied from <1.0 μg/L in several wells to 95,000 μg/L. The high of 95,000 μg/L occurred in well MW025 located north of the SX Building. Unit

1 Shale wells with uranium levels above the MCL of 30 μg/L include MW010, MW012, MW014, MW018, MW025, MW055, MW078, and MW087.

Figure 2-23 shows uranium concentrations in Unit 2 through Unit 4 shales in 2002. In the Unit 2 through Unit 4 shales uranium impacts to groundwater are found at the northwest corner of the MPB, north of the SX Building, northwest of the Emergency Basin, east of the Solid Waster Burial Area No. 2, the Clarifier Basins area, and north of Fluoride Holding Basin No.2. Uranium concentrations in Unit 2 through Unit 4 shale groundwater varied from <1.0 μg/L in several wells to 3710 μg/L. The high of 3710 μg/L occurred in MW012A located at the northwest corner of the MPB. Unit 2 through Unit 4 shale wells with uranium levels above the MCL of 30 μg/L include 2301B, MW012A, MW014A, MW025A, MW050A, MW076A, MW076A, MW081A, and MW087A.

Figure 2-24 shows arsenic concentrations in Terrace/Unit 1 Shale wells during 2002. In the Terrace/Unit 1 Shale system arsenic impacts to groundwater are present north of the MPB, north of the Clarifier Basins, south of the Fluoride Setting Basins, and north of the Emergency Basin. Arsenic levels found in Terrace/Unit 1 Shale groundwater varied from <0.009 mg/l to 1.28 mg/l. The high of 1.28 mg/L occurred in MW075 located south of the incinerator near the Solid Waste Burial Area No. 2. Terrace/Unit 1 Shale wells with arsenic levels above the MCL of 0.05 mg/L include MW017, MW032, MW040, MW042, MW054, MW058, MW065, and MW075.

Figure 2-25 shows arsenic concentrations in Unit 2 through Unit 4 shale wells during 2002. In the Unit 2 through Unit 4 shales arsenic impact to groundwater occurred south of the MPB, southwest corner of Pond 2, the Fluoride Holding Basin No. 1 area and north of the Emergency Basin. Arsenic levels in the Unit 2 through Unit 4 shale groundwater varied from <0.009 mg/L to 3.87 mg/L. The high of 3.87 mg/L occurred in MW064A located east of the Fluoride Sludge Basin No.1 South. Unit 2 through Unit 4 shale wells with arsenic levels above the MCL of 0.05 mg/L include MW031A, MW032A, MW042A, MW046A, MW051A, MW057A, MW058A, MW059A, MW060A, MW061A, MW064A, MW065A, MW082A, MW087A, MW095A, MW102A, and MW103A.

## 3.0 HAZARD ASSESMENT

### 3.1 Source and Contamination Characterization

The following section summarizes radiological and chemical utilization at the Facility, extent of impacted soils, existing and potential future groundwater contamination, and risks posed by COCs to human health and environmental populations. Details of radiological and chemical materials and utilization at the Facility are presented in Section 4.2 of the SCR (SFC, 1998a). Details of the extent of impacted soils are presented in the SCR, Section 4.4, HGSCR, Section 2.1 (MFG, 2002a), and the Preliminary Design Report for the Disposal Cell at the Sequoyah Fuels Corporation Facility, Section 2.4 (MFG, 2002b). Details of existing groundwater contamination are presented in the HGSCR, Sections 5.7 (MFG, 2002a).

#### 3.1.1 Source Terms for COCs

Three COCs have been identified for the Facility, arsenic, nitrate, and uranium. Natural uranium (uranium as found in nature) was the primary form of uranium processed at the Facility. Natural uranium consists of three isotopes having mass numbers of 234, 235, and 238. Each isotope comprises on average 0.006 percent, 0.7 percent, and 99.3 percent of the mass of natural uranium, respectively. Depleted uranium was the only other form of uranium processed at the Facility. Depleted uranium is created by reducing the mass abundance of uranium-235 relative to the other two isotopes. Depleted uranium was handled at the Facility in much smaller quantities and for a shorter period of time than natural uranium. The depleted uranium process was essentially a closed loop system that did not contribute significant amounts of depleted uranium to the Facility grounds. During the site characterization of 1995, analysis of samples from seven locations revealed that uranium contamination at the Facility is in the form of natural uranium (SFC, 1998a).

The uranium feed material contained associated transformation products, including radium-226 and thorium-230, in non-equilibrium ratios.

Natural uranium was delivered to the plant as uranium ore concentrate, primarily as yellowcake ($U_3O_8$), with a limited amount delivered as ammonium diurante slurry. Processing operations at the SFC Facility utilized $U_3O_8$ in the stepwise production of $UF_6$. Intermediate solid compounds such as $UO_2(NO_3)_2$, $UO_3$, $UO_2$, and $UF_4$, were produced. Various chemicals, such as $H_2SO_4$,

$HNO_3$, HF, $NH_3$, $BaCl_2$, CaO, and limestone were stored on-site and used in the process. Major by-products of the operation were $NH_4NO_3$, $CaF_2$, and raffinate sludge. Minor amounts of refrigerants, cleaning solvents, lubricants, and water treatment chemicals were also utilized on the site.

Beginning in 1986, depleted uranium hexafluoride was used to produce depleted uranium tetrafluoride. The main by-product of the process, anhydrous hydrofluoric acid, was utilized in the main plant.

Sources of contamination are found within various Site Characterization Units. The SCU's are listed in Table 2.1. The Facility Environmental Investigation (FEI) Finding Report (RSA, 1991) and the Site Characterization Report (SFC, 1998a) provides a thorough description of most of these features. SFC has determined that approximately 8.6 million cubic feet of radioactively and/or chemically-impacted materials may exist at the Facility (ESC, 1996). Impacted material includes process waste materials, structural debris, underlying utility lines, and subsoil materials associated with the various SCUs, plus soils impacted by the 1986 $UF_6$ release. Details of the extent of the impact for each SCU are provided in Appendix A of the Preliminary Design Report for the Disposal Cell at the Sequoyah Fuels Corporation Facility (MFG, 2002b).

Underground utility lines at SFC were a focus of investigation during the FEI. Underground utility lines at SFC were used for the transport of sanitary and laundry wastewater, electricity, communications, cooling water, fire water supply, and domestic and potable water supply. Many underground utilities were installed in excavated trenches using a porous backfill, such as sand, to immediately surround the utility. The porous backfills have a much higher hydraulic conductivity than the surrounding natural soils; therefore, the utility trenches act as preferential drainage routes for shallow subsurface water (porewater). Historically, the primary sources of site-derived uranium to groundwater are the MPB, SX Building, and Discarded Equipment Storage Areas. Releases of uranium contaminated liquids from these sources and others within the Process Area occurred during Facility operations. Uranium contaminated liquids tended to seep to subsoil and collect within the fill material associated with underground utility trenches and granular backfill material in the MPB area, creating localized subsoil regions of high uranium concentration.

The primary sources of site-derived arsenic to groundwater are the MPB, SX Building, the Pond 2 area, the Emergency Basin, and to lesser extents, the fluoride clarifier, settling basins, and holding basins.

The primary source of site-derived nitrate to groundwater is the SX Building area, the Pond 1 Spoils Pile, Pond 2, Clarifier Basins, and the Fertilizer Ponds.

Reclamation of the Facility includes a program for the decommissioning of the Facility, and includes excavation, and stabilization/solidification of radioactive-contaminated soils, sludges, and structures (SFC, 1998b; MFG, 2002b). The proposed program will place most of the identified radioactive and/or chemically impacted material into an on-site disposal cell, with much of the remaining material remain in place underlying the footprint of the cell. This decommissioning program is designed to remove most of the radioactive/chemically-impacted materials as future sources of COC contamination to groundwater.

### 3.1.2 Existing and Potential Future Groundwater Contamination

Existing groundwater contamination is addressed in Section 2.3. Details of the extent and quality of potential future groundwater contamination will be addressed in Section 4.0. In general, potential future groundwater contamination will consist primarily of the migration of existing plumes. Disposal of solid contaminated materials into the disposal cell, will remove the source of future groundwater contamination.

## 4.0 TRANSPORT AND PATHWAY ASSESSMENT

Transport modeling was performed during the HGSCR (MFG, 2002a). The site conceptual model for COC migration was based on data collected from the MFG site investigation, other Facility investigations, and SFC hydrologic and geochemical database. The flow and transport model developed by MFG was designed based on the hydrogeologic conceptual model framework, and have been calibrated to observed hydrologic and geochemical conditions. The models simulate 1,000-year predictive scenarios based on steady-state flow conditions and current distributions of COCs dissolved in groundwater. The simulations incorporate post-decommissioning modifications to topography, flow field, and COC source materials to more accurately represent future conditions. The modeling results indicate that no significant hazards to humans in the site surface waters or adjacent river resulting from arsenic, nitrate, or uranium in the site groundwater. The arsenic, nitrate, and uranium concentrations in streams are also below protective levels for ecological receptors.

In 2001, SFC submitted new groundwater characterization and modeling data (SMI, 2001). As a result of discussions with the Nuclear Regulatory Commission regarding these submittals, several issues regarding site conditions were identified. These issues included:

- Increasing arsenic concentrations in well MW095A not predicted by, and inconsistent with the groundwater modeling;
- Concerns with the delineation and characterization of the hydrogeologic and geochemical conditions associated with the subsurface swale near MW010; and
- Anomalous uranium and nitrate water quality in the 005 Drainage not predicted by, and inconsistent with the groundwater modeling.

A supplemental data collection effort was perform by Shepherd Miller to address these issues. Results and findings of the supplemental data collection were presented in the HGSCR, Appendix B (MFG, 2002a). Subsequent to the release of the HGSCR, SFC excavated two investigation trenches southwest of Pond 2 to better understand the possible pathways of nitrate and arsenic and the anomalously high nitrate and arsenic concentrations in MW095A. A summary of the pathway and transport assessments for the MW095A, MW010/Swale, and 005 Drainage areas are provided in the following sections. Results of these supplemental data collection efforts indicated that a potential exists for contaminated groundwater within the shale aquifer to discharge to the surface, in the MW095 area, in the MW010/Swale area, and near the head of the 005 Drainage. Based on these results, corrective action measures were deemed necessary for each of these areas.

Results of ongoing groundwater sampling of shallow wells in the Process Area indicate that wells with high uranium concentrations are found near the fill material associated with buried utility lines and within granular backfill material in the MPB area. Because the potential exists for contaminated water within the utility trench system to enter the underlying bedrock aquifer, a corrective action measure to remediate the utility trench system will occur.

### 4.1 Transport and Pathway Assessment of Nitrate and Arsenic Anomaly in MW095A

Groundwater samples collected from monitor well MW095A, located south of the Port Road near the Facilities western boundary, have shown elevated nitrate and arsenic concentrations not predicted by groundwater modeling. Elevated nitrate and arsenic has also been observed at a seep located just north of the Port Road Bridge. The source of the contamination in this area most likely comes from impacts near the southwest corner of Pond 2.

An east-west trending excavation south of the Port Road and a north-south trending excavation west of Pond 2 (Figure 4-1) reveal the existence of sandy seams above the Unit 4 Shale. These sandy seams are up to several feet thick and are highly transmissive. Several pits were excavated during the trenching process and significant amount of water filled the pits within a few hours time. Elevated nitrate and arsenic concentrations were found in the waters collected in the trenches and pits, indicating that the sandy seams represent preferential pathways of COC transport.

### 4.2 Transport and Pathway Assessment of Nitrate and Uranium Anomaly in the MW010 Swale Area

An additional objective of the Supplemental Data Collection field investigation was to evaluate the subsurface swale suspected near monitoring well MW010A (Figure 4-2). This swale is essentially a small surface drainage channel that was covered with local fill materials at the time of facility construction and is suspected of being a subsurface feature that significantly influences local groundwater flow. The technical approach to this field effort consisted of excavating a trench and several test pits.

Groundwater was sampled in MW010 Trench 1, MW010 Trench 2, MW010 Trench 4 and MW010 Trench 5 (Figure 2, Appendix B, HGSCR). The analytical results were used in conjunction with nearby monitoring wells in the unconsolidated deposits (MFG, 2002a). The results indicate that the contaminant migration is limited to the gravel deposits of the backfilled swale. A localized hydraulic gradient reversal is due to the water level in the Decorative Pond prevents southward migration of the uranium plume. Uranium migration in the unconsolidated sediments appears to be limited in extent to the gravel deposits. Uranium groundwater concentrations appear to diminish where more fines are present in the distal edges of the fill material.

### 4.3 Transport and Pathway Assessment of Nitrate and Uranium Anomaly in the 005 Drainage

Recent sampling of the 005 Drainage surface waters indicate elevated levels of uranium and nitrate that were not predicted by, and inconsistent with, groundwater modeling results. It appears likely that fill material placed in the upper end of the 005 Drainage during plant construction may be providing a preferential flow path for impacted groundwater from the SX Building and MPB areas. This is similar to what is observed near MW010. The technical approach for the Supplemental Data Collection process of the 005 Drainage included two components. The first component consisted of excavating a trench in the fill materials at the head of the 005 Drainage between the emergency basin and the existing 005 Sump, south of Fluoride Holding Basin No. 2 (Figure 4-3); this trench is referred to as 005 Drainage Trench 1. The second component consisted of sampling soils and water from small excavations in the banks of the 005 Drainage at various points along its alignment (Figure 4-3).

Interpretation of the laboratory analytic results from groundwater collected during the supplemental data collection process indicate that uranium concentrations are greatest in the 005 Drainage Trench 1, especially in the gravel deposit beneath the French drain lines. It is likely that some of the impacted groundwater in the gravel was not being intercepted by the French drain system and ultimately flows down gradient, either within the unconsolidated sediments or as surface water. The unconsolidated sediments appear to contain more uranium than would be suggested by the groundwater uranium concentrations modeling results and are likely due to past spills or contaminated solids washed from the site being transported downstream prior to construction of the storm water intercept trench in 1990 (MFG, 2002a).

## 5.0 CORRECTIVE ACTION ASSESSMENT

### 5.1 Corrective Action Strategy

It is required of all potential corrective action alternatives that they provide for the protection of public health and safety and the environment for all pathways beyond the points of compliance over the compliance period (1,000 years). The practicability of the alternatives is evaluated on a technical basis, while the reasonableness of the alternatives is evaluated on a relative cost and benefit basis. The primary objective of the potential groundwater corrective action alternatives is to provide protection of human health, aquatic species, and terrestrial species from potential hazards associated with ingestion of contaminated surface water. Secondary objectives include minimizing impacts to the adjacent terrestrial environment, minimizing treatment waste products and reducing costs.

Based on the findings of the HGSCR (MFG, 2002a) and subsequent characterization investigations by SFC of the MW095A area, SFC became proactive in implementing corrective action procedures to control the migration of COC impacted groundwater and limit the amount of surface exposure of COCs. In July 2002, SCF installed a drainage collection trench at the head of the 005 Drainage, and in April 2003 completed the installation of a drainage collection trench between Pond 2 and MW095A. Groundwater recovered in each of these trenches will be pumped out and piped to storage holding basins for future treatment. The use of drainage collection trenches, or the Hydraulic Containment and Pump Back method, as the preferred corrective action plan, was based on the previous evaluation of corrective action alternatives during the Corrective Measures Study (SFC, 1997) and the successful use of containment barriers (i.e. French Drains) at the Facility. This corrective action assessment is therefore provided to evaluate the feasibility of the Hydraulic Containment and Pump Back method as well as other corrective action alternatives, and to demonstrate that the Hydraulic Containment and Pump Back method is a viable alternative for the 005 Drainage and MW095A corrective action areas in the protection of human health and the environment.

This assessment evaluates potential corrective measures for the groundwater system in four areas of the Facility. Three areas, the 005 Drainage, the area southwest of Pond 2 in the vicinity of monitoring well MW095A, and the MW010/Swale area, require corrective measures to intercept and mitigate migrating impacted groundwater prior to reaching POC wells. Corrective measures for the fourth area will focus on removing and treating impacted groundwater from utility trenches in the Process Area and granular backfill near the MPB, and removing and disposing impacted fill and soils associated with the utility trenches and the granular backfill. The area(s) where implementation of corrective action procedures is required will be referred to as a Corrective Action Area. Details of the corrective action methods already implemented at the Facility, the 005 Drainage Collection Trench and the MW095A Collection Trench, and details of the planned corrective action methods for the MW010/Swale area and Utility Trench System of the Process Area will be presented in Section 6.

Potential Corrective Action Alternatives (CAAs) were evaluated by identifying a suite of technologies that can provide the required reasonable assurance of protection to public health and safety and the environment by reduction of COCs in the aquifer and/or reduction of groundwater flow for each of the corrective action areas. The suite of alternatives are evaluated for practicability based on the criteria of effectiveness, implementability, the certainty of a given technologies application, and the relative costs of each technology as applied to each location. These practicable alternatives are evaluated for reasonableness by considering the relative costs and benefits of each alternative.

## 5.2 Previous Corrective Action Programs

In March 1984, Facility personnel discovered the presence of nitrates in concentrations up to 1,000 mg/L in seeps approximately 500 feet south of Pond 2. Based on the location of the seeps and the magnitude of nitrate contamination in the area, two collection trenches and flow barrier slurry walls were constructed to intercept contaminated groundwater. All recovered groundwater was pumped back into Pond 2. In 1985, a French drain system was installed on the southern end of Pond 2. This system was designed with an automatic pumping system to keep the area de-watered. The French drain system was constructed with a gravel-filled trench connected to a buried concrete tank installed approximately 4 feet below ground level. Groundwater collected from the trench gravity flowed into the tank and was subsequently pumped back to Pond 2. Pumping was discontinued prior to 1990 after the area failed to yield enough water to pump. In 1991, liquids in the pond were removed and the pond sludges were removed to levels that exhibited uranium concentrations less than 2,000 pCi/g. A high-density polyethylene (HDPE) liner was then placed over the remaining sludges. In addition, a portion of the west pond embankment was breached to facilitate gravity drainage of rainwater. Intermittent pumping of the French drains was resumed during 1995 and automated pumping began in 1997.

The current approved reclamation plan consists of the construction of an on-site disposal cell and development of groundwater corrective action plans to address remediation of groundwater contamination found in the 005 Drainage area, the area southwest of Pond 2 near MW095A, the MW010/Swale area, and within Utility Trench System in the Process Area. Details of the disposal cell are provided in the Preliminary Design Report for the Disposal Cell at the Sequoyah Fuels Corporation Facility (MFG, 2002b). The disposal cell will be constructed over major areas of contamination at the Facility, and will be built to dispose of most of the potential sources of contamination to groundwater, including raffinate sludge, pond sediments, soil liner and subsoil material, structural materials, and contaminated soils and bedrock.

### 5.3 Potential Corrective Action Alternatives

A wide range of potential CAAs were proposed during the Corrective Measures Study (SFC, 1997b). These CAAs were identified as Corrective Measures Alternatives (CMAs) during the Corrective Measures Study, however the term Corrective Action Alternatives (CAAs) will be used to identify them in this report. A summary of the alternatives considered and selected by SFC will be provided below. Details of theses alternatives are provided in Section 6 of the Corrective Measures Study (SFC, 1997b). The CMAs were evaluated to address the remediation of arsenic from a single plume. The current corrective action plan for the facility involves multiple constituents (arsenic, nitrate, and/or uranium) at four separate locations (corrective action areas). Therefore, the Corrective Action Alternatives will be reevaluated for their ability to mitigate nitrate and uranium as well as arsenic, and for implementation at the four Corrective Action Areas, the MW095A area southwest of Pond 2, the MW010/Swale area, the 005 Drainage and the Utility Trench System within the Process Area.

#### 5.3.1 Corrective Action Alternatives Considered

Some CAAs were eliminated by SFC during initial screening (Section 6.1, SFC, 1997b), primarily because they are intended for the remediation of organics, and are not considered here. These include: bioreactors of recovered groundwater, airstripping of recovered groundwater, ultraviolet oxidation of recovered groundwater, nitrate enhancement, oxygen enhancement with air-sparging, oxygen enhancement with hydrogen peroxide, air sparging, free product recovery, hot water of steam flushing/stripping, and vacuum vapor extraction. Actions considered for further evaluation by SFC include:

- No Action
- Natural Attenuation
- Groundwater Recovery using Vertical Well Arrays
- Groundwater Recovery using Horizontal Well Arrays
- Groundwater Recovery using Containment Walls
- Containment (Slurry) Walls
- Passive Treatment Walls
- Phytoremediation
- Co-Metabolic Processes

Groundwater recovered by the groundwater recovery methods listed above will be treated to meet applicable standards. Details of the method of ex-situ treatment of recovered groundwater that will be used by SFC are provided in Appendix A.

### 5.3.2 Technical Evaluation of CAAs Selected

Section 6.4 of the Corrective Measures Study (SFC, 1997b) provides a technical evaluation of the CAAs selected. These evaluations were conducted considering arsenic as the only COC, and a single, broad, dumbbell shaped area of groundwater contamination, with the very elevated arsenic concentrations centered on the southwest corner of Pond 2 and near the Fluoride Holding Basin No. 1. The technical evaluation of CAAs in this study will be a reevaluation of the evaluation provided by SFC, taking into consideration that remediation of contaminated groundwater will occur in four, separate Corrective Action Areas and includes nitrate and uranium as well as arsenic as COCs. The reassessment will consider the smaller plume size of the individual Corrective Action Areas as opposed to the large area of contamination assessed by SFC, and will consider the applicability of the CAAs to remediation of uranium and nitrate as well as arsenic. Arsenic and nitrate are the COCs to be evaluated for remediation the MW095A area southwest of Pond 2, uranium and nitrate are the COCs to be evaluated for remediation in the MW010/Swale area, and uranium and nitrate are the COCs to be evaluated of remediation in the 005 Drainage. The Corrective Action Alternatives will also be evaluated for remediation of uranium-impacted groundwater associated with the Utility Trench System in the Process Area.

As in the Corrective Measures Study, the CAAs selected for further consideration were evaluated against the General Standards for Corrective Measures: Overall Protection of Human Health and the Environment, Attainment of Media Cleanup Standards, Control of Sources of Releases, and Compliance with Standards for Management of Wastes.

#### 5.3.2.1 Overall Protection

During the Corrective Measures Study, all of the CAAs, with the exception of the No Action Alternative, were considered to provide adequate protection to human health and the environment. Reevaluation of the CAAs in this study reveals that the natural attenuation alternative would not provide adequate protection to human health and the environment. Natural attenuation would rely on subsurface processes such as dilution, dispersion, and adsorption to reduce (attenuate) COC concentrations in groundwater to acceptable levels before reaching probable human or environmental exposure points. Because COCs have already reached exposure points in the 005 Drainage and southwest of Pond 2, this alternative is not applicable to those areas. While uranium has not reached exposure points in the MW010/Swale area, uranium concentrations greater than 30 mg/L is predicted to reach the 009 Stream within 50 years and the 001 Drainage within 75 years. Potential exposure of contaminated water in the 009 and 001 Drainages within the compliance period may occur; therefore natural attenuation is not a viable alternative for this area. Natural attenuation is not considered further as a CAA.

#### 5.3.2.2 Attainment of Media Cleanup Standards

Media cleanup standards would not be expected to be met for the No Action alternative. Media cleanup standards would be expected to be met using any of the other CAA.

### 5.3.2.3 Controlling Sources of Release

Removal of contaminated material during the installation of the disposal cell (MFG, 2002b) will eliminate the sources of groundwater contamination, therefore no future sources of release should occur.

### 5.3.2.4 Compliance with Standards for Management of Wastes

Secondary wastes from treatment of recovered groundwater are expected to meet RCRA Land Disposal Restrictions (40 CFR 268) standards for disposal of hazardous materials.

Additionally, each of the selected CAAs were reevaluated in relation to others in four technical areas, performance, reliability, implementability, and safety. Technical ratings used in the Corrective Measures Study (SFC, 1997b) included: 3-Excellent, 2-Good, 1-Fair, and 0-Poor. The totals of the rating for each CAA are indicative of the overall technical evaluation of the CAA. A reevaluation of the technical ratings of each CAA, along with a short qualitative rationale for the reevaluated rating, will be provided in this section.

Performance is based on an evaluation of the effectiveness and the useful life of the CAA. Effectiveness is the ability of the CAA to reduce the risk to human health or the environment of COCs contained in impacted groundwater. The length of time required to reduce the risk is also a factor in this rating. Useful life is the length of time that the CAA is likely to remain effective.

Reliability is based on assessment of the complexity of implementation and operation of the CAA, the expected frequency of maintenance, and whether or not there are any analogous examples that would demonstrate reliability.

Implementability is based on assessment of the installation or construction requirements, the time required to install or construct the CAA, and the time required to realize the beneficial results.

The Safety assessment considers worker safety during implementation as well as the safety of the public and the environment.

This section will provide a brief description and technical evaluation of the various CAAs. The description will include an estimated configuration of the various technologies at each of the

Corrective Action Areas. The technical evaluation of CAAs will be a reevaluation of the evaluation provided by SFC, and will take into consideration remediation of contaminated groundwater in four, separate Corrective Action Areas and the addition of nitrate and uranium as COCs. The evaluation will determine the performance, reliability, implementability, and safety associated with each alternative as applied to specific Corrective Action Areas, and will reassess the technical rating provided by SFC.

### 5.3.3 No Action

#### 5.3.3.1 Description

The no action alternative would provide no measures to mitigate groundwater loading to Facility surface waters. This alternative requires no Corrective Action Measures, groundwater restrictions, or institutional controls to be implanted. Concentrations of COCs above protective levels due to loading to surface waters above is expected to continue into the future regardless of decommissioning activities, including construction of a disposal cell, in the Process Area.

#### 5.3.3.2 Performance

This alternative would not be protective of human health or the environment and would not reduce contaminant loading to surface waters over the short or intermediate term.

#### 5.3.3.3 Reliability

No reliability assessment of this alternative can be made.

#### 5.3.3.4 Implementability

The no action alternative is technically feasible.

#### 5.3.3.5 Safety

No safety issues are present with this alternative.

#### 5.3.3.6 Overall Technical Rating

This alternative is not rated.

### 5.3.4 Groundwater Recovery using Vertical Wells

#### 5.3.4.1 Description

In this alternative COC impacted water would be recovered by pumping from a series of vertical wells located along the leading edge of the plume and/or through the center of the plume in the areas of highest COC concentration. Within the Process Area groundwater would be pumped from Utility trench fill material. Groundwater recovered would be pumped to a collection area for ex-situ treatment.

The vertical well configuration involves the installation of wells at approximately 100 foot intervals, along with associated pumps, collection tanks, and controls. The estimated pumping duration is the time required to reduce COC concentration below current drinking water standards in the plume of the specific area. Because the shale units underlying the facility have limited yield, pumping will only very slowly dewater the aquifer and reduce arsenic or uranium concentrations. The main effect of this alternative, however, will be for the wells on the leading edge of the plume to impede the downgradient advancement of the plume, allowing both dewatering and natural attenuation to reduce COC concentrations. Ex-situ treatment alternatives would further reduce contaminant concentrations.

The corrective action approach for the area southwest of Pond 2 consists of installing 3 wells along a north-south trending line east of monitoring well MW095A and 8 wells along an east-west trending line extending from MW095A to the southwest corner of Pond 2. The wells would extend to the top of the Unit 4 Sandstone and would be screened in the alluvium and Unit 4 Shale.

The corrective action approach for the MW010/Swale area consists of installing 3 wells along an east-west trending line north of the Decorative Pond and four wells along a north-south trending line extending from the east-west array north to the MPB area. The wells would extend to Unit 1 Sandstone would be installed and would be screened in alluvium and Unit 1 Shale.

The corrective action approach for the 005 Drainage area consists of installing 3 wells along a north-south trending line at the head of the 005 Drainage. The wells would extend to the top of Unit 3 Sandstone and would be screened in alluvium and Unit 3 Shale.

The Corrective Action approach for the Utility Trench System consists of using existing and new wells to pump groundwater from the backfilled trenches. Pumping will continue till the trenches are completely dewatered, which should occur within several months after initiation of pumping.

#### 5.3.4.2 Performance

Through dewatering and impeding the downgradient advancement of impacted groundwater, combined with ex-situ treatment of recovered groundwater, this alternative will reduce contaminant loads to surface waters. Due to the very low hydraulic conductivity of the shale units and the proximity of contaminant plumes to exposure points, however, this method may not be able to capture all of the impacted groundwater flow in the corrective action areas, without the use of a significantly greater number of wells along each well array. Because of the high hydraulic conductivity of the backfill materials associated with the utility trenches, dewatering of within the Utility Trench System should occur fairly rapidly, probably within several months of initiation of pumping.

#### 5.3.4.3 Reliability

Submersible pumps will be required in each well as well as one or more ex-situ treatment plants. Proper maintenance of equipment should assure reliability of the system. Maintenance requirements for this alternative are similar to the groundwater recovery using horizontal wells alternative, but are higher than other alternatives.

#### 5.3.4.4 Implementability

Installation of the pumping wells is highly feasible and has been successfully accomplished at the site for purposes of hydraulic testing. Any ex-situ technology used would be a highly feasible and demonstrated technology. Wells can be installed in any single array within a month or two. Wells can be placed to beneficial use by extracting groundwater as soon as they are completed and the pumps installed.

#### 5.3.4.5 Safety

Installation of wells should not create undue hazard for the workers or the public. Practices employed by SFC during installing of monitoring well at the Facility have successfully prevented worker exposure to hazardous or radioactive material. Well cuttings can be easily handled and disposed of to prevent the spread of any hazardous materials from the job site. Treatment of recovered groundwater will result in an increase of risk of exposure for workers and for the potential of contaminated water spills.

#### 5.3.4.6 Overall Technical Rating

No change in the overall technical rating of 10 provided by the Corrective Measures Study is warranted of the Groundwater Recovery using Vertical Wells alternative.

### 5.3.5 Groundwater Recovery using Horizontal Wells

#### 5.3.5.1 Description

In this alternative COC impacted water would be recovered by pumping from a series of horizontal wells. These wells would be installed located along the leading edge of the plume and/or through the center of the plume in the areas of highest COC concentration. Within the Process Area groundwater would be pumped from Utility Trench System fill material. Groundwater recovered would be pumped to a collection area for ex-situ treatment.

The horizontal well configuration involves the installation horizontal wells along the leading edge of the plume and one horizontal well through the center of the plume with the highest COC concentration, along with associated pumps, collection tanks, and controls. The estimated pumping duration is the time required to reduce COC concentration below current drinking water standards in the plume of the specific area. Because the shale units underlying the facility have limited yield, pumping will very slowly dewater the aquifer and reduce arsenic or uranium concentrations. The main effect of this alternative, however, will be for the wells on the leading edge of the plume to impede the downgradient advancement of the plume, allowing both dewatering and natural attenuation to reduce COC concentrations. Ex-situ treatment alternatives would further reduce contaminant concentrations.

The corrective action approach for the area southwest of Pond 2 consists of installing a north-south trending well west of monitoring well MW095A and an east-west well extending from MW095A to the southwest corner of Pond 2. The wells would be installed slightly above the Unit 4 Shale/Unit 4 Sandstone interface and would collect water from the majority of the well length.

The corrective action approach for the MW010/Swale area consists of installing an east-west well north of the Decorative Pond and an approximately north-south well extending from the east-west array north to the MPB area. The wells would be installed slightly above the Unit 1 Shale/Unit 1 Sandstone interface and would collect water from the majority of the well length.

The corrective action approach for the 005 Drainage area consists of installing an approximate north-south trending well at head of the Drainage northwest of Pond 2. The wells would be installed slightly above the Unit 3 Shale/Unit 3 Sandstone interface and would collect water from the majority of the well length.

The Corrective Action approach for the Utility Trench System consists of using existing and new wells to pump groundwater from the backfilled trenches. Pumping will continue until the trenches are completely dewatered, which should occur within several months after initiation of pumping.

### 5.3.5.2 Performance

Through dewatering and impeding the downgradient advancement of impacted groundwater, combined with ex-situ treatment of recovered groundwater, this alternative will reduce contaminant loads to surface waters from groundwater in Shale units. Because the horizontal transmissivity within unconsolidated surface aquifer material is much higher than the transmissivity within the Shale units, impacted groundwater flow in aquifer material overlying bedrock will not be effectively recovered by pumping from horizontal wells located within Shale units, increasing the likelihood of unacceptable loading to surface water. Because of the high hydraulic conductivity of the backfill materials associated with the utility trenches, dewatering of within the Utility Trench System should occur fairly rapidly, probably within several months of initiation of pumping.

### 5.3.5.3 Reliability

A number of submersible pumps will be required in each well as well as one or more ex-situ treatment plants. Proper maintenance of equipment should assure reliability of the system. Maintenance requirements for this alternative are similar to the groundwater recovery using horizontal wells alternative, but are higher than other alternatives.

#### 5.3.5.4 Implementability

Installation of the horizontal wells requires special equipment and skills beyond that required for vertical well installation. Installation time of two or three wells at any single Corrective Action Area is likely to require several months. Wells can be placed to beneficial use by extracting groundwater as soon as they are completed and the pumps installed. Any ex-situ technology used would be a highly feasible and demonstrated technology.

#### 5.3.5.5 Safety

Installation of wells should not create undue hazard fort he workers or the public. Practices employed by SFC during installing of monitoring well at the Facility have successfully prevented worker exposure to hazardous or radioactive material. Well cuttings can be easily handled and disposed of to prevent the spread of any hazardous materials from the job site. Treatment of recovered groundwater will result in an increase of risk of exposure for workers and for the potential of contaminated water spills.

#### 5.3.5.6 Overall Technical Rating

Due to the ineffectiveness of wells constructed within bedrock units to contain groundwater flow through unconsolidated surface material, the effectiveness of this alternative is less than that suggested during the Corrective Measures Study (SFC, 1997b). Therefore, a change in the overall technical rating of 8 provided by the Corrective Measures Study to 7 is warranted. This evaluation is applicable to implementation of this CAA at any of the Corrective Action Areas.

### 5.3.6 Passive Treatment Walls

#### 5.3.6.1 Description

This alternative involves the installation of a "funnel and gate" passive containment and treatment system. An interceptor trench containing a bed of adsorbent material is installed downgradient of contaminant plume, creating a permeable reaction barrier across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. These barriers allow the passage of water while prohibiting the movement of contaminants by employing such agents as zero-valent metals, chelators (ligands selected for their specificity for a given metal), sorbents, microbes, and others.

The contaminants will either be degraded or retained in a concentrated form by the barrier material. The wall could provide permanent containment for relatively benign residues or provide a decreased volume of the more toxic contaminants for subsequent treatment.

Modifications to the basic passive treatment walls may involve a funnel-and-gate system or an iron treatment wall. The funnel-and-gate system for in situ treatment of contaminated plumes consists of low hydraulic conductivity (e.g., $1^{E-6}$ cm/s) cutoff walls (the funnel) with a gate that contains in situ reaction zones. Groundwater primarily flows through high conductivity gaps (the gates). The types of cutoff walls most likely to be used in the current practice are slurry walls or sheet piles. Innovative methods such as deep soil mixing and jet grouting are also being considered for funnel walls.

The containment wall configuration involves the installation interceptor trench across the downgradient side of the contaminant plume. The trench would be backfilled with gravel, providing a preferential pathway for groundwater flow. Near the central portion of the trench, a bed of adsorbent material in a porous matrix would be installed, through which the groundwater would be directed. Zero-valent iron can effectively mediate arsenic, nitrate, and uranium. A carbon source would be required to promote denitrification reactions of nitrate to $N_2$ gas. This carbon source could be in the form of peat, which has been demonstrated to effectively remove uranium from groundwater. Pilot-scale testing of media combinations should be performed to determine the most effective adsorbent material. Dissolved contaminants would be absorbed by the porous media, resulting in clean water exiting the adsorbent bed. Water discharging from the lower end of the adsorbent bed would be monitored to verify the effectiveness of the adsorbent.

The corrective action approach for the area southwest of Pond 2 consists of installing a north-south trending interceptor trench west of monitoring well MW095A. The trench would be approximately 300 feet long and would be excavated into the top of the Unit 4 Shale

The corrective action approach for the MW010/Swale area consists of installing an east-west trending interceptor trench along the boundary of the Process Area south of the Decorative Pond. The trench would be approximately 200 feet long and would be excavated to the top of the Unit 1 Sandstone.

The corrective action approach for the 005 Drainage area consists of installing a north-south trending interceptor trench at head of the Drainage northwest of Pond 2. The trench would be approximately 100 feet long and would be excavated to the top of the Unit 3 Sandstone.

Because groundwater flow from the Utility Trench System fill material is primarily vertical into underlying bedrock and not lateral to surface exposure points, the Passive Treatment Walls alternative would not be a feasible corrective action method for remediation of the Utility Trench System.

#### 5.3.6.2 Performance

The interceptor trench is expected to effectively prevent any further downgradient movement of COC impacted groundwater as long as the adsorbent material remains effective. In-situ water treatment of groundwater should effectively reduce COC concentrations to appropriate standards.

#### 5.3.6.3 Reliability

Once constructed, the interceptor trench is expected to last indefinitely. The gravel drainage zone and the overlying fill material would not be expected to deteriorate with time, other than some limited surface erosion which can easily be repaired. There is no reasonable mechanism identified that would result in plugging of the gravel bed in the proposed configuration. Adsorbent bed life may be limited requiring replacement; especially in passive treatment systems installed in the 005 Drainage and the MW010/Swale area, increasing the maintenance requirements for this alternative compared to other groundwater recovery methods.

#### 5.3.6.4 Implementability

Excavation of a trench and installation of the groundwater collection system could be easily accomplished within one month. No significant amount of overburden would need to be excavated, nor would any excavation of sandstone be required at any of three Corrective Action Areas. Upon completion of the collection system, remediation of recovered groundwater will begin immediately.

#### 5.3.6.5 Safety

Installation of the interceptor trench should not create any undue hazard for the workers of the public. Practices employed by SFC during installation of trench systems have successfully prevented worker exposure to hazardous or radioactive material in the past. Excavated material can be easily handled and disposed of to prevent the spread of any hazardous material from the job site. Normal industrial safety precautions would be used during construction to minimize the construction risk.

#### 5.3.6.6 Overall Technical Rating

No change in the overall technical rating of 8 provided by the Corrective Measures Study is warranted or the Passive Treatment Walls alternative. This evaluation is applicable to implementation of this CAA at any of the Corrective Action Areas except the Utility Trench System.

### 5.3.7 Phytoremediation

#### 5.3.7.1 Description

Phytoremediation is a process that uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment. The mechanisms of phytoremediation include enhanced rhizosphere biodegradation, phyto-extraction (also called phyto-accumulation), phyto-degradation, and phyto-stabilization. Selected species of vegetation that have the ability to assimilate arsenic would be planted in the area southwest of Pond 2. Selected species of vegetation that have the ability to assimilate uranium would be planted in the 005 Drainage and MW010/Swale areas. Because the fill material in the Utility Trench System would probably not be able to support a healthy growth of vegetation, the Phytoremediation alternative would not be a feasible corrective action method for remediation of the Utility Trench System.

Nitrate present in groundwater is expected to stimulate growth of these plants. Long term monitoring of surface water and near-surface groundwater below the elevation of planted vegetation would be required in order to verify effectiveness. In addition, periodic analysis of the vegetation would be required to determine if the levels of bio-accumulation would require that the plants be harvested and appropriately dispositioned.

#### 5.3.7.2 Performance

Phytoremediation is expected to be effective in reducing COC concentrations in groundwater as it exits the bedrock or where root systems can penetrate, i.e. shallow soils. Therefore, because of the time required for COC impacted groundwater to exit the bedrock aquifer, groundwater use restrictions would be required. The useful life of this CAA is dependent on the life span of the selected vegetation and whether or not periodic harvesting and disposal is required.

#### 5.3.7.3 Reliability

This CAA is very simple to implement (planting trees) and little or no maintenance would be required until such time as the vegetation might need to be harvested, disposed of and the area replanted.

#### 5.3.7.4 Implementability

Implementation of this CAA would be easy and quick and beneficial results would begin occurring once the vegetation begins to establish a root system in the underlying soil.

#### 5.3.7.5 Safety

Hazards during implementation are essentially nonexistent. If harvesting is required, the concentrations of COC are not expected to pose a hazard to workers or the environment.

#### 5.3.7.6 Overall Technical Rating

No change in the overall technical rating of 9 provided by the Corrective Measures Study is warranted for the Phytoremediation alternative. This evaluation is applicable to implementation of this CAA at any of the Corrective Action Areas except the Utility Trench System.

### 5.3.8 Co-Metabolic Process

#### 5.3.8.1 Description

Co-Metabolic Process, or enhanced bioremediation, is a process in which indigenous or inoculated micro-organisms (e.g., fungi, bacteria, and other microbes) degrade (metabolize) contaminants found in soil and/or groundwater, converting them to innocuous end products. Nutrients, oxygen, or other amendments may be used to enhance bioremediation and contaminant desorption from subsurface materials. While it cannot degrade inorganic contaminants, bioremediation can be used to change the valence state of inorganics and cause adsorption, immobilization onto soil particulates, precipitation, uptake, accumulation, and concentration of inorganics in micro or macroorganisms. These techniques, while still largely experimental, show considerable promise of stabilizing or removing inorganics from soil.

Nutrients and carbon substrate would be injected into the groundwater to facilitate remediation processes. The injection wells at each corrective action area would have an arrangement similar to the pattern and number described for the Groundwater Recovery using Vertical Wells method.

#### 5.3.8.2 Performance

Limited lab scale testing of bioremediation indicates that bioremediation processes are effective in reducing arsenic and uranium in groundwater. Extensive lab scale testing would be required to determine the effectiveness of any bioremediation process given the site-specific conditions.

#### 5.3.8.3 Reliability

Introduction of the nutrients and inoculation of the groundwater with the appropriate species are straightforward steps utilizing existing wells, portable tanks and pumps. Once completed, extended groundwater monitoring would be required to confirm that the process is working.

#### 5.3.8.4 Implementability

This alternative is easily implemented, as indicated above. There is a possibility that additional nutrient injection points would be required, however, installation of additional wells can be completed very quickly. Based on lab testing, results near the wells should be realized within a few weeks of injection. The remedial results at distances further away from the wells will depend on how fast the nutrients and the bacteria migrate through the bedrock groundwater.

#### 5.3.8.5 Safety

The nutrients and bacteria proposed for this alternative can be safely handled without exposure to workers. There is little or no chance for added risks to the public or the environment.

#### 5.3.8.6 Overall Technical Rating

No change in the overall technical rating of 10 provided by the Corrective Measures Study is warranted for the Co-Metabolic Process alternative for implementation.

### 5.3.9 Groundwater Recovery using a Containment Wall (Hydraulic Containment and Pump Back)

#### 5.3.9.1 Description

This alternative, as presented in the Corrective Measures Study, incorporates an interceptor trench surrounding the main arsenic plume as a barrier to groundwater flow and as an accumulation area for subsequent groundwater recovery. Water recovered from the trench would be treated to reduce selected COC concentrations. The alternative as presented in this report will be referred to as the Hydraulic Containment and Pump Back method. Interceptor trenches are placed downgradient of the plumes in the MW095A, MW010/Swale, and 005 Drainage corrective action areas. COC impacted groundwater recovered from the collection trenches would first be pumped to the water treatment plant to reduce COC concentrations to land application standards, and the treated water will subsequently be pumped to Pond 5 for application as fertilizer, or discharged to the 001 Drainage. Mixing of recovered groundwater with storm water collected in the collection pond, and subsequent dispersal of collected water over a large land surface would dilute COC concentrations so that no significant health or environmental impacts would occur from handling of the recovered water with the storm water currently being collected and spread as fertilizer.

The containment wall configuration involves the installation of an interceptor trench across the downgradient side of the contaminant plume. A typical trench design consists of a trench with an approximate three-foot wide bottom with 2H:1V side slopes. The trench is filled with, from bottom to top, geo-fabric, HDPE pond liner, concrete, gravel, pond liner, geo-fabric, and back fill soil. Geo-fabric and pond liner materials are draped over the downgradient bank of the trench. The liner material extends onto the bottom of the trench about one foot and located immediately on the sandstone surface. Approximately five feet of gravel is placed on top of the liner. The geo-fabric and liner material wraps from the bottom along the downgradient side of the trench and over the top of the gravel. The upgradient side of the trench is open, allowing groundwater to drain into and collect in the gravel contained in the trench. Backfill soil is placed in the trench above the liner material and the area graded to match the topography.

A riser pipe extends from the concrete surface to above the ground surface. The base of the riser pipe is located at the lowest elevation point in the trench. The pipe is either open to the bottom of the trench or is connected to a "T" to which is attached perforated pipe that extends along the bottom of the trench for part of its length. A low-flow submersible electric pump is installed into the riser pipe to permit water to be pumped out of the containment system. Water pumped from the sump will be piped to storage for treatment or disposal.

The corrective action approach for the 005 Drainage area consisted of installing a north-south trending interceptor trench at head of the Drainage northwest of Pond 2. The trench was excavated to the top of the Unit 3 Sandstone. A smaller, leak detection monitor trench was installed approximately 50 feet west of the 005 Collection Trench. The leak detection monitor trench will provide an assessment of the effectiveness of the trench collection system. A riser pipe will be installed with no sump in the monitor trench to allow for collection of water quality samples.

The corrective action approach for the area southwest of Pond 2 consisted of installing a north-south trending interceptor trench west of monitoring well MW095A. The trench was excavated into the top of the Unit 4 Shale.

The corrective action approach for the MW010/Swale area consists of installing an east-west trending interceptor trench just north of the Decorative Pond. The trench would be excavated to the top of the Unit 1 Sandstone.

Because groundwater flow from the Utility Trench System fill material is primarily vertical into underlying bedrock and not lateral to surface exposure points, Hydraulic Containment and Pumpback alternative would not be a feasible corrective action method for remediation of the Utility Trench System.

#### 5.3.9.2 Performance

The interceptor trench is expected to effectively prevent any further downgradient movement of COC impacted groundwater provided the pumping system remains in operation. Ex-situ water treatment of recovered groundwater should effectively reduce COC concentrations to appropriate land application standards.

#### 5.3.9.3 Reliability

Once constructed, an interceptor trench is expected to last indefinitely. The gravel drainage zone and the overlying fill material would not be expected to deteriorate with time, other than some limited surface erosion which can easily be repaired. There is no reasonable mechanism identified that would result in plugging of the gravel bed in the proposed configuration. Riser pipes and submersible pumps are used extensively for recovering impacted groundwater. Maintenance requirements for this alternative are similar to other groundwater recovery methods.

#### 5.3.9.4 Implementability

Excavation of a trench and installation of the groundwater collection system is easily accomplished within one month. No significant amount of overburden needed to be excavated, nor was any excavation of sandstone required for the 005 Drainage and MW095A collection trenched, and no excavation of significant amount of overburden or sandstone is expected for the MW010/Swale collection trench. Recovered groundwater from the collection trenches is pumped to storage for eventual treatment at the water treatment plant. Recovered groundwater will be treated to land application standards. Treated water will then be pumped to Pond 5 for application as fertilizer. Details of water treatment facility, water treatment method, and the process for treatment and application, are discussed in detail in Appendix A.

#### 5.3.9.5 Safety

Installation of the interceptor trench should not create any undue hazard for the workers of the public. Practices employed by SFC during installation of trench systems have successfully prevented worker exposure to hazardous or radioactive material in the past. Excavated material can be easily handled and disposed of to prevent the spread of any hazardous material from the job site. Normal industrial safety precautions would be used during construction to minimize the construction risk.

#### 5.3.9.6 Overall Technical Rating

An overall technical rating of 10 was presented by the Corrective Measures Study for the Groundwater Recovery using a Containment Wall alternative. This alternative received a performance, reliability, implementability, and safety ratings of 2, 3, 2, and 3, respectively.

This alternative was given a performance rating of 2 during the Corrective Measures Study. A factor in the performance rating was the assumption that an extended period of time (in the thousands of years) would be required to recover all the impacted groundwater. Within the current configuration of the three areas of corrective action implementation, however, each area of impacted water is significantly smaller in extent than the area of impacted water evaluated during the Corrective Measures Study. Because of the reduced time required to operate the system, the groundwater recovery method using the Hydraulic Containment and Pump Back method is reassessed a performance rating of 3.

This alternative was given an implementability rating of 2 during the Corrective Measures Study. A factor in the implementability rating was the assumption that excavation of a significant amount of overburden would be required and that excavation of sandstone units overlying Unit 4 Sandstone would also be required near the north end of the trench. This problem would not be encountered at the 005 Drainage, MW095A, or MW010/Swale Corrective Action Areas. Excavation in the 005 Drainage and MW010/Swale areas would be down to the first encountered sandstone, eliminating any need to excavate hard sandstone. In the MW095A area, excavation would be to the Unit 4 Shale to capture flow in the transmissive sand lenses. Furthermore, no significant overburden exists at any of the three areas. Because problem due to excavation in any area should not be encountered, the groundwater recovery method using the Hydraulic Containment and Pump Back method is reassessed an implementability rating of 3.

No changes in the ratings of reliability and safety are warranted. The technical ratings for the groundwater recovery using the Hydraulic Containment and Pump Back alternative are therefore as follows: performance-3, reliability-3, implementability-3, and safety-3, for an overall technical rating of 12.

## 5.4 Environmental Impact of Each CAA

As a part of the Corrective Measures Study (SFC, 1997b), an assessment of the environmental impact of each alternative was performed. The assessment was based on Facility conditions and pathways of contamination addressed by each alternative, and include both short- and long-term beneficial and adverse affects. In addition, mitigative measures to correct adverse effects are presented. The assessment assumes that the respective alternative was approved by the EPA and was successfully implemented.

The No Action alternative was not assessed during the Corrective Measures Study. The other alternatives were reevaluated for this report considering the additional COCs and current corrective action areas. Natural attenuation was not reevaluated. The environmental impact assessments for each alternative and mitigative measures are presented in Table 5.1.

## 5.5 Potential Impact of each CAA on Human Health

As a part of the Corrective Measures Study (SFC, 1997b), an assessment of the impact of each alternative on human health was performed. Each CAA was assessed in terms of the extent to which the CAA mitigates short-and long-term potential exposure to COCs and projects human health both during and after the implementation of the CAA. The assessment describes the level of contaminants, potential exposure routes, and the potentially affected population. The assessment of the human health impact for each alternative is presented in Table 5.1

## 5.6 Selected Corrective Action Plan

Based on numerous Facility investigations and evaluation of multiple CAAs, SFC has determined that the Hydraulic Containment and Pumpback corrective action method will provide adequate protection of human health and the environment and is the most feasible of the CAAs for the 005 Drainage, the MW095A, and the MW010/Swale Corrective Action Areas. Groundwater recovery using vertical wells, followed by removal and disposal of impacted trench fill material, will provide adequate protection of human health and the environment and is the most feasible of the CAA's for remediation of groundwater within the Process Area associated with the Utility Trench System and granular backfill.

Since 2002, SFC has been proactive in the recovery of arsenic, nitrate, and uranium impacted groundwater in the 005 Drainage area and the area southwest of Pond 2 near MW095A by implementing the Hydraulic Containment and Pumpback corrective action method. The SFC also proposes to use the Hydraulic Containment and Pumpback corrective action method for the MW010/Swale area.

The Hydraulic Containment and Pumpback method was deemed to meet the four general criteria for corrective measures at all three of the corrective action areas, assuming that controls on the use of Facility ground and surface water could be established and enforced. Overall protection of human health and the environment would be attained by intercepting impacted groundwater prior to its reaching exposure points in natural drainages. This method, however, creates an environmental exposure pathway by discharging recovered groundwater to the surface after treatment. COC concentrations of the treated groundwater will be diluted by combining it with collected storm water, plus the discharge of the recovered water to surface will be over a larger portion of the Agland surface, spreading COC loading to the surface or a wide area, to the point that any long-term risk to the environment is negligible. Attainment of media cleanup standards will occur over time as contaminant plumes are intercepted and contaminated groundwater recovered. This alternative has a technical rating of 12.

The No Action alternative would not provide protection of human health or the environment. COC impacted groundwater already reaches exposure points in the 005 Drainage and near MW095A, and may reach exposure points in the upper 001 Drainage within 100 years. Since the No Action alternative does not provide protection of human health or the environment, it cannot be considered as a reasonable corrective action method.

The Groundwater Recovery using Vertical Wells method was deemed to meet the four general criteria for corrective measures at all three of the corrective action areas, assuming that controls on the use of Facility ground and surface water could be established and enforced. Overall protection of human health and the environment and attainment of media cleanup standards would be attained by actively recovering groundwater prior to reaching exposure points. However, due to the low hydraulic conductivity of the shale units, active pumping is not expected to reduce the time to complete the removal of impacted groundwater significantly compared to the time to intercept the groundwater using passive interception methods. This alternative has negative aspects of having a greater number of pumps requiring maintenance than the Hydraulic Containment and Pumpback method, increasing operation costs and increasing the opportunity for failure of the containment aspect of the system. The technical rating for this alternative was 10 versus 12 for the Hydraulic Containment and Pumpback method.

The Groundwater Recovery using Vertical Wells alternative is, however, preferable to the Hydraulic Containment and Pumpback method for remediation of the Utility Trench System. The hydraulic conductivity of the fill material within the Utility Trench System is significantly higher than the shale units, therefore the length of time required to dewater all of the trenches can be accomplished within several months, using primarily existing wells and with only a minimum number of new wells required. Therefore, Groundwater Recovery using Vertical Wells is a more feasible corrective action alternative for the Utility Trench System than the Hydraulic Containment and Pumpback method.

The Groundwater Recovery using Horizontal Wells may not meet all of the four general criteria for corrective measures at all three of the corrective action areas. The horizontal well would be constructed at the base of the shale unit for the respective area, and not necessarily within the higher conductivity alluvium that could transport impacted groundwater. Therefore, it could not be assured that pumping would capture all the impacted groundwater prior to reaching surface exposure points near MW095A, and overall protection of human health and the environment can not be assured. The technical rating for this alternative was 7 versus 12 for the Hydraulic Containment and Pumpback method.

The Passive Treatment Walls method was deemed to meet the four general criteria for corrective measures at all corrective action areas except the Utility Trench System, assuming that controls on the use of Facility ground and surface water could be established and enforced. Overall protection of human health and the environment would be attained by intercepting groundwater prior to its reaching exposure points. Media cleanup standards would be attained by the adsorption material. Passive treatment walls may lose their reactive capacity or experience a decrease in wall permeability, requiring replacement of the reactive medium and a significant amount of capital costs in the future. The technical rating for this alternative was 8 versus 12 for the Hydraulic Containment and Pumpback method.

Phytoremediation may not be able to provide overall protection to human health or the environment or provide attainment of media cleanup standards. Phytoremediation is expected to be effective in reducing COC concentrations in groundwater as it exits the bedrock or where root systems can penetrate, i.e. shallow soils. Phytoremediation will not be effective in reducing COC concentrations in the shale bedrock; therefore, phytoremediation may only be effective after groundwater exits the bedrock aquifer. The result would be a higher risk of contaminated water migrating past the corrective action area, and increased potential of human or environmental exposure. The technical rating for this alternative was 9 versus 12 for the Hydraulic Containment and Pumpback method.

Co-metabolic processes has the potential to reduce COC concentrations in groundwater faster than other CAA, however, there are significant uncertainties associated with the effectiveness of this technology for remediation of inorganics. The technical rating for this alternative was 10 versus 12 for the Hydraulic Containment and Pumpback method.

Based on the above evaluations, SFC has selected the Hydraulic Containment with Pumpback method as the preferred corrective action alternative for the 005 Drainage, MW095A, and MW010/Swale Corrective Action Areas, and the Groundwater Recovery using Vertical Wells method has been selected as the preferred corrective action alternative for the Utility Trench System.

The details of the Corrective Action Alternative for each corrective action area are provided in Section 6.

## 6.0 PROPOSED CORRECTIVE ACTION PLANS

Corrective action projects have been implemented using the Hydraulic Containment and Pumpback method in the 005 Drainage and the area southwest of Pond 2 near MW095A. The hydraulic containment and pumpback alternative has been selected as the corrective action method for the MW010/Swale area. Groundwater Recovery using Vertical Wells, along with removal and disposal of contaminated fill material and adjacent soils, has been selected as the corrective action method for the Utility Trench System.

Recovered groundwater will be pumped and stored in the Clarifier Basins. Treatment to reduce COC concentrations will occur in the water treatment plant. Treatment of recovered groundwater will reduce arsenic, nitrate and uranium concentrations to meet land application standards. After treatment, the treated water will be pumped to Pond 5 and stored for eventual use as fertilizer on company-owned property. The treated groundwater, stored and mixed with storm water in Pond 5, would be further diluted prior to application as fertilizer. The treatment to reduce COC concentrations and the dilution of the recovered groundwater will assure that COC loading to the surface will be negligible and that there should be no significant environmental impacts from the use of recovered impacted groundwater as fertilizer. Details of the water treatment plant design and operation, along with procedures for land application of treated water, are provided in Appendix A.

The benefits of the Hydraulic Containment and Pumpback corrective action approach include interception of COC impacted groundwater prior to exposure at the surface or loading to surface waters. With the removal of COC sources within the Process Area, along with natural attenuation of groundwater, long term risks of surface exposure to the COCs is eliminated.

Potential adverse effects of the Hydraulic Containment and Pumpback corrective action approach include exposure of contaminants during construction and installation of the system, exposure to contaminants during operation of the system, failure of the containment wall, and surface impacts. No undue exposure to hazardous or radioactive material has been, or is expected to be, experienced by workers or the public during installation of the trench system. Excavated material has been and will be properly disposed of to prevent the spread of any hazardous material from the job site. Accepted engineering controls should prevent failure of containment trench. Accepted engineering controls and proper maintenance should prevent the failure of piping and treatment systems, preventing the release of recovered groundwater during transport to the storage basins and water treatment plant.

Benefits of using the Groundwater Recovery using Vertical Wells as the corrective action method for the Utility Trench System is the removal of both contaminated groundwater and fill material, eliminating any potential future source of uranium to the groundwater.

Potential adverse effects of the Groundwater Recovery using Vertical Wells corrective action approach include exposure of contaminants during operation of the system, and surface impacts. No undue exposure to hazardous or radioactive material has been or is expected to be experienced by workers or the public during well installation. Excavated material will be properly disposed of to prevent the spread of any hazardous material from the job site. Accepted engineering controls and proper maintenance should prevent the failure of piping and treatment systems, preventing the release of recovered groundwater during transport to the storage basins and water treatment plant.

This section will describe the conceptual design, feasibility, short and long-term effectiveness in protecting human health and environment, and effectiveness in reducing COC concentrations to levels that are ALARA of the Hydraulic Containment and Pumpback System at the 005 Drainage, MW095A, and MW010/Swale corrective action areas and the Groundwater Recovery using Vertical Wells at the Utility Trench System corrective action area.

## 6.1 Corrective Action Plan for the 005 Drainage

### 6.1.1 Conceptual Design Description

The 005 Collection Trench was installed near the head of the 005 Drainage during July 2002. Figure 6-1 shows the location of the 005 Collection trench and the adjacent 005 Monitor Trench. The trench was excavated in the same location as the investigation trench completed during the Supplemental Data Collection Trip activities of April 2002 (SMI, 2002). The 005 Collection Trench is deeper than the investigation trench, extended further to the south and excavated in a straight line to facilitate installation of pond liner material. The 005 Collection Trench was excavated to the top of the Unit 3 Sandstone, 8 to 10 feet below the surface. Figure 6-2 shows a profile of the 005 Collection Trench. The trench bottom, exposed sandstone surface, is 104 feet long. Details of the installation and design of the 005 Drainage Collection Trench is provided in Appendix B.

Preexisting French drain pipes that daylight into the trench remained in place. The upgradient pipe ends were trimmed and are open to transmit flow. The gravel backfill was placed to a level about one foot above the invert of the French drain pipes. Pipe ends on the downgradient side were trimmed, capped, and covered by the plastic membrane liner installed on the downgradient side of the trench.

A leak detection monitor trench (005 Monitor Trench) was installed approximately 50 west of the 005 Collection Trench to provide performance monitoring of the trench collection system. The 005 Monitor Trench was excavated down to bedrock in a location that is believed to be the bottom of the 005 Drainage. The trench is approximately 25 feet long and contains, from bottom to top, pond liner, gravel, pond liner, and back fill soil. Two 10-foot sections of perforated pipe lie on the trench bottom above the pond liner material; these pipes are connected with a "T" to a 4-inch riser pipe in the center of the trench.

### 6.1.2 Feasibility of Hydraulic Containment and Pumpback Method at the 005 Drainage Area

The installed trench should be highly effective in intercepting groundwater prior to reaching exposure points in the 005 Drainage. Ex-situ treatment of groundwater collected in the 005 Drainage Collection Trench should reduce COC concentrations to meet appropriate land application standards.

The hydraulic containment trench should effectively intercept all impacted groundwater prior to reaching exposure points in the 005 Drainage. With no loading of contaminants to surface water in the 005 Drainage, concentrations of both nitrate and uranium should be reduced to levels that are ALARA, both in surface waters of the 005 Drainage and in the headwaters of the Robert S. Kerr Reservoir.

### 6.1.3 Performance Assessment for the 005 Intercept Trench

For the years 2005 through 2009, a total of 1,774,000 gallons of groundwater containing 0.14 kg of arsenic, 1613 kg of nitrate (N), 1.1 kg of uranium and 4.9 kg of fluoride was recovered and transferred to the clarifier basins for treatment. Uranium concentrations in the surface water monitoring locations in the 005 drainage have shown some improvement, but not to the extent expected at this point.

## 6.2 Corrective Action Plan for the MW095A Area

### 6.2.1 Conceptual Design Description

The MW095A Collection Trench was installed southwest of Pond 2 approximately 200 feet east of monitoring well MW095A in April 2003. Figure 6-3 shows the location of the MW095A Collection Trench, along with the MW095A Investigation Trenches. The trench was excavated along part of the investigation trench completed during the Monitoring Well MW095A Trench Investigation of November 2002. The MW095A Collection Trench trends approximately north-south perpendicular to Port Road and extends approximately 65 feet north of the Port Road and approximately 240 feet south of Port Road. The MW095A Collection Trench was excavated into the top of the Unit 4 Shale, a depth of approximately twenty-five feet below the surface. Figure 6-4 shows a profile of the MW095A Collection Trench. Details of the installation and design of the MW095A Collection Trench are provided in Appendix B.

An additional pumpback system was installed at the far west end of the east-west exploratory trench that was excavated in 2002. This system, called the MW095A Collection Pit, is removing perched groundwater from the top of Unit 4 Shale downgradient from the MW095A Trench.

### 6.2.2 Feasibility of Hydraulic Containment and Pumpback Method at the MW095A Area

The installed trench should be highly effective in intercepting groundwater prior to reaching exposure points in the 001 Drainage. Ex-situ treatment of groundwater collected in the MW095A Collection Trench should reduce COC concentrations to meet appropriate land application standards.

The hydraulic containment trench should effectively intercept all impacted groundwater prior to reaching exposure points in the 001 Drainage. With no loading of contaminants to surface water in the 001 Drainage, concentrations of both nitrate and arsenic should be reduced to levels that are ALARA, both in surface waters of the in the MW095A area and in the headwaters of the Robert S. Kerr Reservoir.

### 6.2.3 Performance Assessment for the MW095A Intercept Trench

For the years 2005 through 2009, a total of 875,000 gallons of groundwater containing 0.14 kg of arsenic, 3599 kg of nitrate (N), 0.0 kg of uranium and 1.1 kg of fluoride was recovered and transferred to the Pond 5 for land application as fertilizer. Nitrate and arsenic concentrations in the water recovered from the MW095 Collection Pit and in the monitoring samples from MW095 have significantly dropped, indicating that the intercept trench is working as expected.

### 6.2.4 Performance Assessment for the MW095A Collection Pit

For the years 2005 through 2009, a total of 556,200 gallons of groundwater containing 0.04 kg of arsenic, 600 kg of nitrate (N), 0.0 kg of uranium and 0.6 kg of fluoride was recovered and transferred to the Pond 5 for land application as fertilizer. The Port Road Seep is now dry except following periods of heavy rain. Nitrate and arsenic concentrations in samples from the Seep when it is flowing have dropped significantly as well. This indicates that the MW095A Collection Pit is providing beneficial improvement to the water quality in the area.

## 6.3 Corrective Action Plan for the MW010/Swale Area

### 6.3.1 Conceptual Design Description

Figure 6-5 shows the proposed location of the MW010 Collection Trench. To effectively control the southward migration of uranium impacted groundwater, the MW010 Collection Trench will be located just to the north of the Decorative Pond. The trench will extend approximately 300 feet westward from southwest of monitor well MW009A. The MW010 Collection Trench will be excavated to the top of the Unit 1 Sandstone, approximately eight feet below the surface. The collection trench will have a design similar to that of the MW005 Collection Trench (Figure 6-2).

Groundwater from the Decorative Pond will impact the trench construction. A barrier trench was completed prior to the construction of the collection trench and concrete was placed into the trench down to the bedrock surface as the excavation advanced. The collection trench will subsequently be constructed adjacent to and north of the barrier trench

The hydraulic conductivity of the gravel fill material overlying the Unit 1 Sandstone near MW010 was calculated at 72.6 feet/day during the Supplemental Data Collection Trip activities (SMI, 2002). Given the thickness of the gravel layer, the average daily volume of groundwater collected in the MW010 Collection Trench should be approximately 100 gallons per day (gpd). Groundwater collected in the MW010 Collection Trench will be pumped to the water treatment plant for treatment.

### 6.3.2 Feasibility of Hydraulic Containment and Pumpback Method at the MW010/Swale Area

The installed trench should be highly effective in intercepting groundwater prior to reaching exposure points in the 009 and 001 Drainages. Ex-situ treatment of groundwater collected in the MW010/Swale Collection Trench should reduce COC concentrations to meet appropriate land application standards.

The hydraulic containment trench should effectively intercept all impacted groundwater prior to reaching exposure points in the 009 and 001 Drainages.

### 6.3.3 Performance Assessment for the MW010/Swale Area Intercept Trench

For the years 2005 through 2009, a total of 2,667,000 gallons of groundwater containing 0.10 kg of arsenic, 34 kg of nitrate (N), 0.6 kg of uranium and 4.9 kg of fluoride was recovered and transferred to the Clarifier Basins for treatment and disposal. The small amount of uranium recovered by this system indicates that very little of the highly uranium impacted water from the area between the Main Plant Building and the Solvent Extraction Building is reaching the trench. As a result, additional vertical recovery wells, as described below, were installed in the vicinity of MW010 in early 2006.

### 6.3.4 Description of additional MW010/Swale Area Vertical Recovery Wells

Vertical Recovery Well MWRW2 was installed in the MW010 area in the early 90's and was used to recover perched groundwater that had elevated uranium concentrations. Recovered groundwater was transferred to the Clarifier Basins for treatment and disposal. It was determined that this well was screened above the top of bedrock and probably not located in the lowpoint of the bedrock swale that is known to exist in this area. As a result, there was concern that MWRW2 would not be able to remove all of the affected water. It was decided in early 2006 to install three new wells, MWRW6, 7 and 8, along an east-west line near MW010 and to install sumps into the bedrock surface for each well to intercept water flowing on top of the bedrock. After installation and development, the three new wells were sampled and the water analyzed for U, As, nitrate and fluoride. MWRW7 had much higher levels of these constituents and produced a large volume of water compared to MWRW 6 or 8. As a result, groundwater recovery capability was only installed on MWRW7 and the system in MWRW2 was shutdown.

### 6.3.5 Performance assessment for additional MW010/Swale Area Vertical Recovery Wells

During the 15.5year period that MWRW2 was operated, more than 5.6 million gallons of water containing about 42 kg of uranium was recovered. Uranium concentrations in MW010 dropped from over 20,000ug/l uranium to its current level of 1,800 ug/l, indicated that the vertical well recovery effort in this area has been very effective. Since switching from MWRW2 to MWRW7 in 2006, 631,900 gallons of groundwater containing 0.04 kg of arsenic, 8.1 kg of nitrate (N), 16.3 kg of uranium and 2.4 kg of fluoride have been recovered from this area.

## 6.4 Corrective Action Plan for Utility Trench System and Granular Fill Areas

### 6.4.1 Conceptual Design Description

The objectives of the Utility Trench System corrective action plan is to remove groundwater from utility trench fill and granular backfill material in the Main Process Building Area by pumping, then excavate fill material and impacted soils adjacent to the trenches. Excavated material will be placed within the proposed disposal cell. To effectively remove groundwater from the trenches, pumping will occur in several stages. Initial pumping will occur in the French Drain northwest of the SX Building Vault, followed by pumping of TM wells adjacent to the SX Building. An assessment of the effectiveness of the initial pumping will provide the basis for additional pumping.

After dewatering of the utility trenches and granular fill areas, fill material and soils adjacent to the trenches with natural uranium concentrations greater than 100 pCi/g will be excavated and placed within the disposal cell. Trench and granular fill material will be excavated and disposed of during the excavation of Layer D materials as described in the Preliminary Design Report for the Disposal Cell at the Sequoyah Fuels Corporation Facility (MFG, 2002b).

### 6.4.2 Feasibility of the Groundwater Recovery using Vertical Wells Method in the Utility Trench System

Pumping should be highly effective in dewatering the Utility trenches and granular fill and should occur within several months of initiation of the corrective action program. Dewatering can be accomplished using existing wells and installation of only a small number of shallow wells. Recovered groundwater will be treated to meet land application standards and will be subsequently used as part of the Facility fertilizer program. Details of the water treatment program are provided in Appendix A. Excavation of fill material and contaminated soils will occur in conjunction with Disposal Cell construction. Removal of contaminated groundwater and contaminated fill material and soils will effectively remove a potential future source of groundwater contamination.

### 6.4.3 Performance Assessment

For the years 2005 through 2009, a total of 619,000 gallons of groundwater containing 0.27 kg of arsenic, 3.0 kg of nitrate (N), 5.2 kg of uranium and 13.3 kg of fluoride was recovered using French Drain-B and transferred to the Clarifier Basins for treatment and disposal. There is little noticeable change in the water levels and concentrations in the surrounding monitoring wells in this area, suggesting that French Drain-B is only marginally effective. Additional pumping from the Utility Trench Monitors and from excavation pits will be done as site remediation progresses.

## 6.5 Corrective Action Plan for Northwest Area

The groundwater modeling consultants recommended that two vertical recovery wells be installed in this area, one just north of the No. 2 fluoride Holding Basin and one just to the east of the basin, both to be screened in the Shale 4 interval. The locations of these wells, designated as MWRW-4 and MWRW-5, are shown in Figure 6.5.

### 6.5.1 Design Description of the Vertical Recovery Wells in the Northwest Area

MWRW-4 and-5 are constructed of 8-inch I.D. threaded PVC pipe with a 15 foot slotted interval at the bottom. Well completion drawings can be found in Appendix C of this report. Each well is equipped with a submersible pump, which is operated manually on a periodic basis. Recovered water is transferred to the Clarifier Basins for treatment and disposal.

### 6.5.2 Performance Assessment for the Vertical Recovery Wells in the Northwest area

For the years 2006 through 2009, a total of 6,360 gallons and 15,200 gallons of groundwater containing minute quantities of arsenic, nitrate (N), uranium and fluoride was recovered using MWRW-4 and MWRW-5, respectively. These wells are not effective and will be replaced with groundwater recovery systems in one or more of the higher shale units. Also, during soil remediation in this area, any perched water that is encountered will be recovered and treated if elevated uranium concentrations are measured.

## 6.6 Water Treatment

All water recovered for the corrective action areas will be treated to meet land application standards included in the existing radioactive materials license. Water will first be pumped from the various corrective action areas to storage for eventual treatment. Water treatment will consist of chemical addition to facilitate precipitation of metals followed by filtration and ion exchange. Details of the water treatment plant and water treatment method are provided in Appendix A.

Subsequent to treatment of the recovered groundwater, the treated water will be pumped to Pond 5, which already impounds storm water that contains elevated concentrations of nitrate. Water collected at Pond 5 is applied to the land surface as part of the SFC fertilizer program after sampling and analysis indicate the water meets the license condition requirements for land application.

## 6.7 Corrective Action Monitoring

SFC has proposed a Groundwater Monitoring Plan that satisfies and supersedes the groundwater monitoring requirements contained in Chapter 5 of the NRC license and the Groundwater Monitoring Interim Measures Work plan approved by the EPA. The proposed monitoring plan includes an extensive program to monitor the extent of COC impacted groundwater, to provide for compliance monitoring, and to establish monitoring well construction, sampling, and quality assurance and control criteria, along with a monitoring schedule. Corrective action monitoring will employ the practices and standards described in the Groundwater Monitoring Plan. Groundwater monitoring will continue for the duration of the Corrective Action Program. The Groundwater Monitoring Plan report will be submitted under a separate cover in June of 2003.

## 7.0 REFERENCES

Earth Science Consultants, Inc. (ESC), 1996. "Conceptual Design Report, Decommissioning, Excavation, and Stabilization/Solidification Program." Consultant's Report. December.

MFG, Inc. (MFG), 2002a. "Hydrogeological and Geochemical Site Characterization Report." Consultant's Report. October.

MFG, Inc. (MFG), 2002b. "Preliminary Design Report for the Disposal Cell at the Sequoyah Fuels Corporation Facility." Consultant's Report. December.

Roberts/Schornick & Associates, Inc. (RSA), 1991. "Sequoyah Fuels Corporation Facility Environmental Investigation Findings Report." Consultant Report. Volumes I – V. July 31.

Sequoyah Fuels Corporation (SFC), 1997a. "Final RCRA Facility Investigation of the Sequoyah Fuels Uranium Conversion Industrial Facility."

Sequoyah Fuels Corporation (SFC), 1997b. "Draft Corrective Measures Study Report." October 27.

Sequoyah Fuels Corporation (SFC), 1998a. "Site Characterization Report." December 15.

Sequoyah Fuels Corporation (SFC), 1998b. "Final Decommissioning Alternatives Study Report [FDASR]." June 8.

Shepherd Miller, Inc. (SMI), 2001. "Hydrogeological and Geochemical Site Characterization Report." Consultant's Report. October.

Shepherd Miller, Inc. (SMI) 2002. "Supplemental Data Collection Trip Report." Consultant's Report. April.

# TABLES

**Table 2.1 Site Characterization Units**

| SCU Number | Location Description |
|---|---|
| 1 | Main Process Building Area (MPB) |
| 2 | Solvent Extraction (SX) Building |
| 3 | Initial Lime Neutralization Area |
| 4 | Solid Waste Burial Area No.1 (South) |
| 5 | Emergency Basin |
| 6 | Sanitary Lagoon |
| 7 | Pond 1 Spoils Pile |
| 8 | North Ditch |
| 9 | Contaminated Equipment Area |
| 10 | Fluoride Holding Basin No. 1 (South) |
| 11 | Fluoride Holding Basin No. 2 (North) |
| 12 | Fluoride Clarifier and Setting Basins (South) |
| 13 | Fluoride Sludge Burial Area |
| 14 | South Yellowcake Sump |
| 15 | Clarifier A Basin area |
| 16 | Pond 2 |
| 17 | Area West of Pond 2 |
| 18 | Solid Waste Burial Area No. 2 (North) |
| 19 | Yellowcake Storage Pad |
| 20 | Fertilizer Pond Area |
| 21 | Former Raffinate Treatment Area |
| 22 | Combination Stream |
| 23 | Present Lime Neutralization Area |
| 24 | $DUF_4$ Building Area |
| 25 | Tank Farm and Cylinder Storage Area |
| 26 | South Perimeter Area |
| 27 | Scrap Metal Storage Area |
| 28 | Drainage/Runoff Area |

**Table 2.2 Constituent Concentration of Raffinate Liquor Sample of January 2003 and Comparison to MCLs**

| Contaminant | MCL (mg/L) | Raffinate Pore Water (mg/L) | Exceeds MCL |
|---|---|---|---|
| Antimony | 0.006 | <0.008 | Y |
| Ammonia (N) | N/A | 1850 | |
| Arsenic | 0.01 | 0.464 | Y |
| | as of 01/23/06 | | |
| Barium | 2 | <0.147 | N |
| Beryllium | 0.004 | <0.002 | N |
| Cadmium | 0.005 | 0.16 | Y |
| Chromium (total) | 0.1 | 0.126 | Y |
| Fluoride | 4 | | |
| Lead | TT Action Level=0.015 | <0.168 | Y |
| Mercury (inorganic) | 0.002 | <0.0002 | N |
| Nitrate (N) | 10 | 3360 | Y |
| Nickel | N/A | 1.11 | |
| Radium 226 and Radium 228 (combined) | 5 pCi/L | 3.32 | N |
| Selenium | 0.05 | 0.118 | Y |
| Silver | N/A | <0.007 | |
| Thallium | 0.002 | <.003 | Y |
| Th-230 | N/A | 3.18 | |
| Uranium | 0.03 | 22300 | Y |
| | as of 12/08/03 | | |

**Table 5.1 Human Health and Environmental Assessment of CAAs**

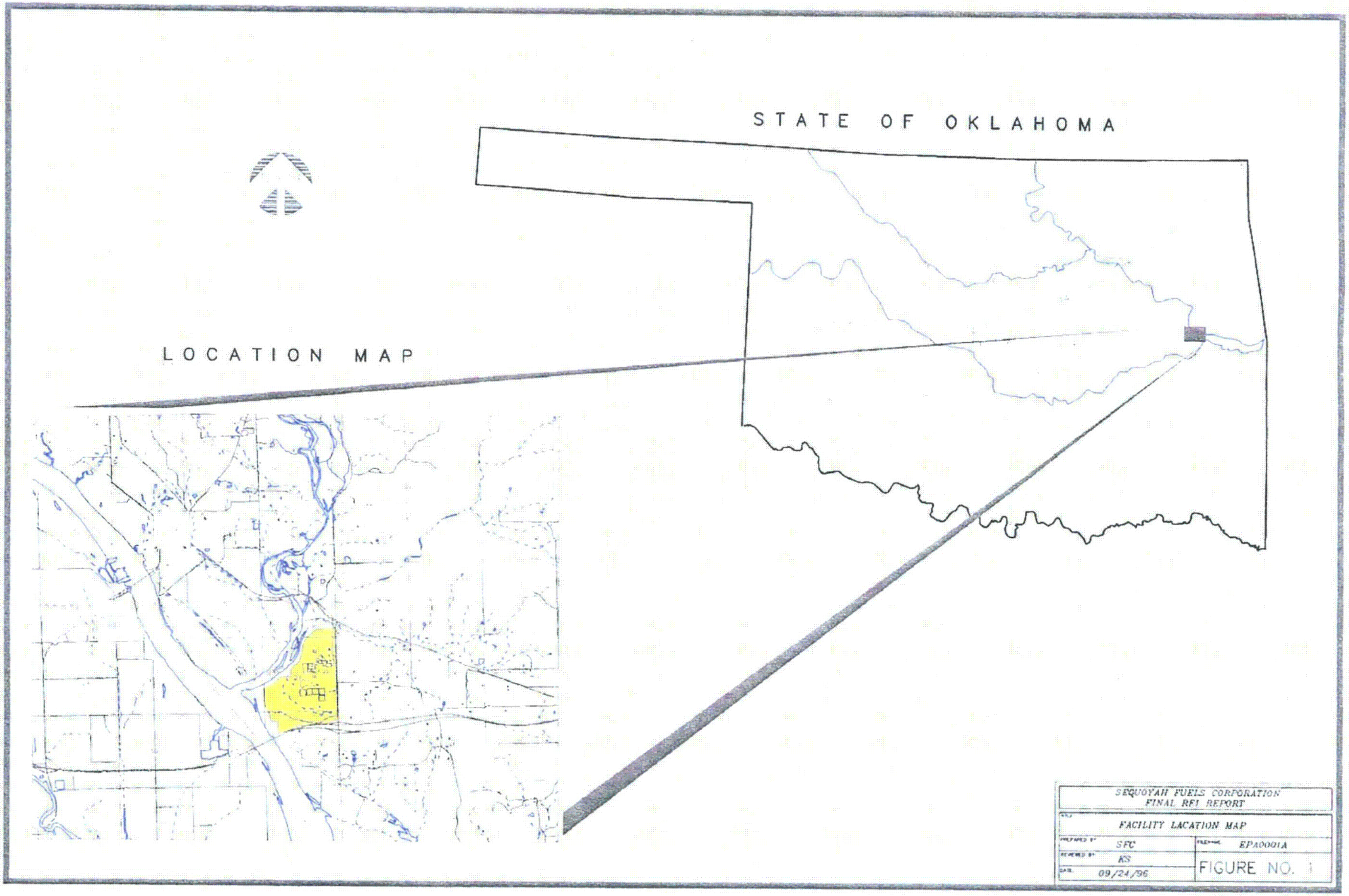
| | | | | |
|---|---|---|---|---|
| **Groundwater recovery using vertical well or horizontal well and Recovered groundwater treatment** | | | | |
| | | **Short Term** | | **Long Term** |
| Beneficial Effects | 1) | Plume movement controlled | 1) | Long term risks eliminated |
| | 2) | Reduction of contaminant concentration | | |
| Adverse Effects | 1) | Exposure to contaminants during extraction and treatment | | |
| Mitigative Measures | 1) | Engineered controls to limit/prevent exposure | | |
| | | | | |
| Hydraulic Containment and Pumpback | | | | |
| | | Short Term | | Long Term |
| Beneficial Effects | 1) | Plume movement controlled | 1) | Long term risks eliminated |
| | 2) | Reduction of contaminant loading to surface waters | | |
| Adverse Effects | 1) | Exposure to contaminants during construction and installation of system | 1) | Failure of containment wall |
| | | | 2) | Exposure to contaminants during operation of system |
| Mitigative Measures | 1) | Engineered controls during construction and operation | 1) | Long term monitoring and repair |
| | | | 2) | Restricted access/institutional controls |
| | | | | |
| Passive Treatment Wall | | | | |
| | | Short Term | | Long Term |
| Beneficial Effects | 1) | Plume movement controlled | 1) | NA |
| | 2) | Reduction of contaminant concentration | | |
| Adverse Effects | 1) | Exposure to contaminants during construction and installation of system | 1) | Failure of treatment wall |
| | | | 2) | Adsorbent media is depleted prior to end of corrective action |
| Mitigative Measures | 1) | Engineered controls during construction and operation | 1) | Long term monitoring and repair |
| | | | 2) | Long term monitoring and replacement of adsorbent media |

**Table 5.1 Human Health and Environmental Assessment of CAAs (continued)**

| **Phyto Remediation** | | | | |
|---|---|---|---|---|
| | | **Short Term** | | **Long Term** |
| Beneficial Effects | 1) | Mobility of contaminants is reduced | 1) | Same as short term |
| Adverse Effects | 1) | Toxicity of contaminants is not changed | 1) | Same as short term |
| | 2) | Contaminant bypass of root system | 2) | Same as short term |
| | | | 3) | Bioaccumulation of contaminants |
| Mitigative Measures | 1) | Institutional controls | | |
| | 2) | Deed restrictions | | |
| | 3) | long term monitoring | | |
| | 4) | Plant configuration may need to be adjusted | | |
| | 5) | Periodic harvesting of contaminant accumulating plants | | |
| | | | | |
| **Co-Metabolic Processes** | | | | |
| | | **Short Term** | | **Long Term** |
| Beneficial Effects | 1) | Toxicity and mobility of contaminants is reduced | 1) | NA |
| | 2) | Plume movement is inhibited | | |
| Adverse Effects | 1) | Short term risk of exposure to community | 1) | Resolubilized contaminants would pose long term risk of exposure |
| Mitigative Measures | 1) | Restricted access | | |
| | 2) | Long term monitoring | | |

# FIGURES

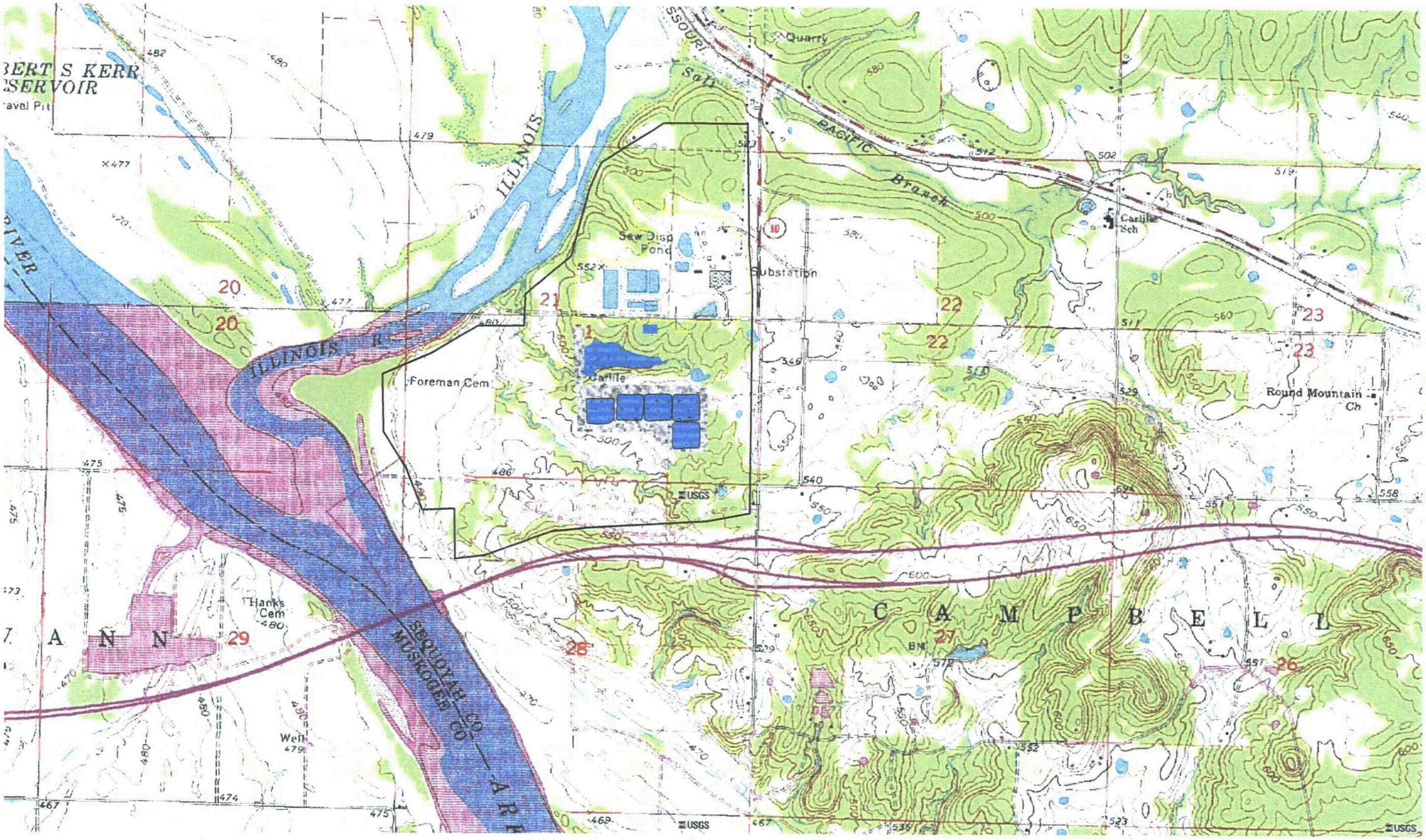
# FIGURES




consulting scientists and engineers

FIGURE 2-1
LOCATION MAP

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2 1, 2 |

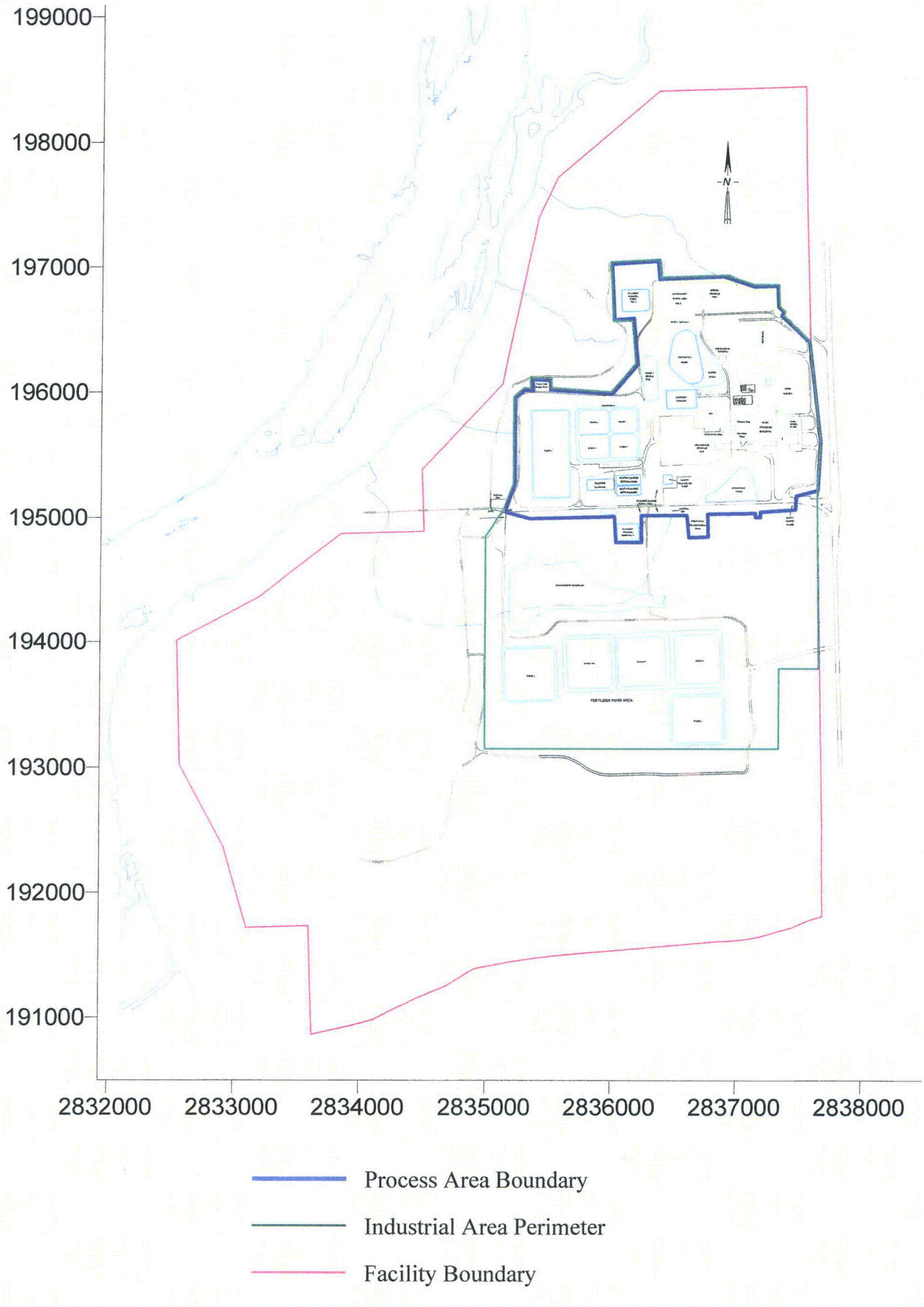



After U.S.G.S. 7.5 Min. Topographic quadrangles, Gore, OK (1974) and Stigler NE, OK (1963).

consulting scientists and engineers

FIGURE 2-2
TOPOGRAPHIC MAP

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2 1, 2 |




MFG consulting scientists and engineers

FIGURE 2-3
FACILITY AREA DESIGNATIONS

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2: 3, 4, 5 |


M F G consulting scientists and engineers

FIGURE 2-4
GENERAL FACILITY LAYOUT

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2: 3, 4, 5 |

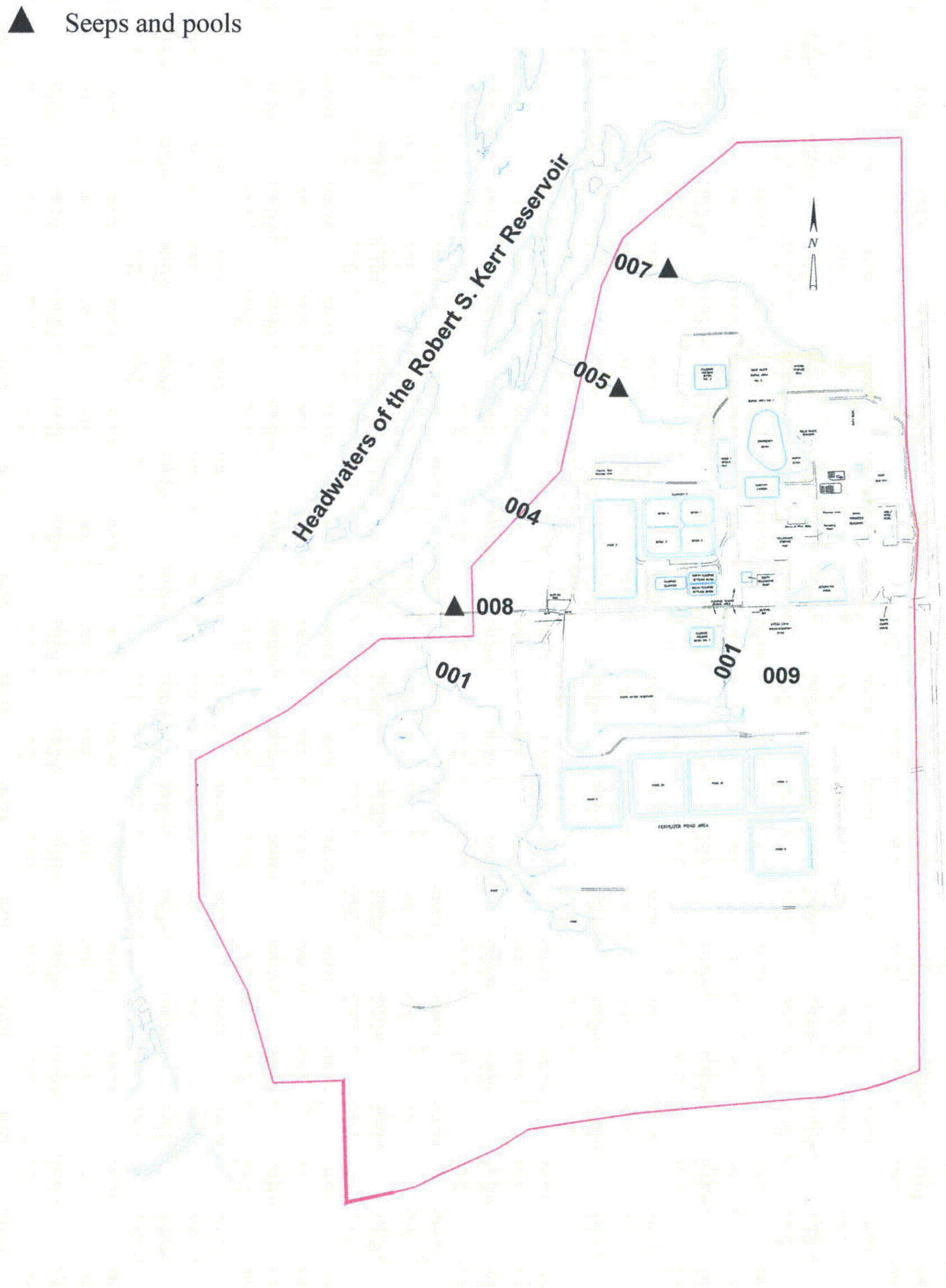
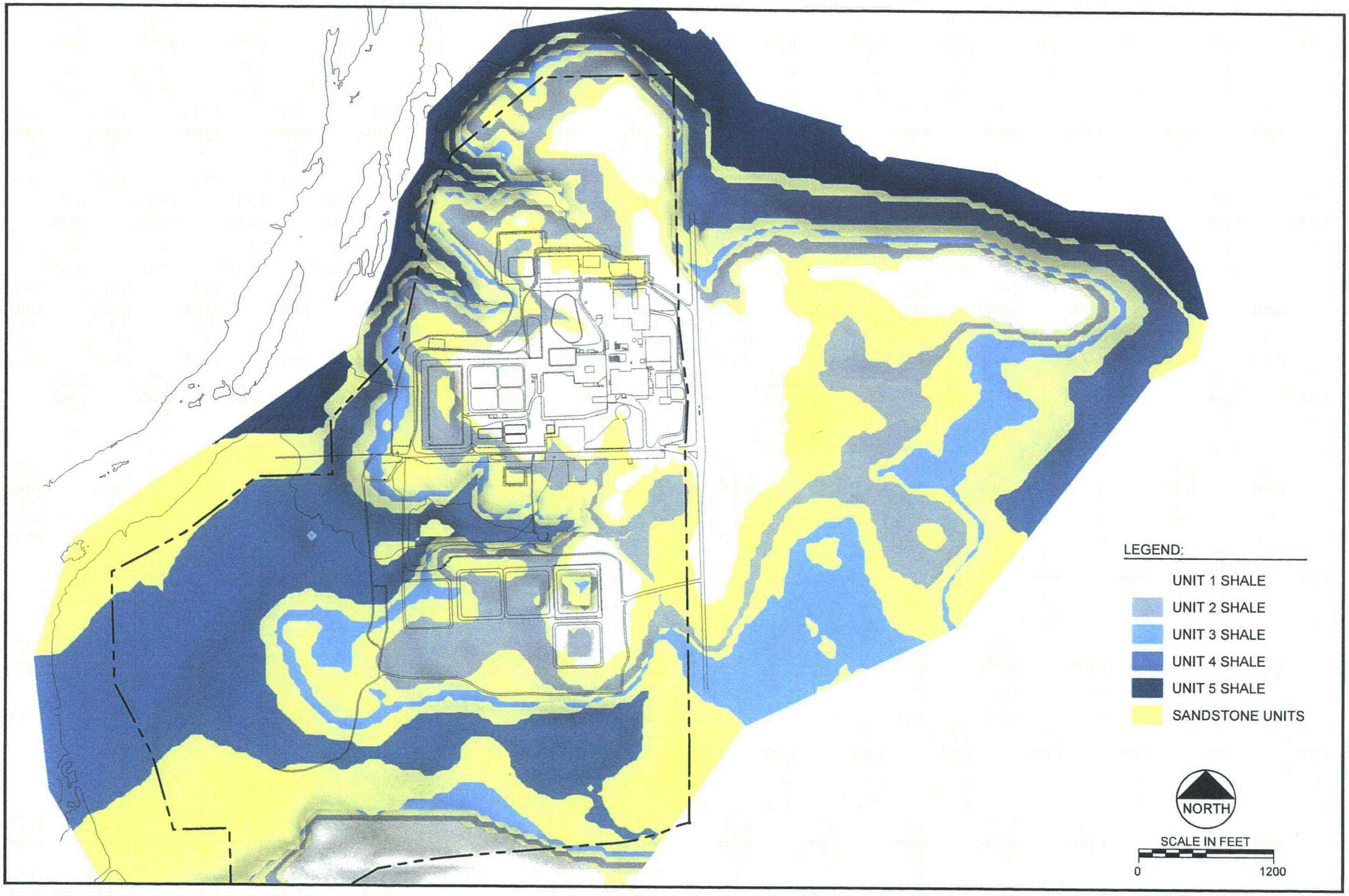



FIGURE 2-5
LOCATIONS OF FACILITY
DRAINAGES AND SPRINGS

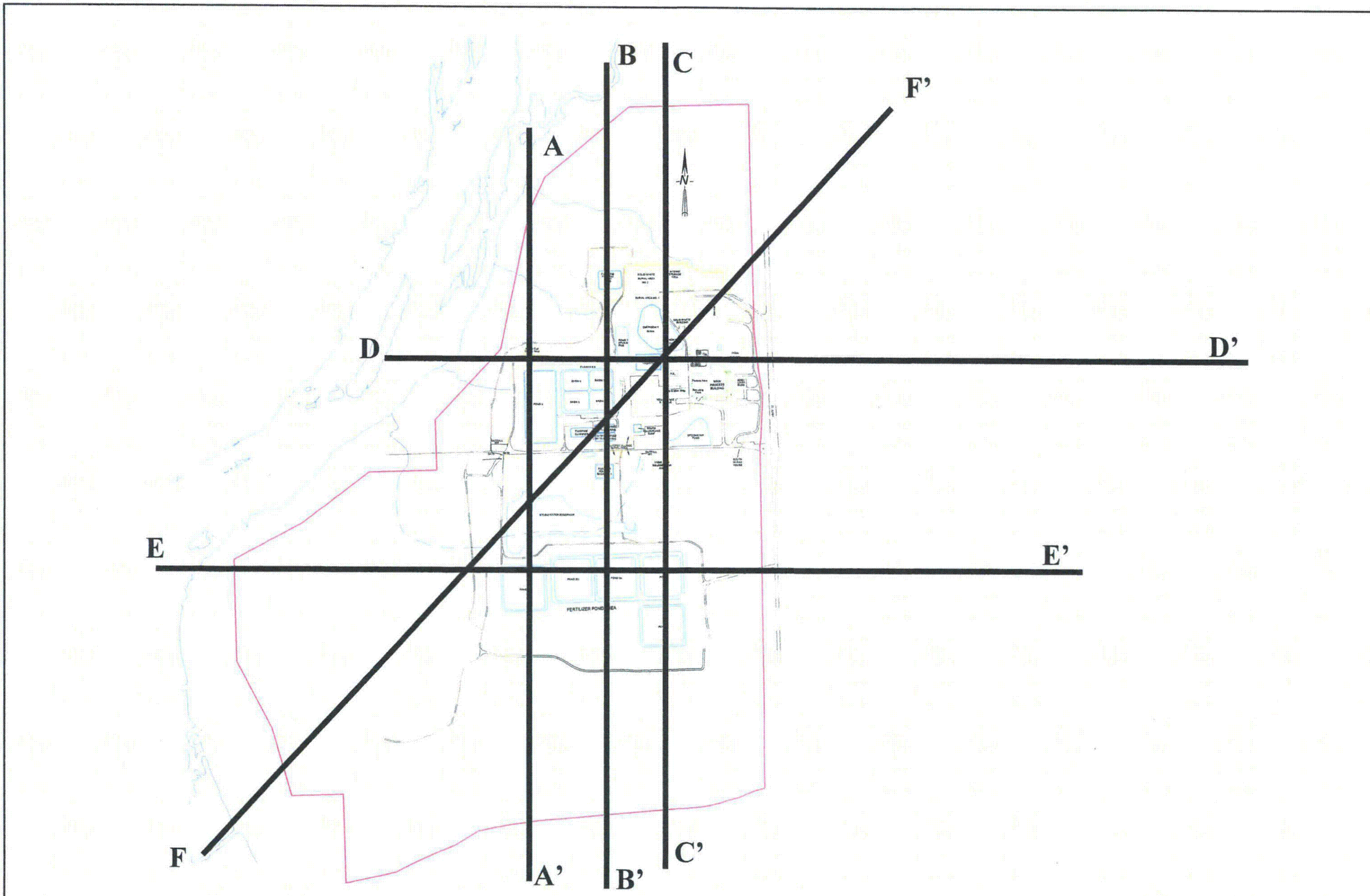
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2: 3, 4, 5 |




consulting scientists and engineers

FIGURE 2-6
HYDROSTRATIGRAPHIC MODEL
BEDROCK GEOLOGY MAP

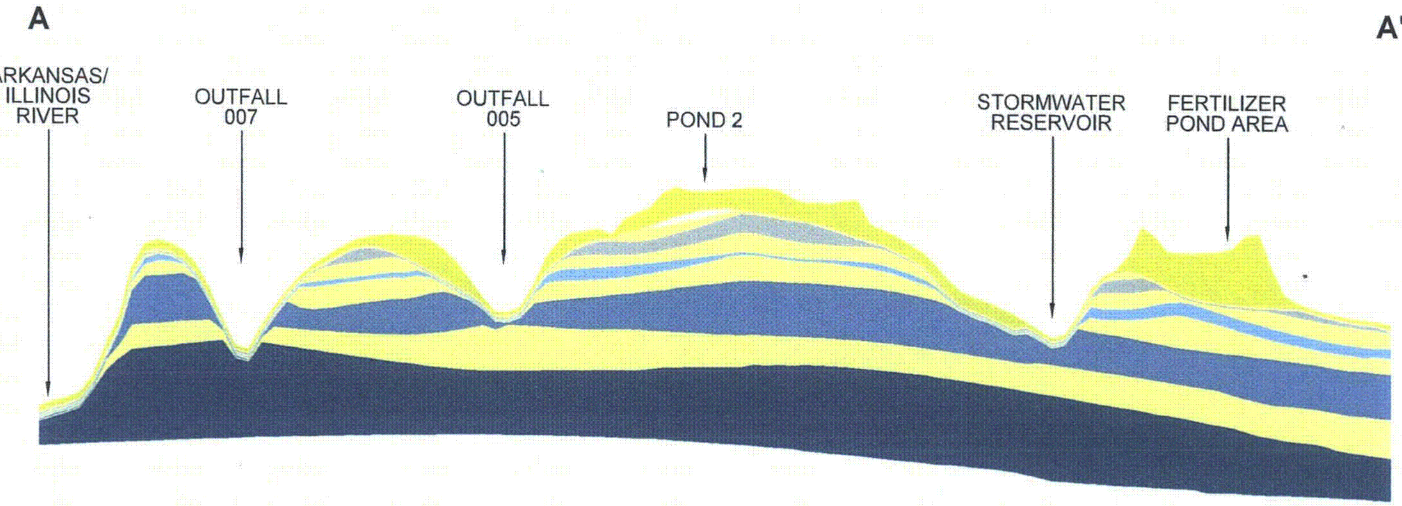
| | |
|---|---|
| Date: | May 2003 |
| Project: | 100734\CAP Figures\ |
| File: | GEO-MAP.dwg |




consulting scientists and engineers

FIGURE 2-7
GEOLOGIC CROSS-SECTION LOCATIONS

| | |
|---|---|
| Date: | JUNE 2002 |
| Project: | P:\100734\CAP |
| File: | SECT7.ppt |




LEGEND:

- ALLUVIUM AND COLLUVIUM TERRACE DEPOSIT
- UNIT 1 SHALE
- UNIT 2 SHALE
- UNIT 3 SHALE
- UNIT 4 SHALE
- UNIT 5 SHALE
- SANDSTONE UNITS

VERTICAL EXAGERATION = 10x

NORTH

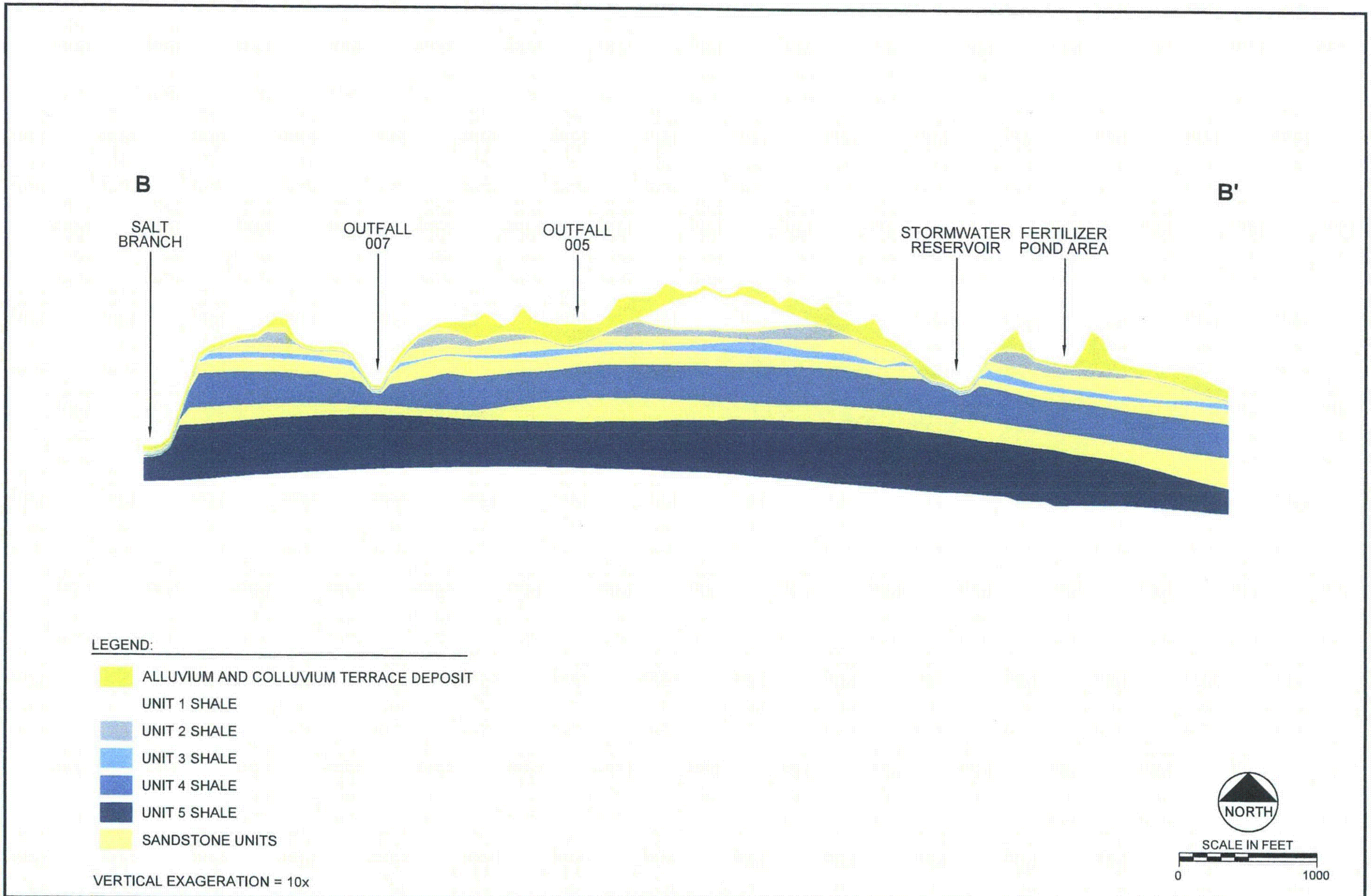
SCALE IN FEET

0 1000

consulting scientists and engineers

FIGURE 2-8
LAYER 1
HYDROSTRATIGRAPHIC MODEL CROSS SECTION A-A'

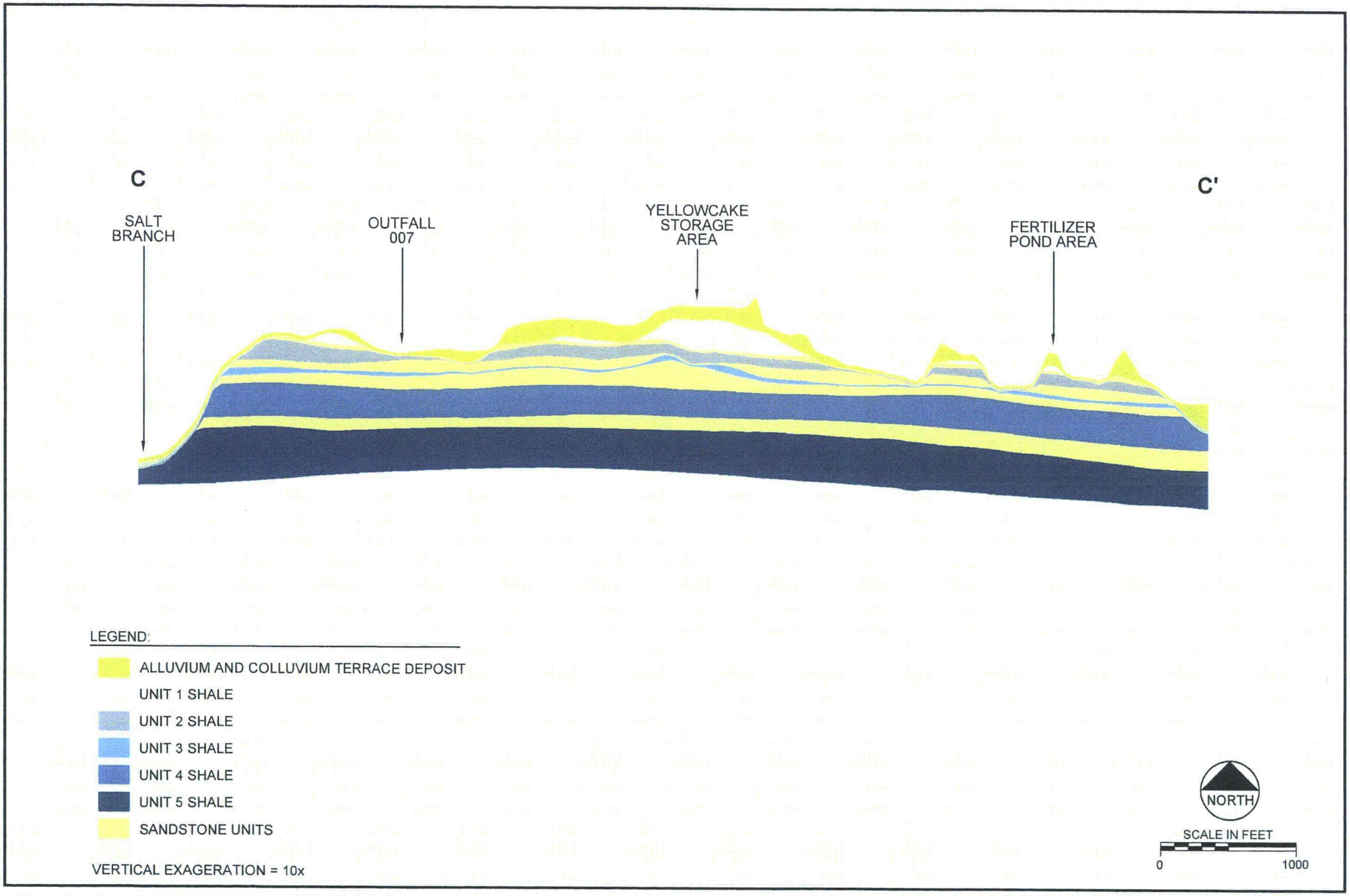
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP Figures\ |
| File: | SECTIONS.dwg |




consulting scientists and engineers

FIGURE 2-9
LAYER 2
HYDROSTRATIGRAPHIC MODEL CROSS SECTION B-B'

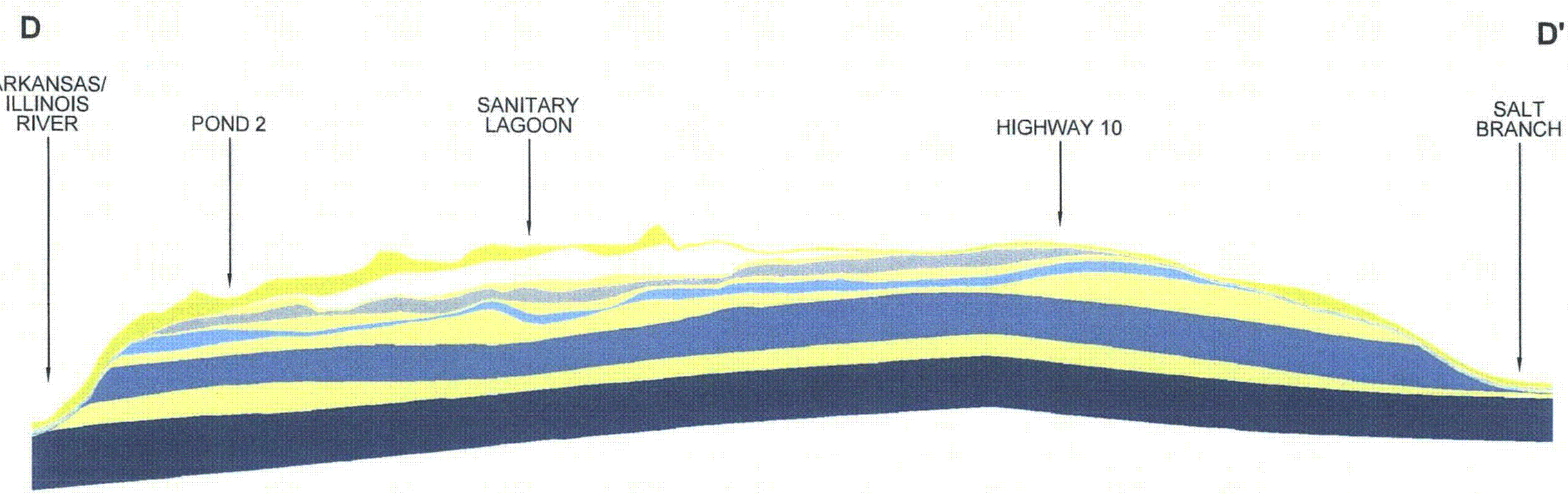
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP Figures\ |
| File: | SECTIONS.dwg |




consulting scientists and engineers

FIGURE 2-10
LAYER 3
HYDROSTRATIGRAPHIC MODEL CROSS SECTION C-C'

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP Figures\ |
| File: | SECTIONS.dwg |




LEGEND:

- ALLUVIUM AND COLLUVIUM TERRACE DEPOSIT
- UNIT 1 SHALE
- UNIT 2 SHALE
- UNIT 3 SHALE
- UNIT 4 SHALE
- UNIT 5 SHALE
- SANDSTONE UNITS

VERTICAL EXAGERATION = 10x

NORTH

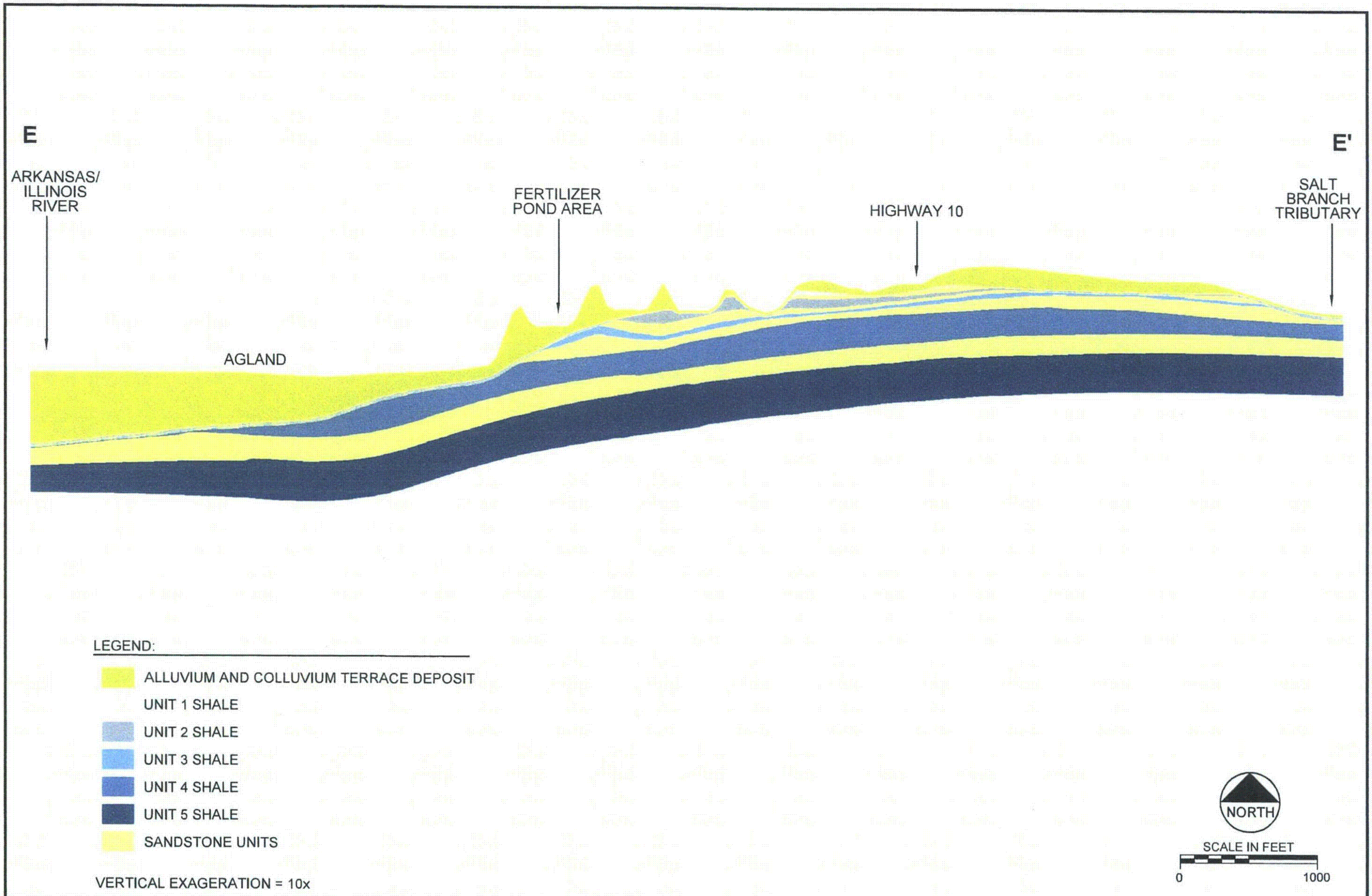
SCALE IN FEET

0 1000

consulting scientists and engineers

FIGURE 2-11
LAYER 4
HYDROSTRATIGRAPHIC MODEL CROSS SECTION D-D'

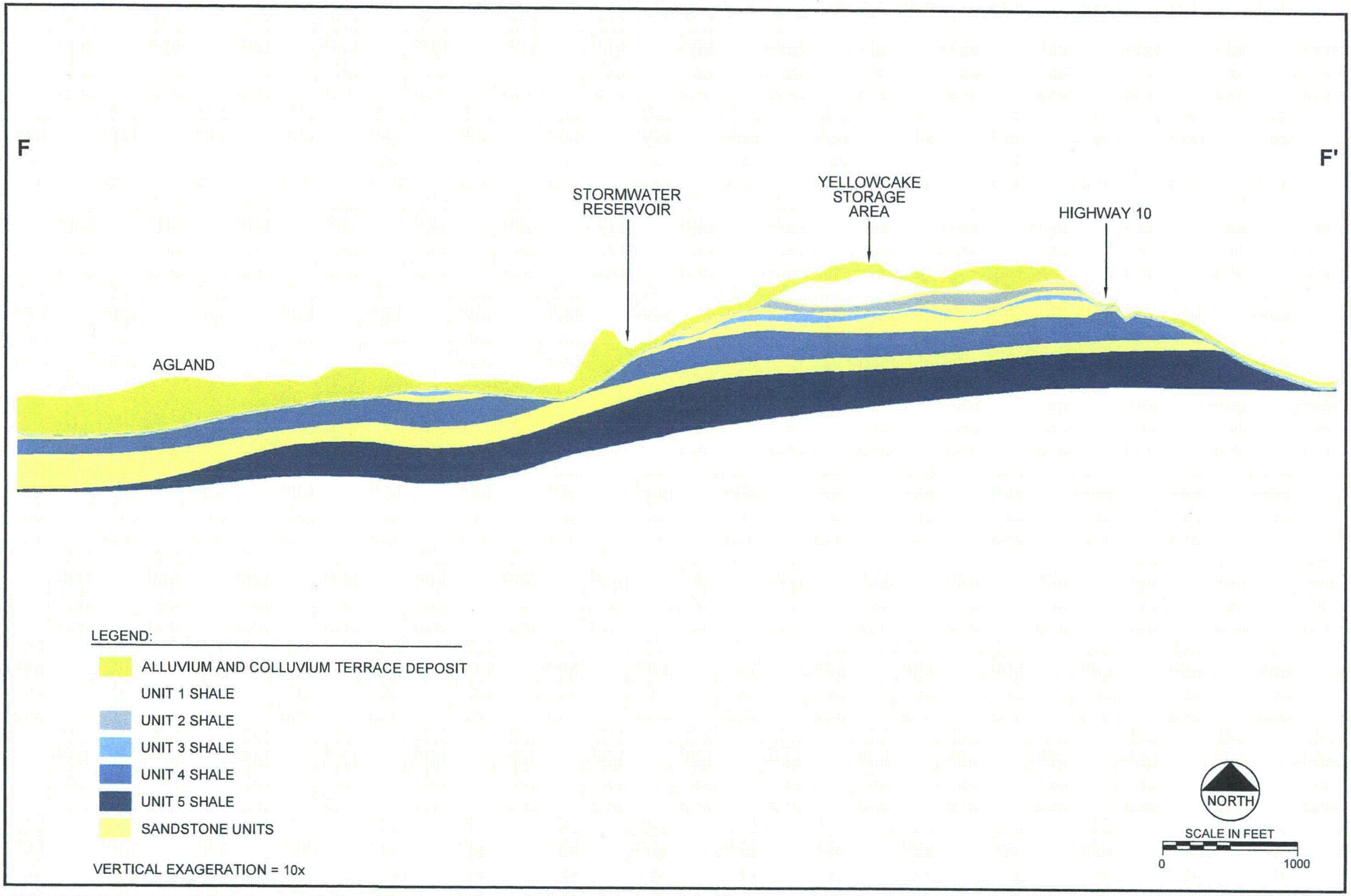
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP Figures\ |
| File: | SECTIONS.dwg |




consulting scientists and engineers

FIGURE 2-12
LAYER 5
HYDROSTRATIGRAPHIC MODEL CROSS SECTION E-E'

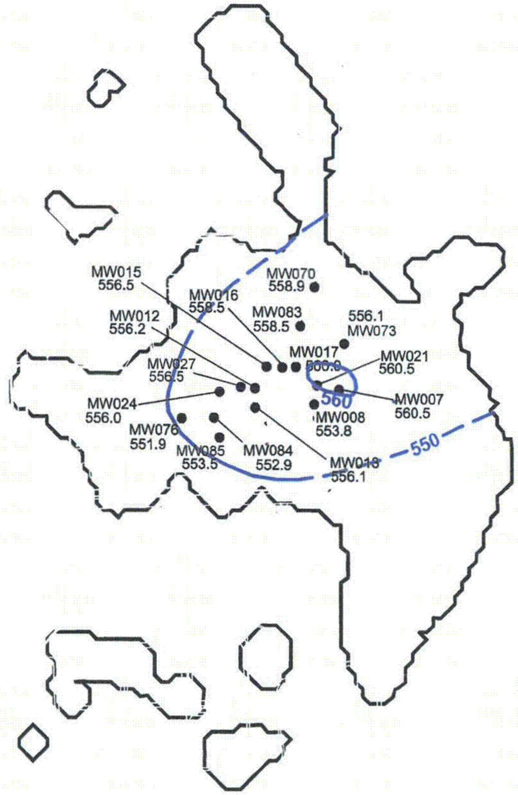
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP Figures\ |
| File: | SECTIONS.dwg |




consulting scientists and engineers

FIGURE 2-13
LAYER 6
HYDROSTRATIGRAPHIC MODEL CROSS SECTION F-F'

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP Figures\ |
| File: | SECTIONS.dwg |




LEGEND

• HEAD LOCATION AND MEASUREMENT (FT, MSL)

POTENTIOMETRIC CONTOUR (FT, MSL)

EXTENT OF SHALE UNIT

N

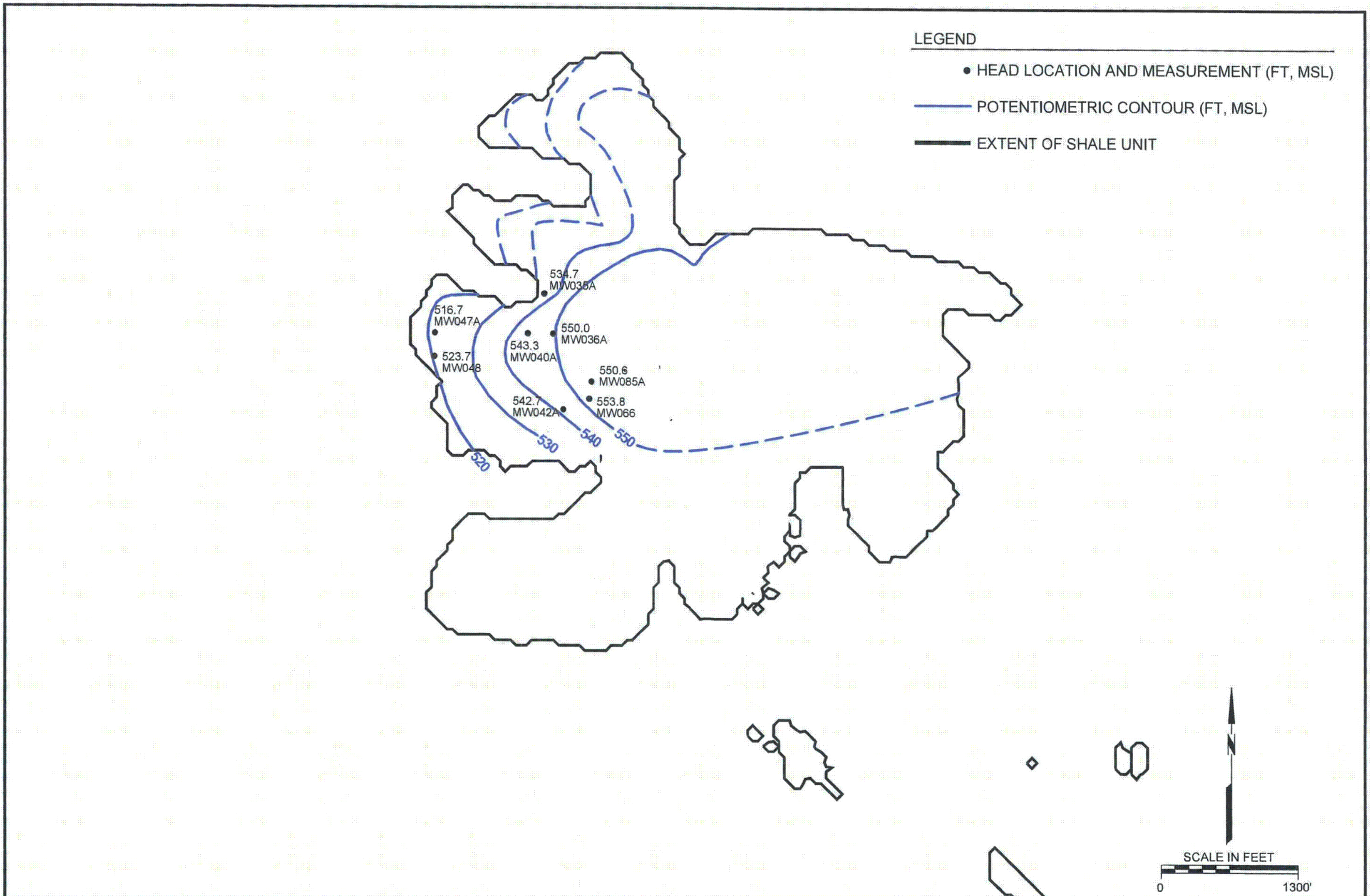
SCALE IN FEET

0 1300'

consulting scientists and engineers

FIGURE 2-14
POTENTIOMETRIC SURFACE SHALE 1
JUNE 2001

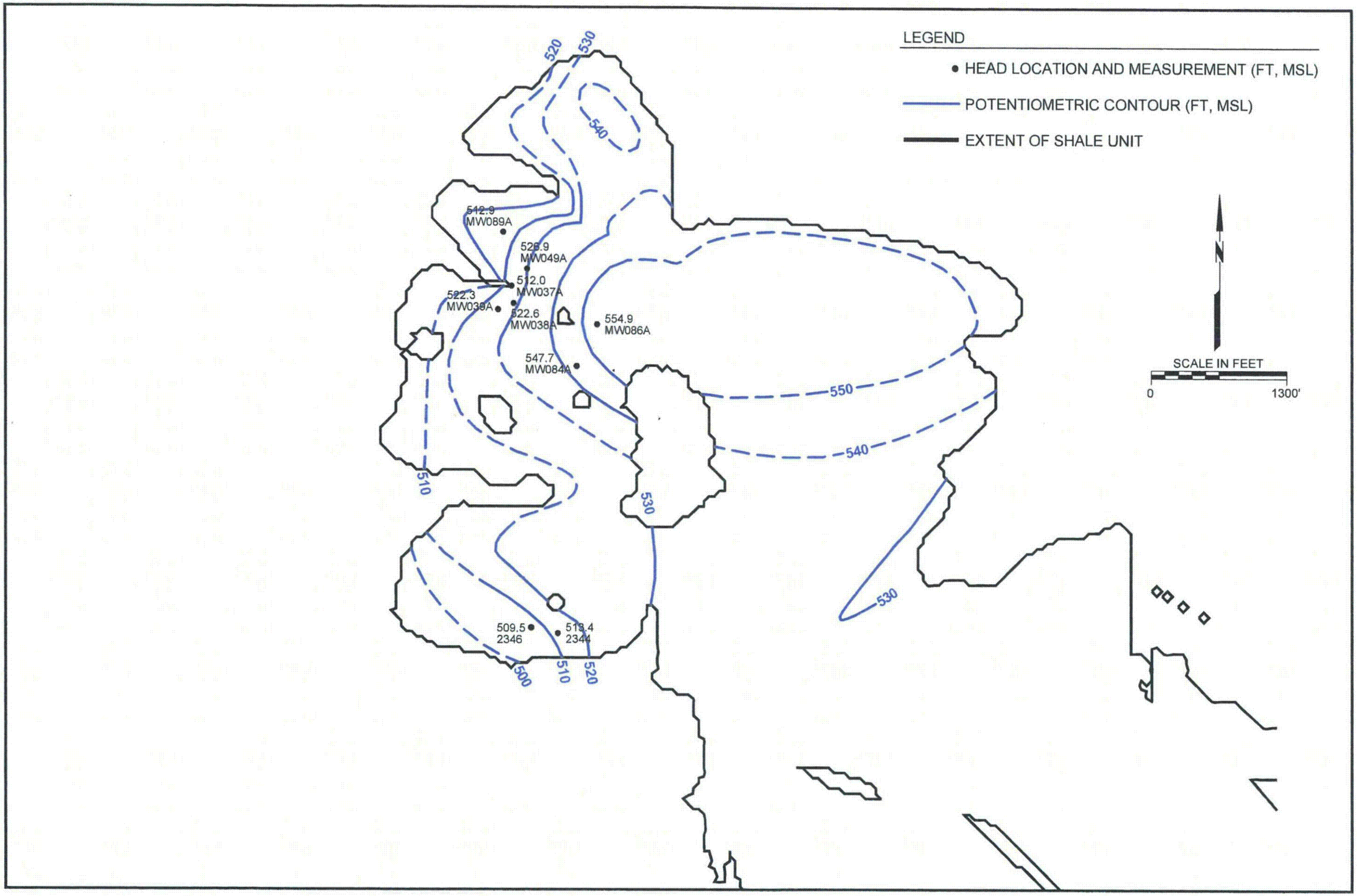
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734/CAP Figures |
| File: | SHALE.dwg |




consulting scientists and engineers

FIGURE 2-15
POTENTIOMETRIC SURFACE SHALE 2
JUNE 2001

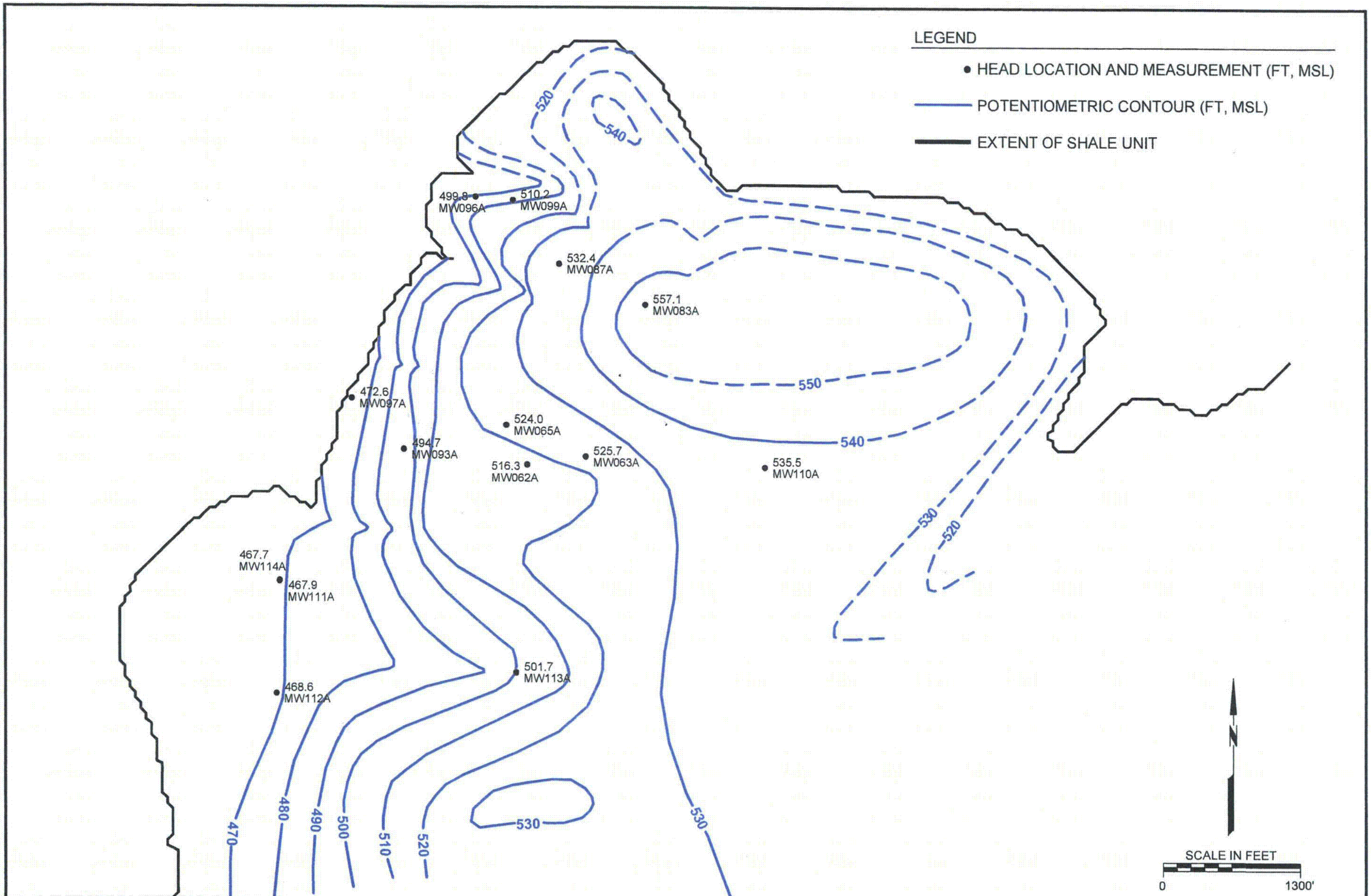
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734/CAP Figures |
| File: | SHALE.dwg |




consulting scientists and engineers

FIGURE 2-16
POTENTIOMETRIC SURFACE SHALE 3
JUNE 2001

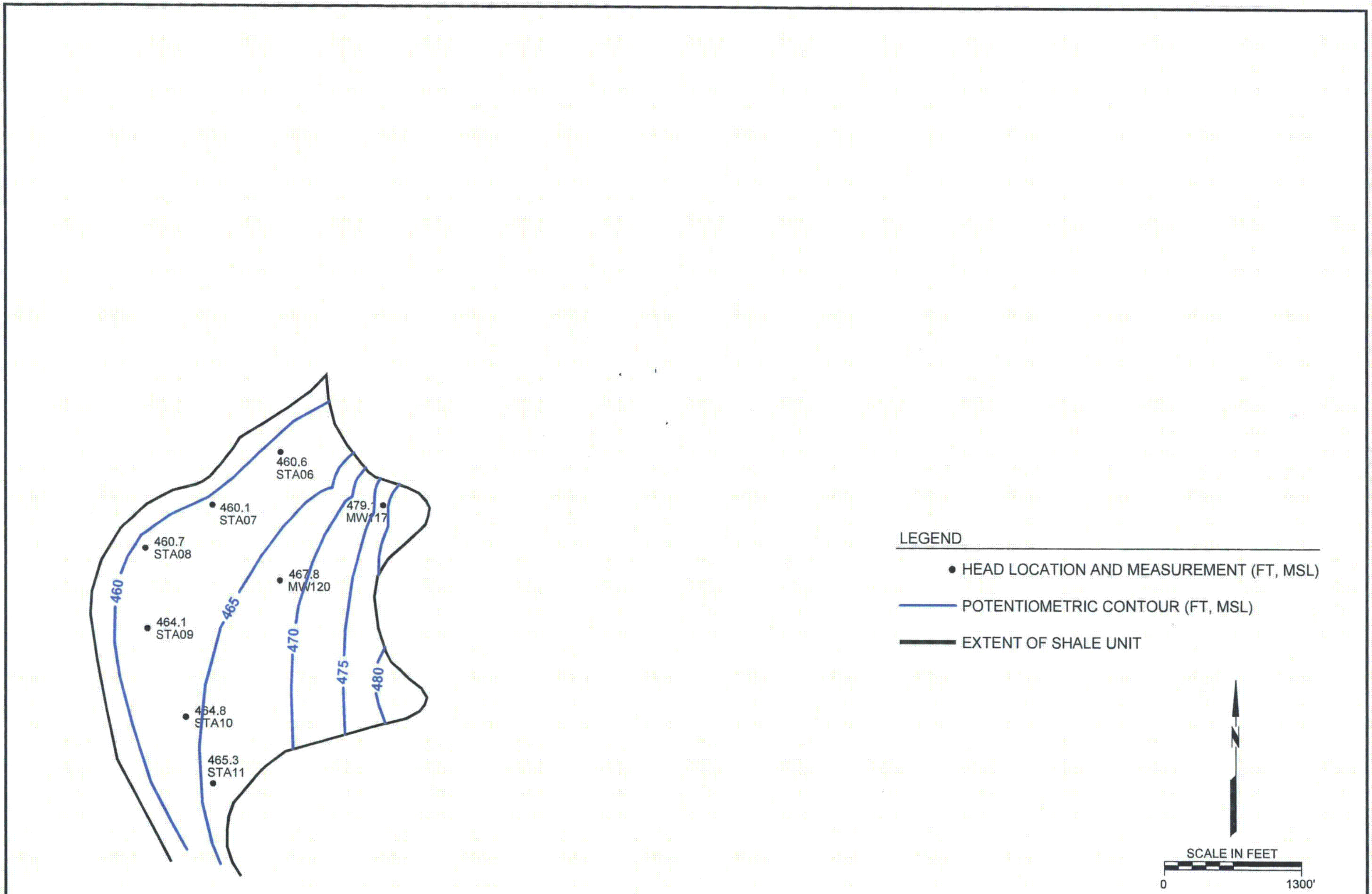
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734/CAP Figures |
| File: | SHALE.dwg |




consulting scientists and engineers

FIGURE 2-17
POTENTIOMETRIC SURFACE SHALE 4
JUNE 2001

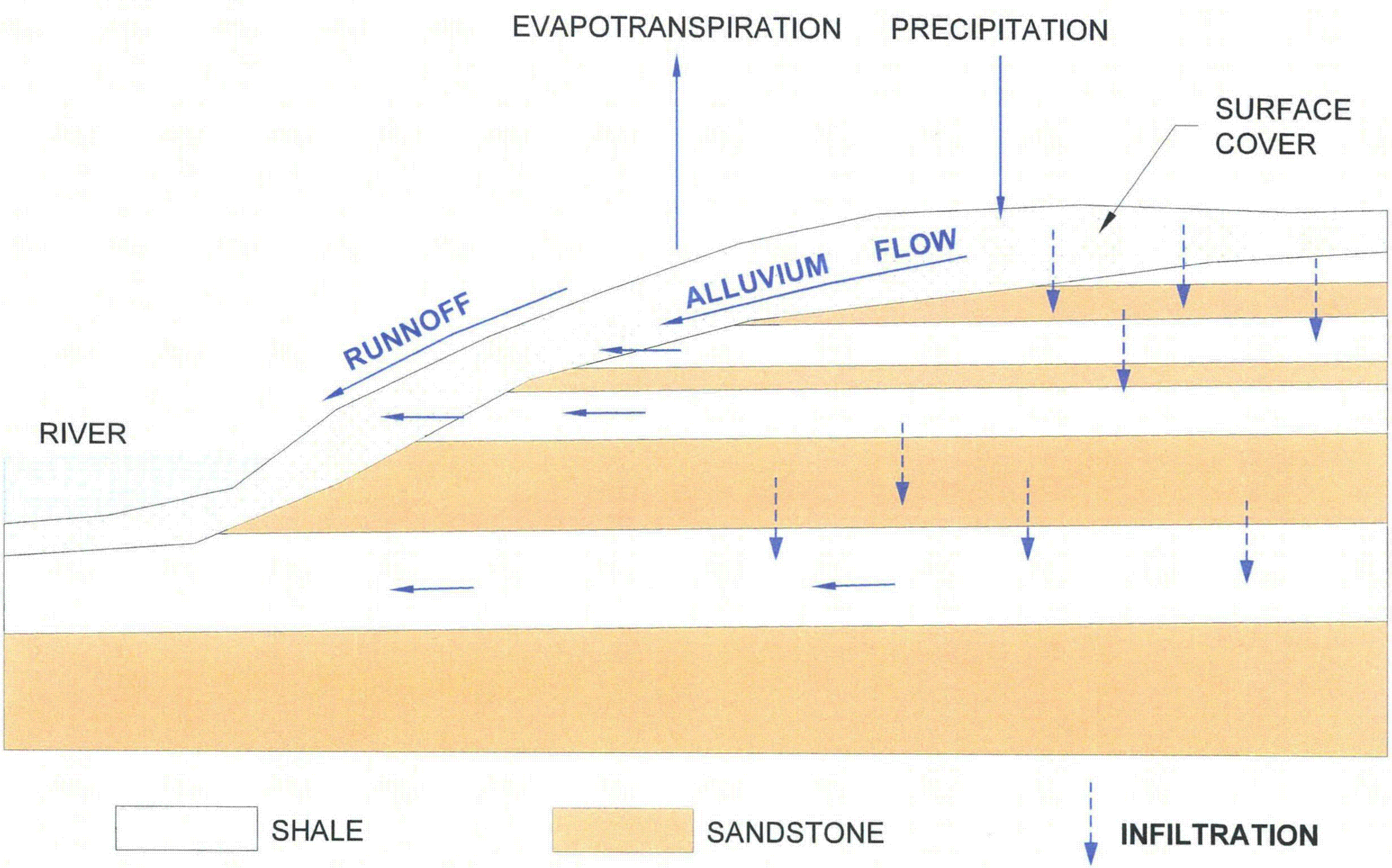
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734/CAP Figures |
| File: | SHALE.dwg |




consulting scientists and engineers

FIGURE 2-18
POTENTIOMETRIC SURFACE ALLUVIUM
5 JUNE 2001

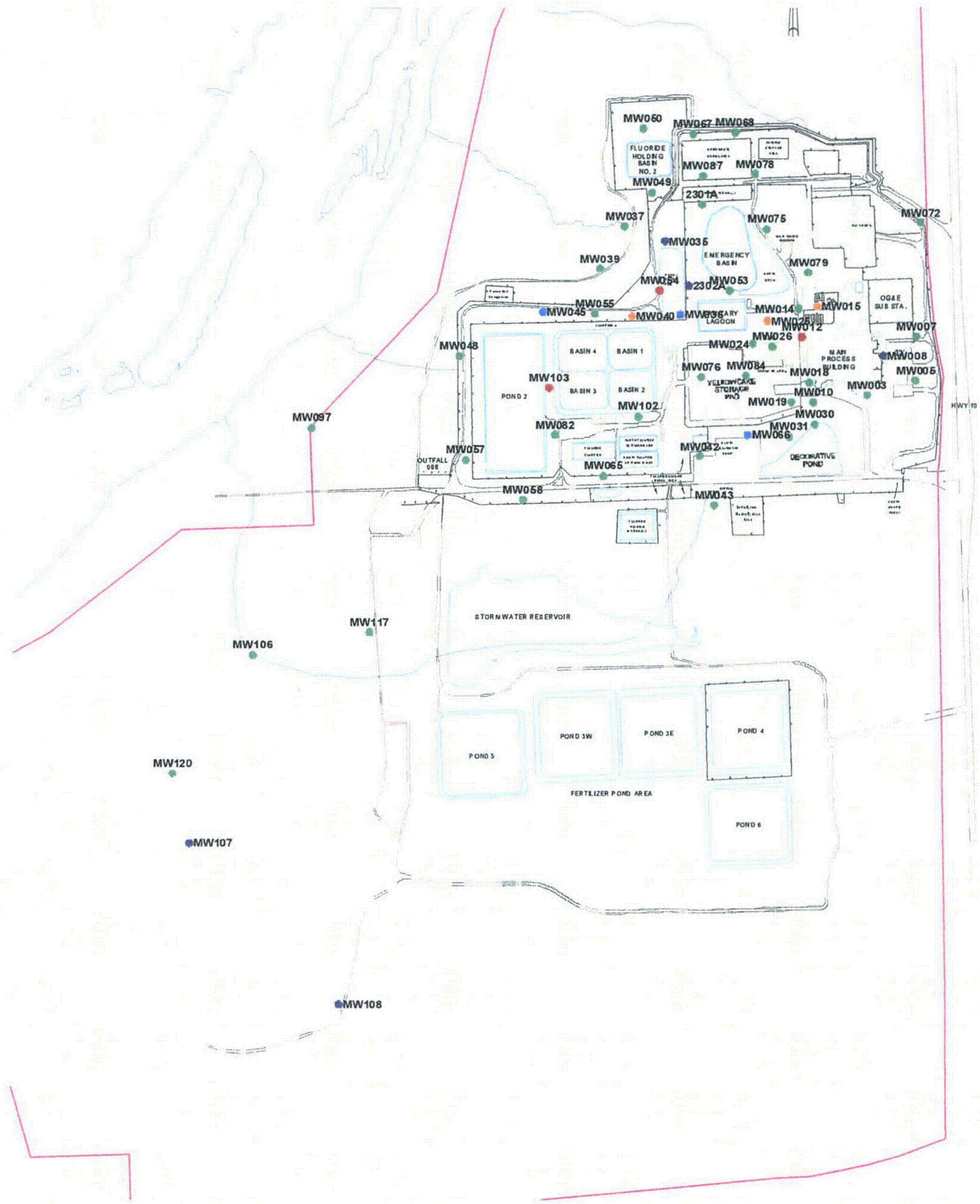
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734/CAP Figures |
| File: | SHALE.dwg |




consulting scientists and engineers

FIGURE 2-19
CONCEPTUALIZED HYDROGEOLOGY

| | |
|---|---|
| Date: | JUNE 2002 |
| Project: | P:\100734\CAP |
| File: | SECT7.ppt |




< 10 mg/L (MCL)

10-<20 mg/L

20-<100 mg/L

100-500 mg/L

>500 mg/L

| | | |
|---|---|---|
| | FIGURE 2-20<br>NITRATE IN TERRACE/UNIT 1 SHALE<br>GROUNDWATER, 2003 | Date: JUNE 2003<br>Project: P:\100734\CAP<br>File: Sec 2 20-25 |

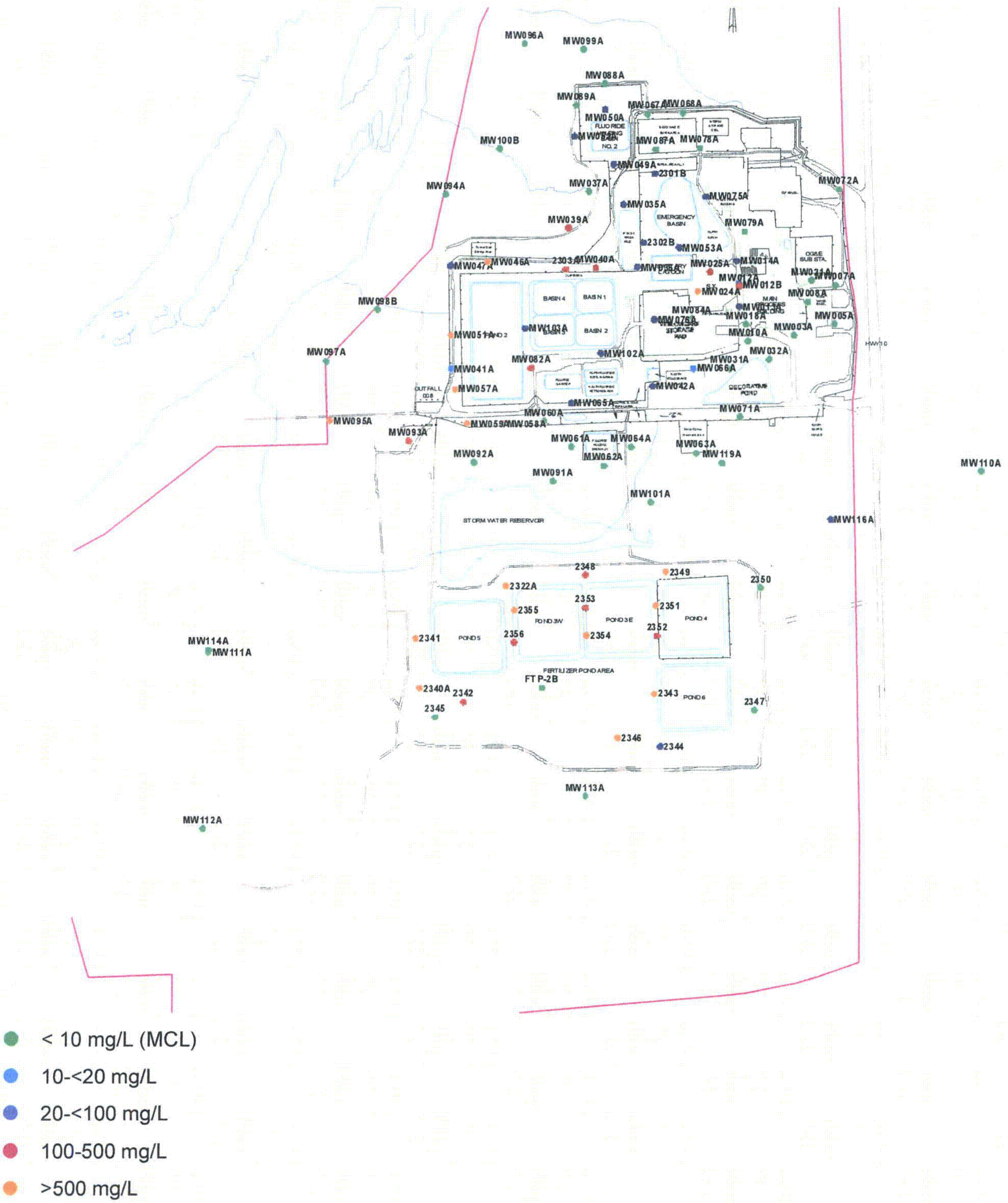



FIGURE 2-21
NITRATE IN SHALLOW BEDROCK GROUNDWATER, 2003

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2 20-25 |

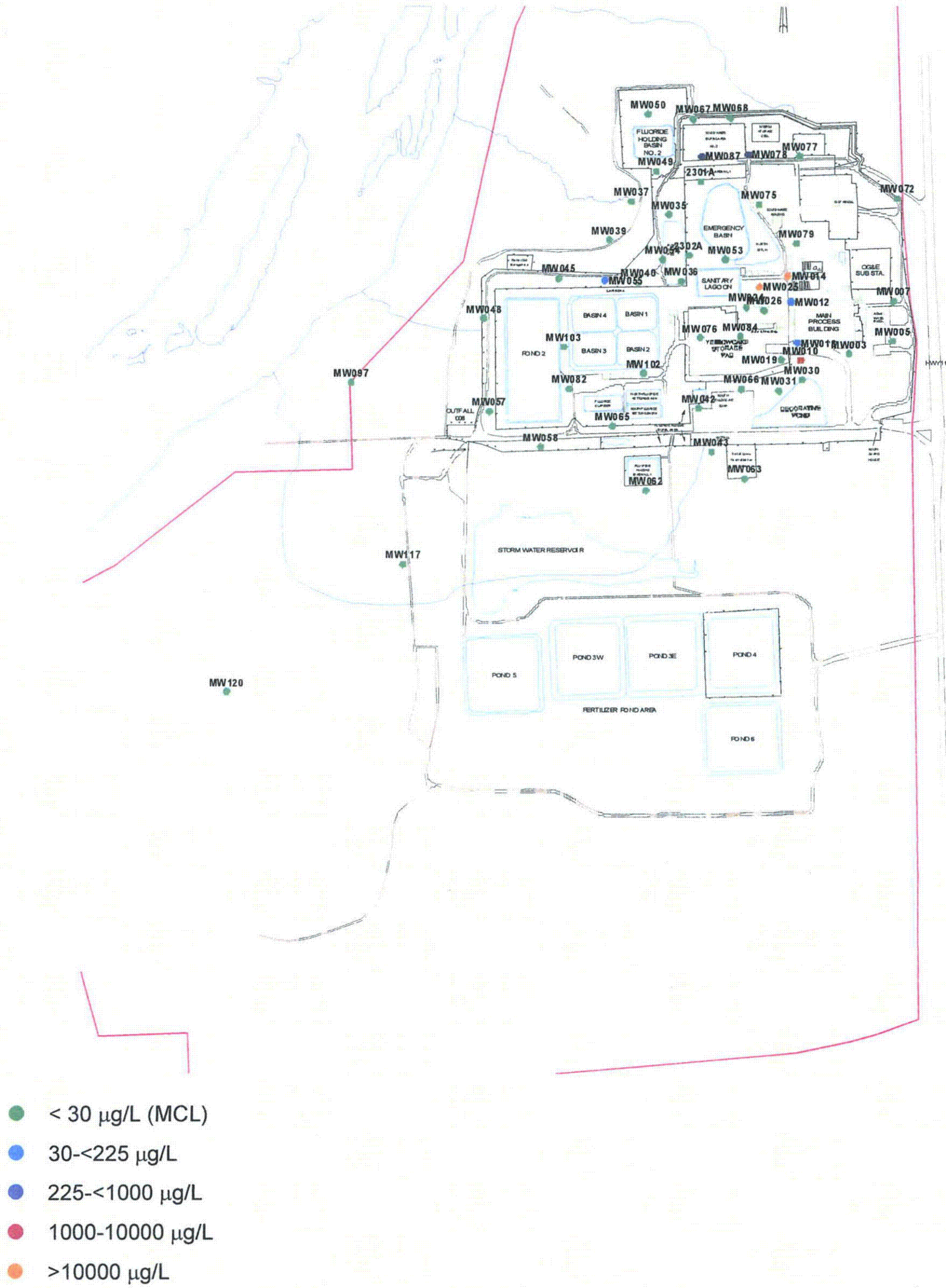
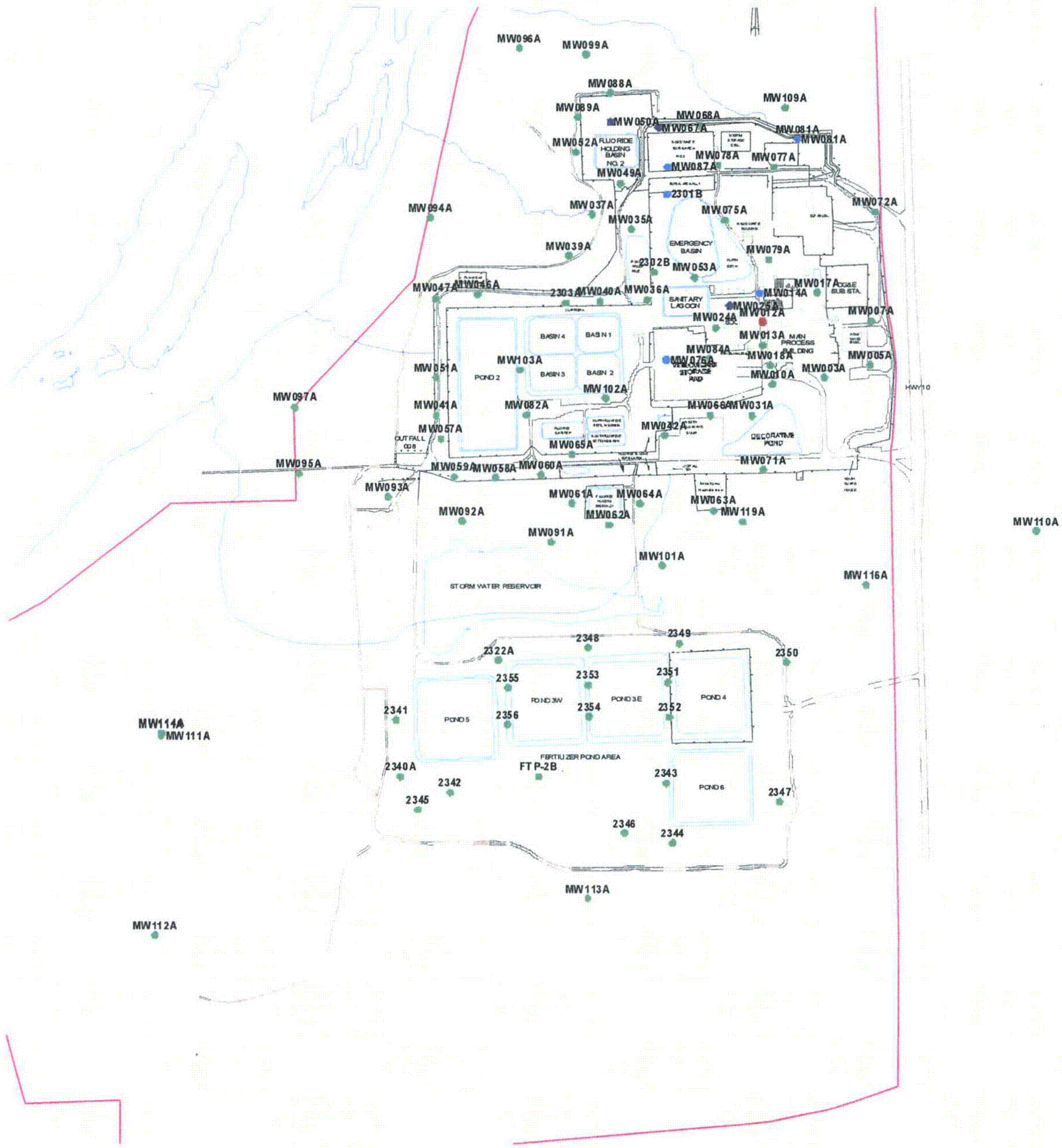



FIGURE 2-22
URANIUM IN TERRACE/ UNIT 1 SHALE
GROUNDWATER, 2003

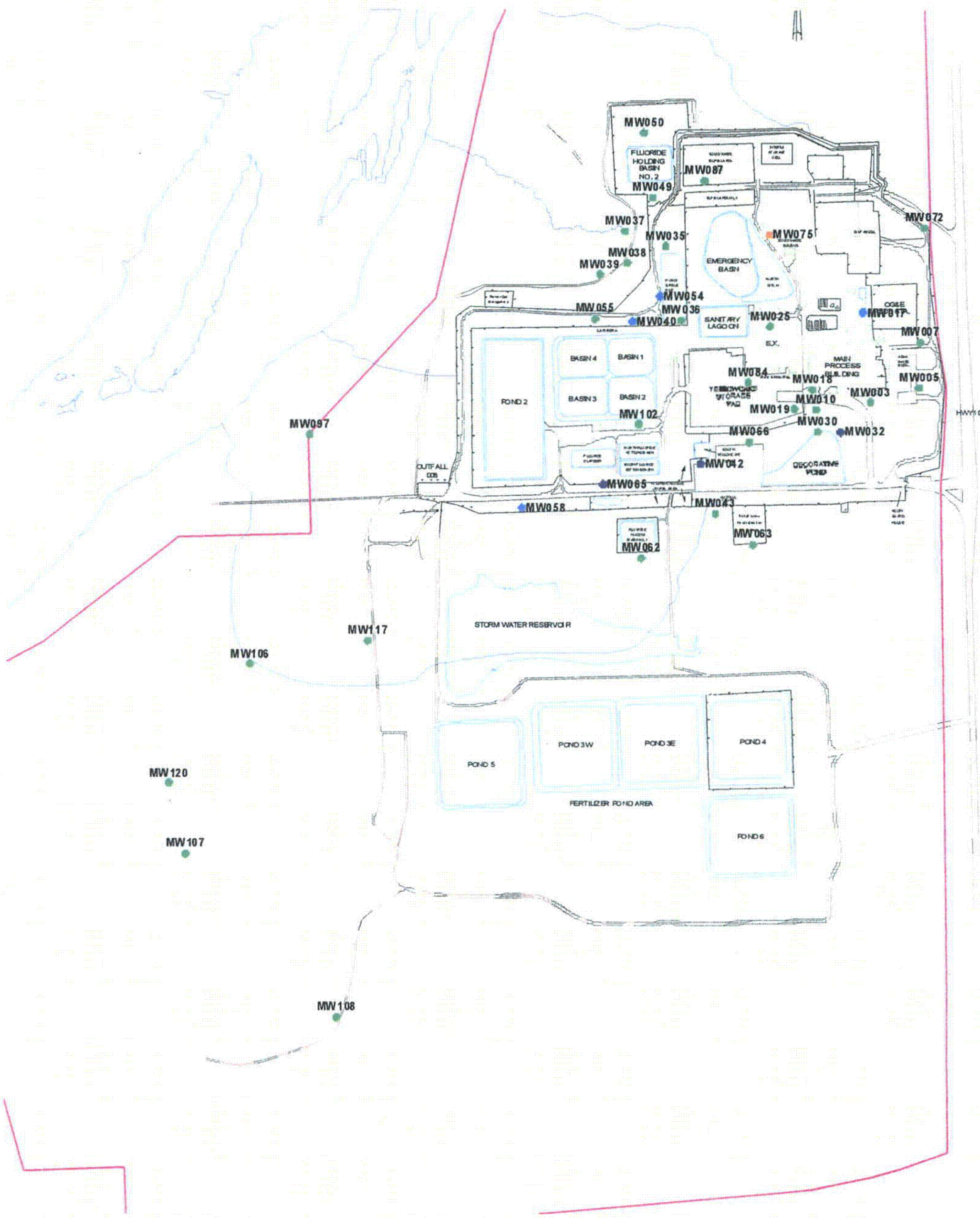
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2 20-25 |




- < 30 μg/L (MCL)
- 30-<225 μg/L
- 225-<1000 μg/L
- 1000-10000 μg/L
- >10000 μg/L

FIGURE 2-23
URANIUM IN SHALLOW BEDROCK
GROUNDWATER, 2003

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2 20-25 |




- < 0.050 mg/L (MCL)
- 0.050-<0.1 mg/L
- 0.1-<0.5 mg/L
- 0.5-<1.0 mg/L
- >1.0 mg/L

consulting scientists and engineers

FIGURE 2-24
ARSENIC IN TERRACE/UNIT 1 SHALE GROUNDWATER, 2003

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2 20-25 |

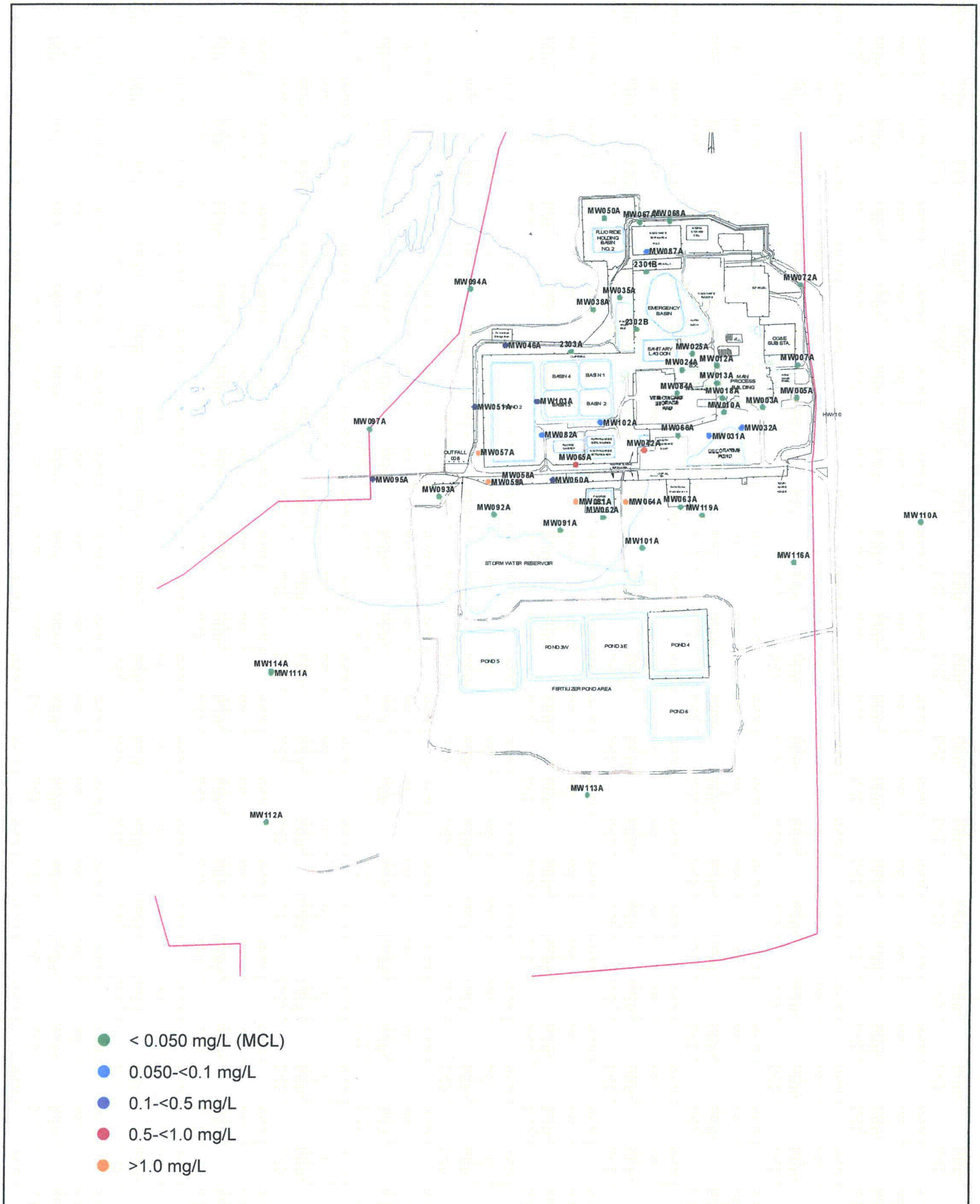
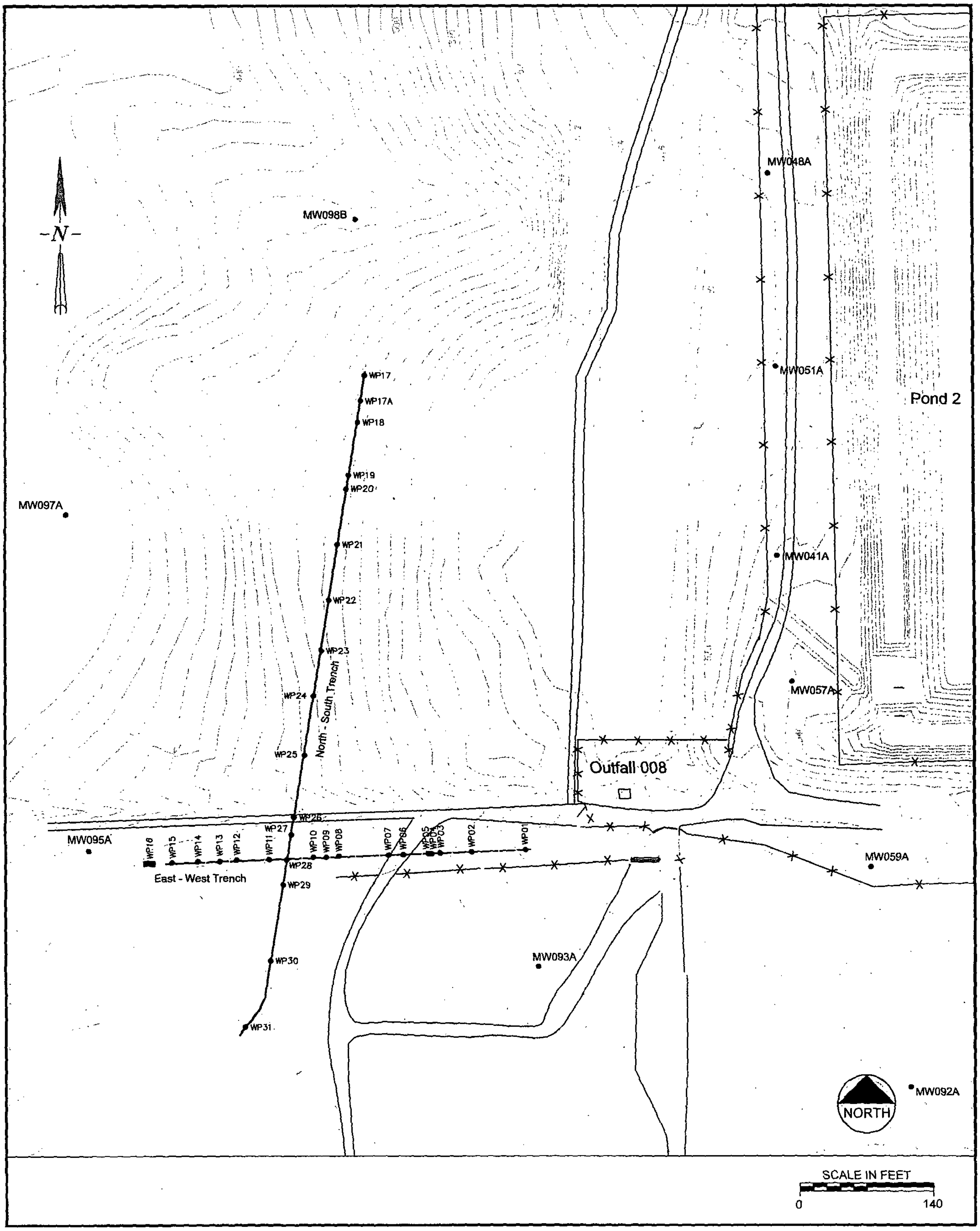



FIGURE 2-25
ARSENIC IN SHALLOW BEDROCK SHALE
GROUNDWATER, 2003

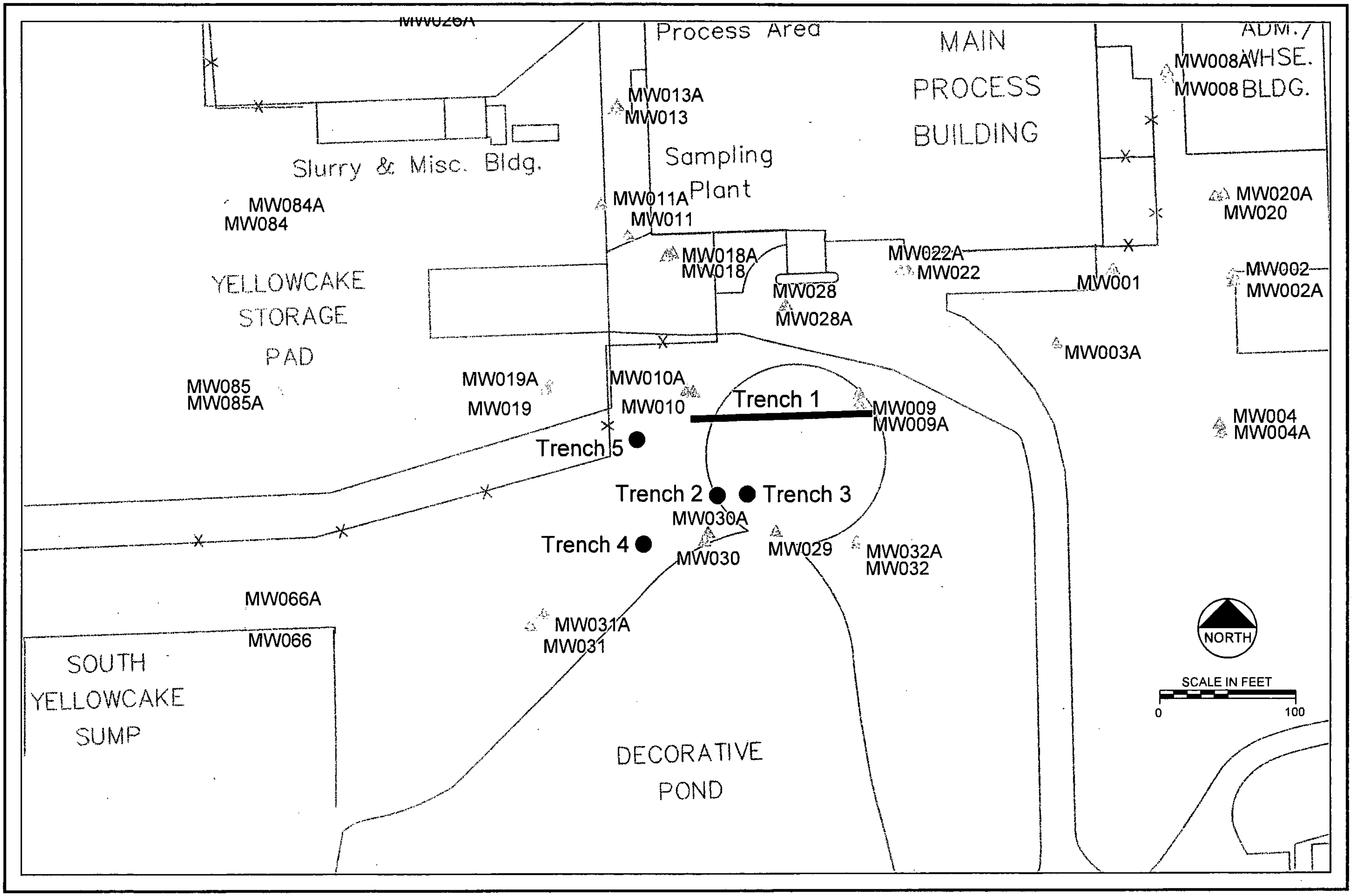
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | P:\100734\CAP |
| File: | Sec 2 20-25 |




consulting scientists and engineers

FIGURE 4-1
TRENCH AND WAYPOINT LOCATIONS

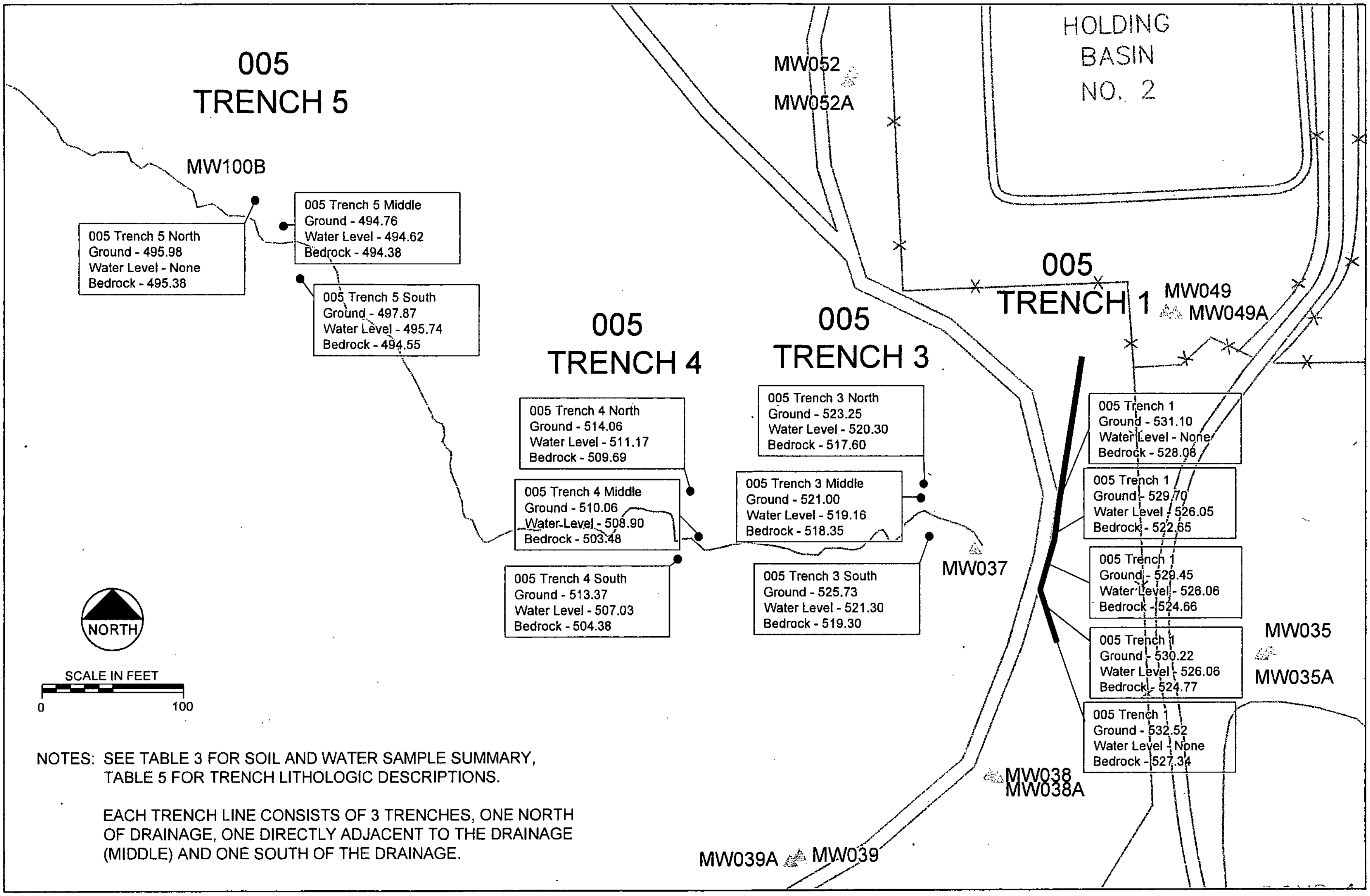
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP FIG. |
| File: | TRENCH-WAYPNT.dwg |




consulting scientists and engineers

FIGURE 4-2
MW010 SWALE TRENCH LOCATIONS

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734/CAP Figures |
| File: | TRENCH-FIGS |



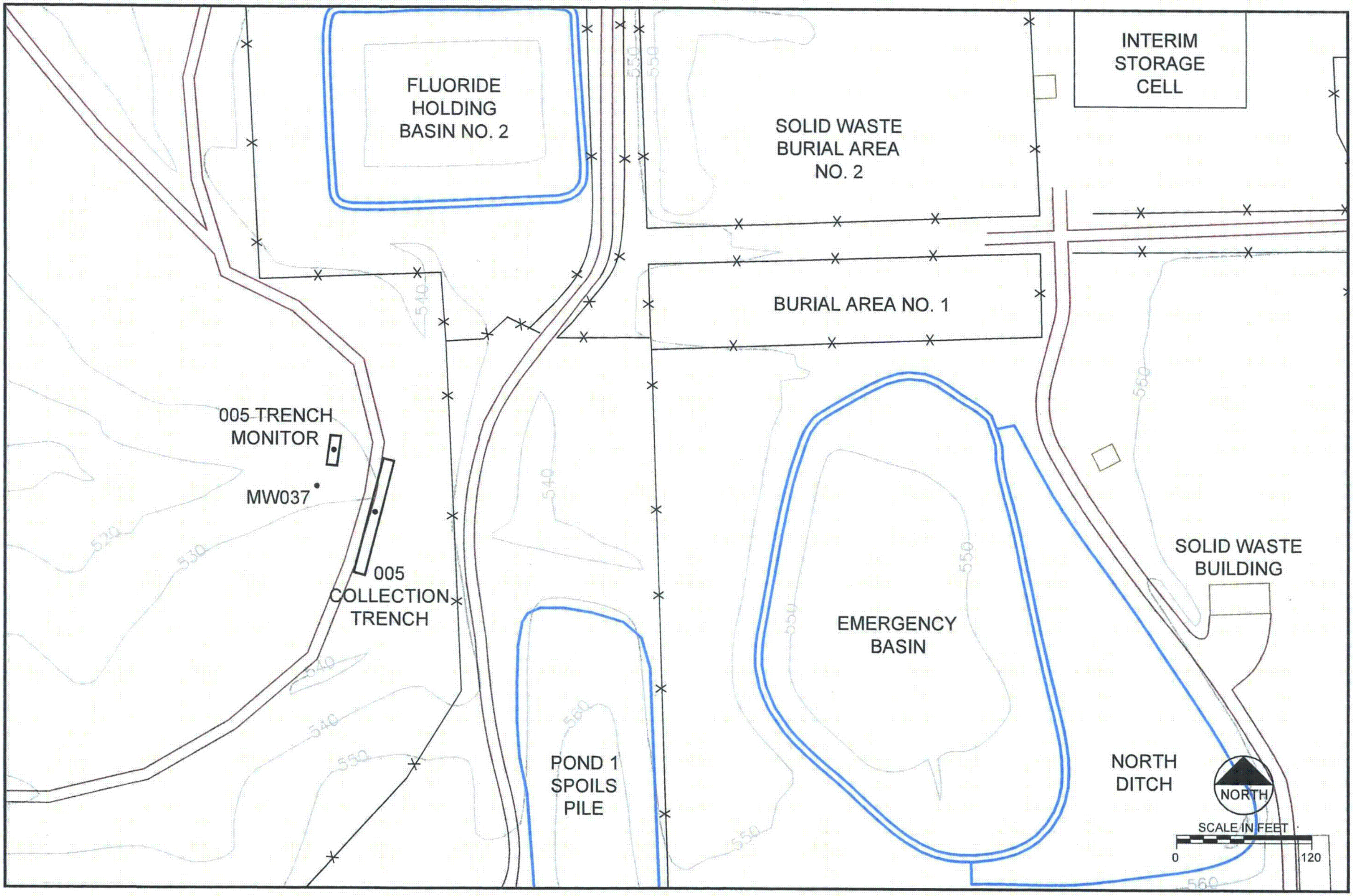

NOTES: SEE TABLE 3 FOR SOIL AND WATER SAMPLE SUMMARY, TABLE 5 FOR TRENCH LITHOLOGIC DESCRIPTIONS.

EACH TRENCH LINE CONSISTS OF 3 TRENCHES, ONE NORTH OF DRAINAGE, ONE DIRECTLY ADJACENT TO THE DRAINAGE (MIDDLE) AND ONE SOUTH OF THE DRAINAGE.

consulting scientists and engineers

FIGURE 4-3
005 DRAINAGE TRENCHING AND SOIL/WATER SAMPLING LOCATIONS

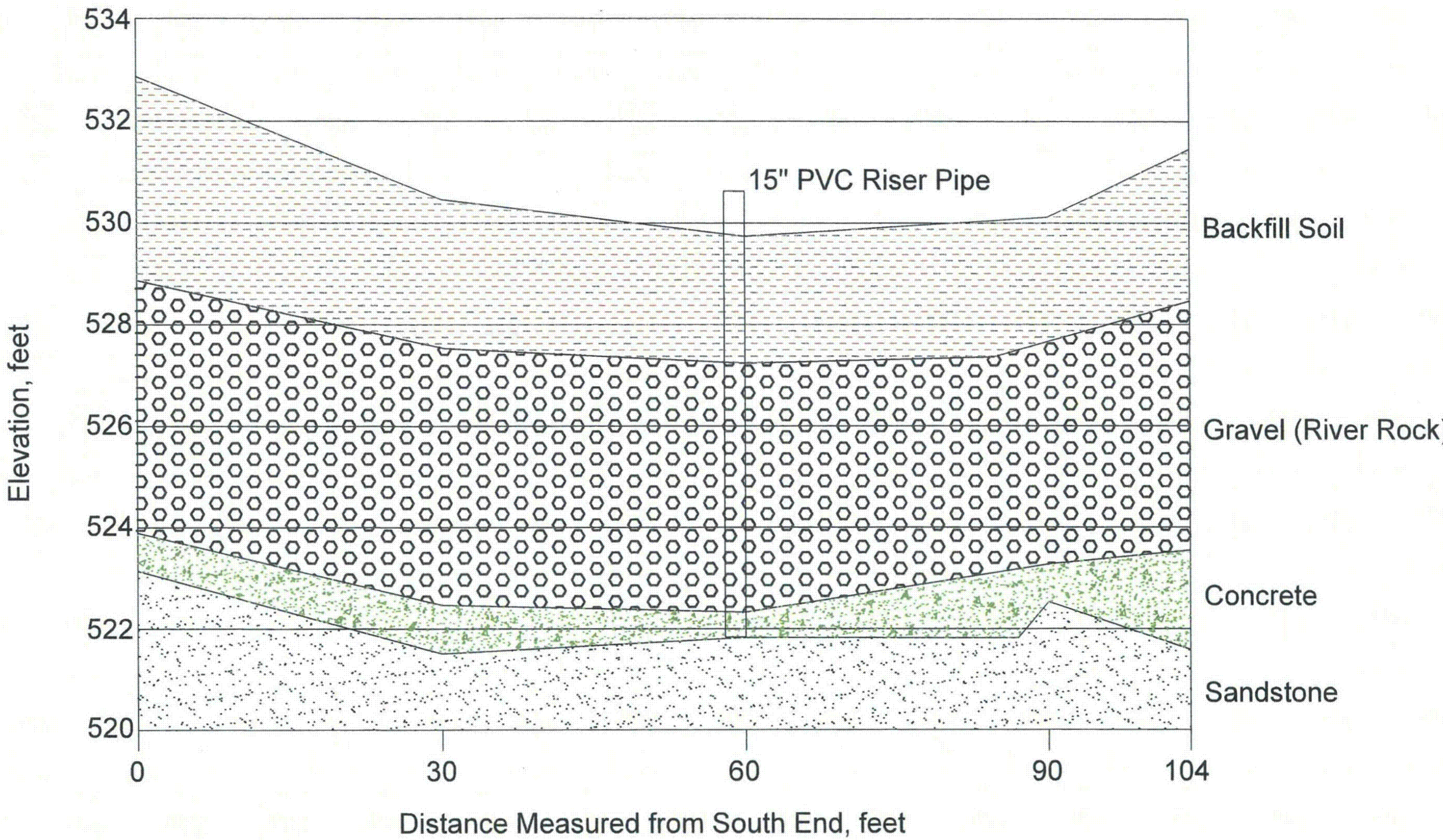
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734/CAP Figures |
| File: | TRENCH-FIGS |




consulting scientists and engineers

FIGURE 6-1
LOCATION OF 005 COLLECTION TRENCH
AND 005 MONITOR TRENCH

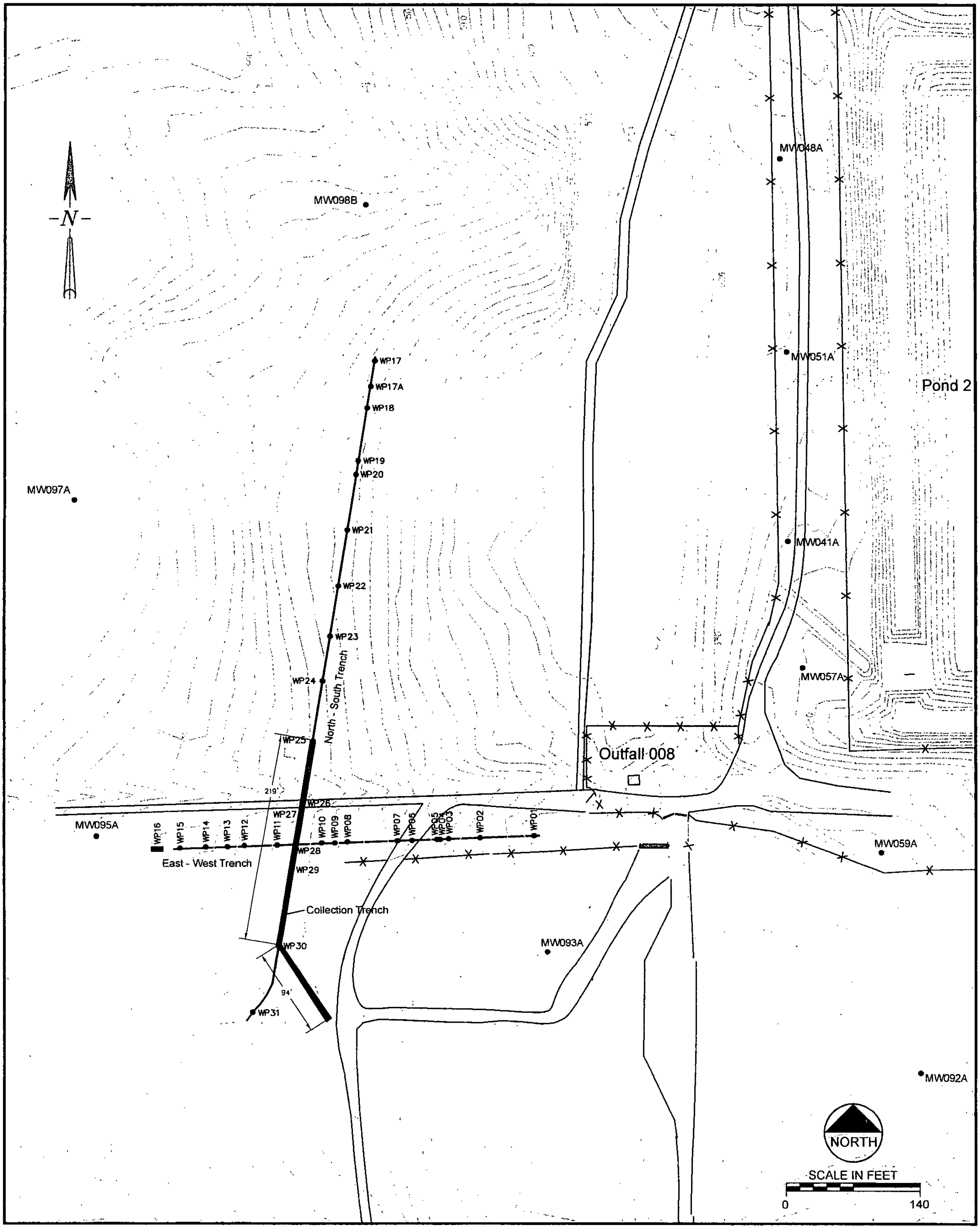
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP FIG. |
| File: | TRENCH-005.dwg |




consulting scientists and engineers

FIGURE 6-2
PROFILE OF 005 DRAINAGE COLLECTION TRENCH LOOKING WEST
INSTALLED ON JULY 8 - 11, 2002

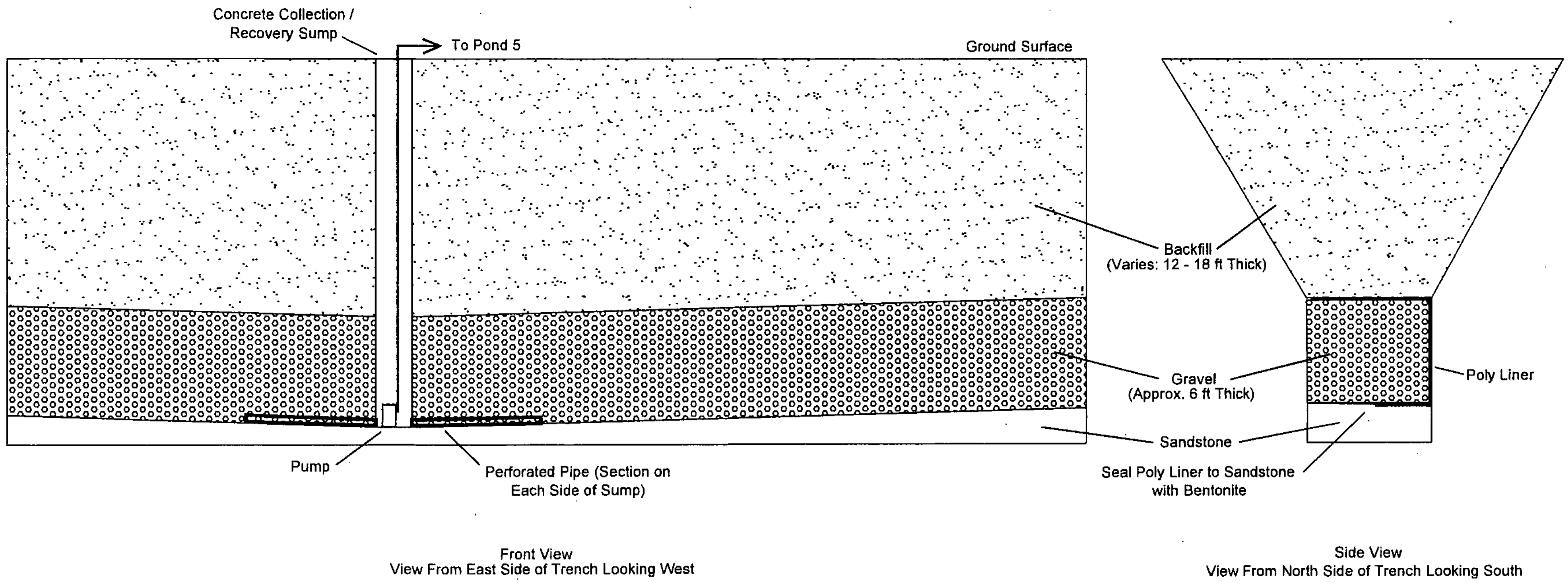
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP FIG. |
| File: | TRENCH-005-PROF.dwg |




consulting scientists and engineers

FIGURE 6-3
LOCATION OF PROPOSED
COLLECTION TRENCH

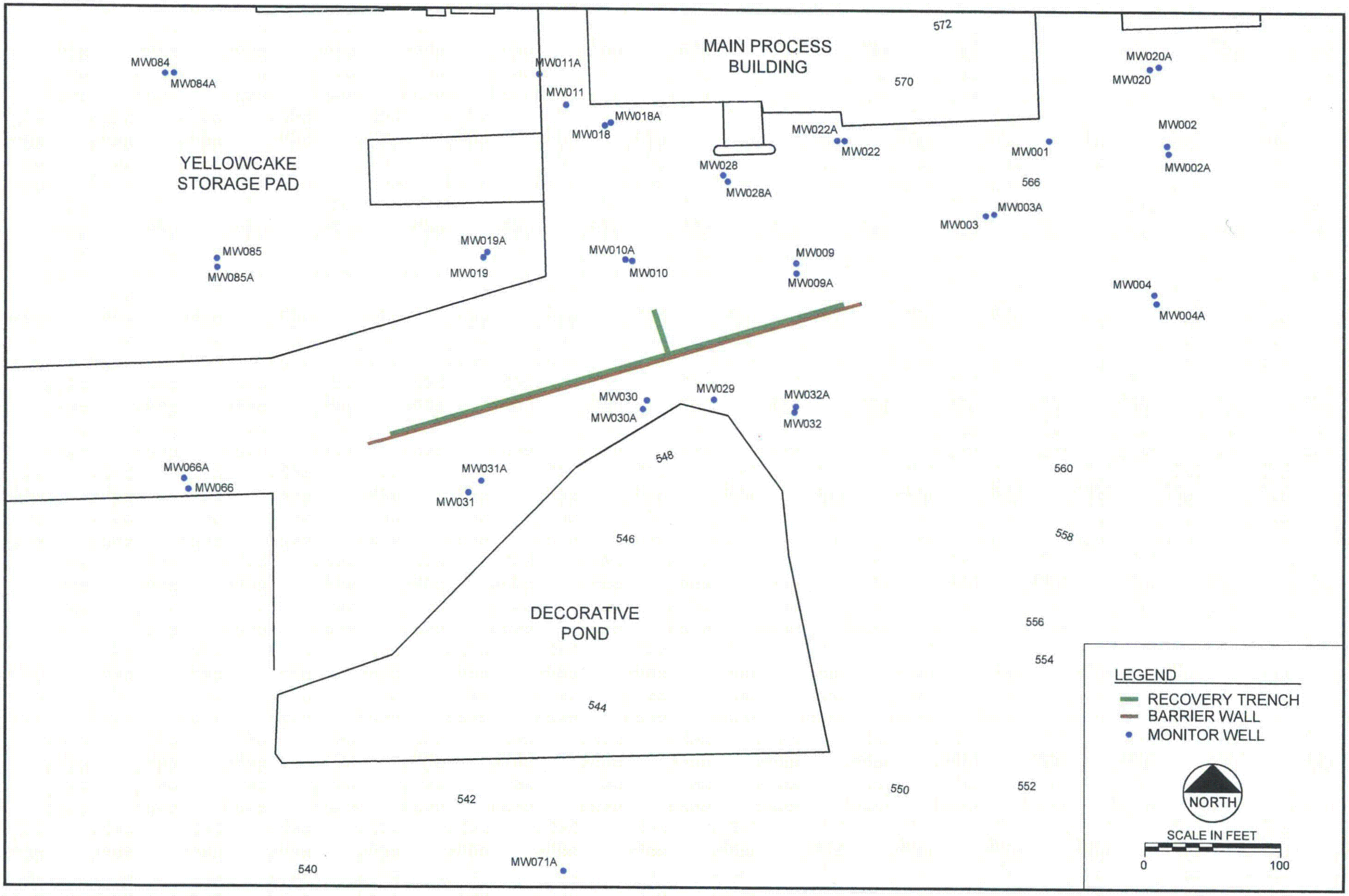
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP FIG. |
| File: | TRENCH-LOC.dwg |




consulting scientists and engineers

# FIGURE 6-4
## PROPOSED COLLECTION TRENCH
## N-S TRENCH BETWEEN POND 2 AND MW095A

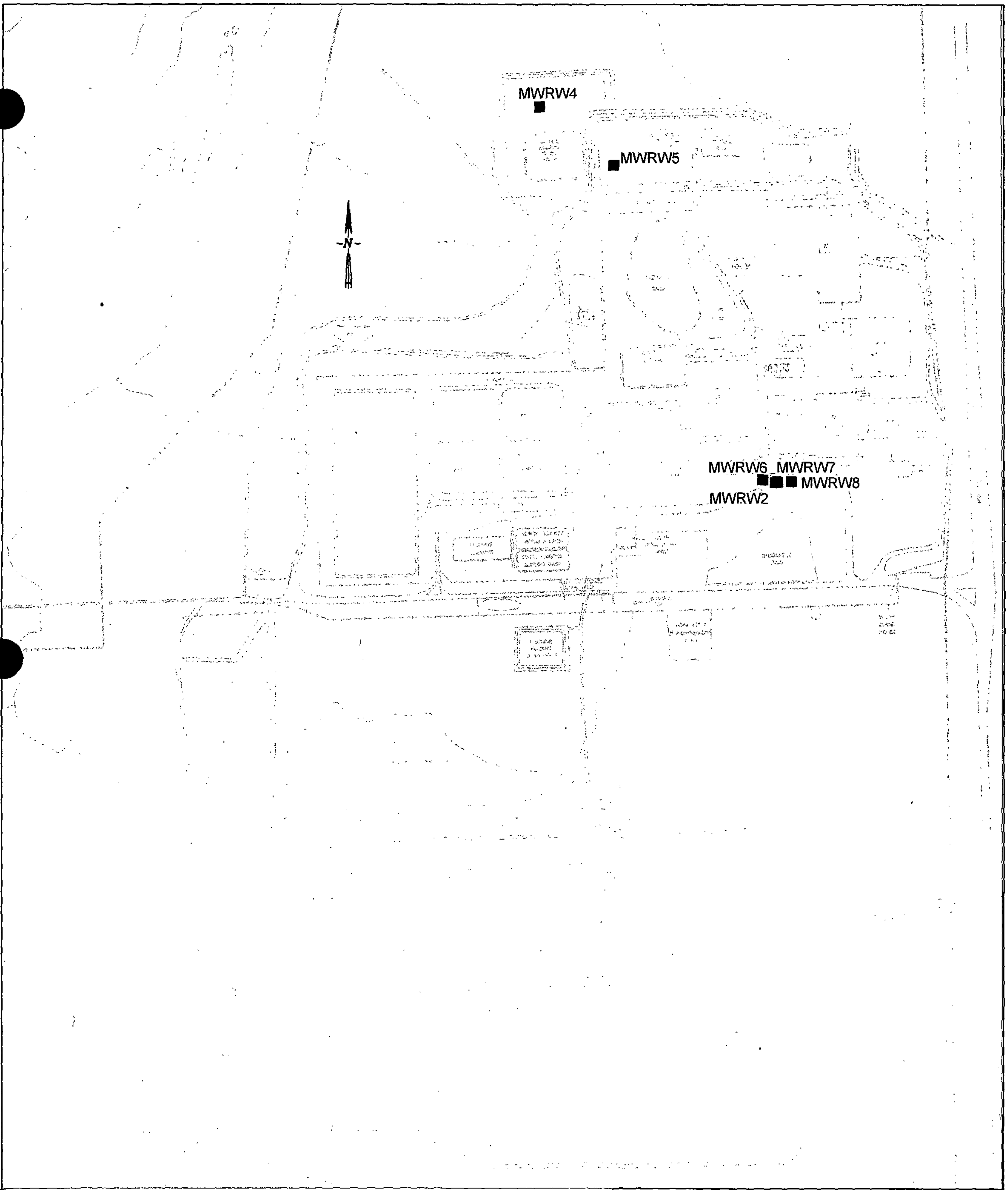
| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | 100734\CAP FIG. |
| File: | TRENCH-XSEC.dwg |




consulting scientists and engineers

# FIGURE 6-5
# PROPOSED MW010 SWALE TRENCH LOCATION

| | |
|---|---|
| Date: | JUNE 2003 |
| Project: | E:\100734 |
| File: | MW010TRENCH.dwg |




| | |
|---|---|
| SEQUOYAH FUELS CORPORATION<br>Groundwater Corrective Action Plan | |
| TITLE: Groundwater Recovery Well Locations | |
| PREPARED BY: SCM | FILENAME: RecoveryWellLocations.dwg |
| REVIEWED BY: SCM | FIGURE NO. 6-6 |
| DATE: 26 May 2010 | |

# APPENDIX A

# APPENDIX A

## Water Treatment Plant Description

### Introduction

The Water Treatment Plant is designed for batch treatment of recovered groundwater for uranium recovery. The system utilizes chemical precipitation, settling, filtration and ion exchange processes to remove uranium prior to release of the water. Figure 1 is a process flow schematic for the system that has been constructed.

### Process Flow

Existing monitoring wells, recovery wells and the three intercept trenches (one near MW-010, one near MW-095A and one uphill from the 005 drainage) will be used for groundwater recovery. Initially, it is expected that groundwater recovery will be the rate limiting activity. The pump discharges from these sources are being routed to the Receiving/Chem Treatment Tank. Existing tanks near the Solvent Extraction Building (holding Tanks 1, 2 and 3) will be used for collection and temporary storage of recovered groundwater from the process area. The water stored in these tanks will be pumped batchwise to the Receiving/Chem Treatment Tank for treatment. Eventually, excavations to remove uranium contaminated soil will allow more access to impacted terrace groundwater. Modifications and/or expansions to the Water Treatment Plant will be made as necessary at that time.

Recovered groundwater from various sources will be transferred into the Receiving/Chem Treatment tank (vessel #1). When about 12,000 gallons have been accumulated, the batch will be mixed, sampled and analyzed for uranium concentration. If the uranium concentration is less then about 250 µg/l, the batch will be moved into the Treatment Feed Tank (vessel #3). If the uranium concentration is greater than about 250 µg/l, phosphoric acid will be added to convert the uranium to uranyl phosphate, a low solubility form of uranium. Then, sodium or potassium hydroxide will then be added to raise the pH to approximately 8 to promote precipitation and to prepare the water for subsequent ion exchange treatment. The treated water will then be transferred to the Precipitate Settling Tank (vessel #2) and the solids allowed to settle. Clarified wastewater will then be decanted to the Treatment Feed Tank where sodium carbonate will be added to convert the residual uranium to uranyl carbonate.

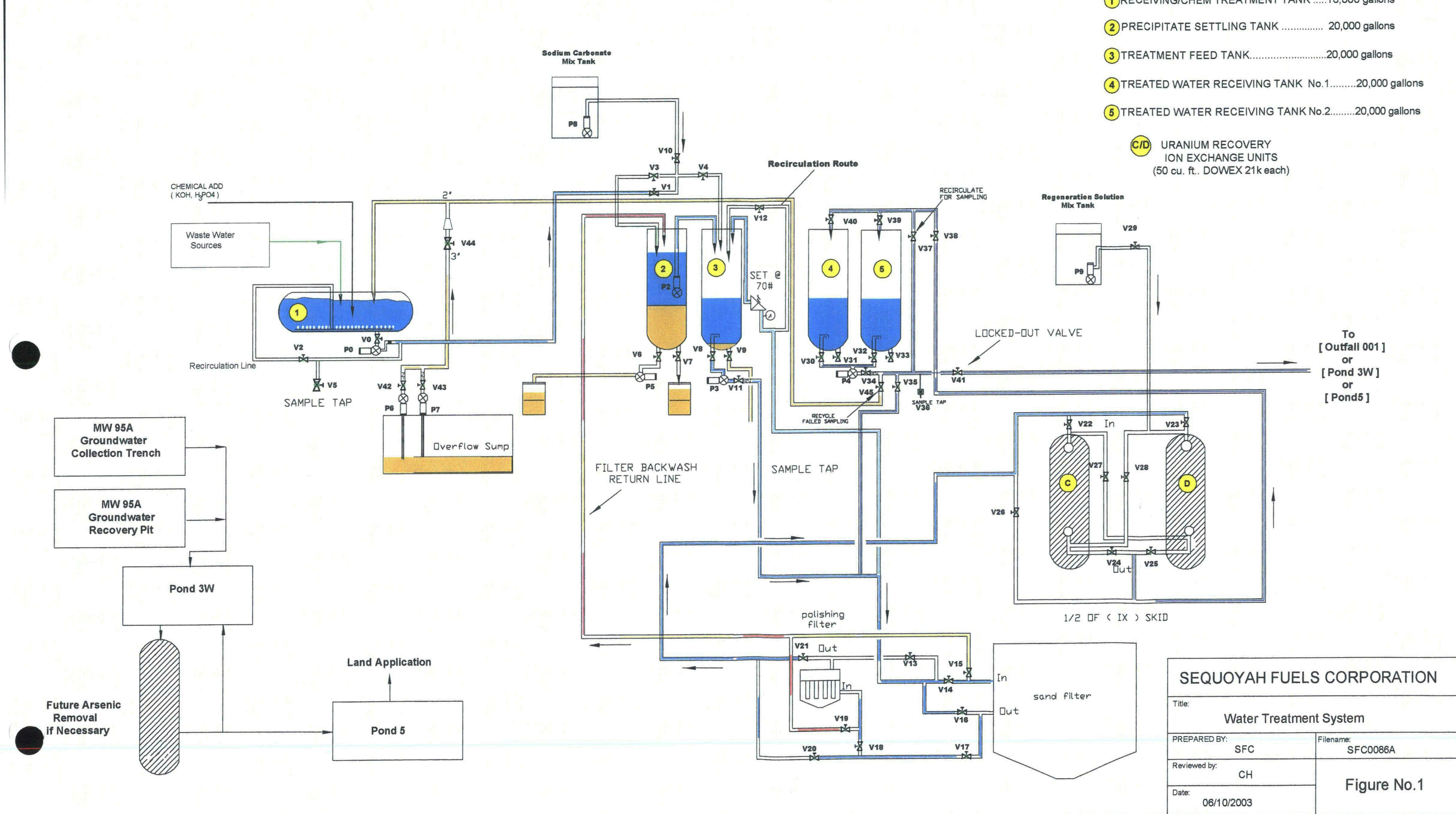
The wastewater will then be pumped from the Treatment Feed Tank through a sand filter and a polishing filter, and then to the ion exchange columns (Columns C and D in series). Columns C and D will each contain approximately 50 cubic feet of DOWEX 21-K Type II Strong Base Anion resin. This type of resin has a strong affinity for uranyl carbonate (ref. 1. – A. Sengupta; "ION EXCHANGE TECHNOLOGY - Advances in Pollution Control"; Technomic Publishing Company; 1995). Treated effluent will then be routed into one of two Treated Water Receiving Tanks (vessels #4 and #5). Treated water will be sampled and analyzed for uranium and then either discharged through SFC's permitted outfall 001 (if nitrate (N) is less than 32 mg/l) or to Pond 5 for land application as a fertilizer. The cleanup goal for this system is to reduce the uranium concentration to less than 30 µg/l, the drinking water MCL.

### Management of Recovered Uranium

When fully loaded with uranium, the ion exchange resin must be re-generated or replaced. The ion exchange resin can be stripped and re-generated using sodium chloride or dilute hydrochloric acid and sodium hydroxide. Based on the data in reference 1 and assuming an average feed uranium concentration of 250 µg/l, it is estimated that up to 100,000 bed volumes or 37,000,000 gallons of waste water can be processed before this would become necessary. The re-generation solutions and rinses would be collected in one of the Treated Water Collection Tanks and re-cycled back to the Receiving/Chem Treatment Tank. It is expected that the precipitation step would take out in excess of 95% of the uranium stripped from the ion exchange resin. Alternatively, the loaded resin may be shipped to a licensed uranium mill for uranium recovery.

Uranium bearing sludge from the Precipitate Settling Tank will be periodically flushed out, de-watered using a small vacuum drum filter and shipped offsite for uranium recovery and recycle. The sand filter and polishing filter will be backwashed as necessary to the Precipitate Settling Tank.

# WATER TREATMENT SYSTEM



# APPENDIX B

# APPENDIX B

## Installation of 005 Drainage Collection Trench
July, 2002

### Introduction

Surface water samples collected from the 005 Drainage during 2001 indicated elevated levels of uranium and nitrate. An investigation was conducted during the later part of 2001 and early 2002 to determine the source of the uranium. Groundwater appeared to be flowing along the surface of the bedrock through the backfill materials at the head of the drainage, migrating past the French drain collection system (identified as 005 Sump) and intermittently discharging into the 005 Drainage surface waters. Excavation of fill at the head of the 005 Drainage during the spring of 2002 confirmed that the French Drain system was not intercepting all the subsurface waters flowing along the bedrock surface at the 005 Drainage. Therefore, SFC decided to install a new hydraulic containment and pump back system (005 Collection Trench) at the head of the 005 Drainage. Installation of the system was completed during July 2002.

### Trench Location and Excavation

The Outfall 005 investigation trench was excavated at the head of the 005 Drainage during February 2002, and was designated as 005 Drainage Trench 1 by Shepherd Miller, Inc. in a report titled "Supplemental Data Collection Trip Report", April 2002. In July, 2002, a new collection trench was installed in the same location as the trench dug during the investigation. The 005 Collection Trench was deeper than the investigation trench, extended further to the south and excavated in a straight line to facilitate installation of synthetic liner material.

The 005 Collection Trench was excavated to the top of sandstone. Digging continued until a solid sandstone surface was encountered and could not be removed with the track hoe. Some thin layers of sandstone were encountered but these were removed. The bottom of the trench was cleaned of loose soil and the water pumped out. The exposed sandstone surface at the trench bottom measured 104 feet long. This distance does not include the distance from the bottom at each end to the ground surface, which was sloped. Elevations were obtained for the exposed sandstone surface of the excavation. The south end of the trench was designated as the origin, and measurements were taken heading north from this location. The trench was dug 104 feet north from the south end, so the north bottom of the trench would be referred to as "104 feet North." Figure 1 shows the resulting 005 Collection Trench excavation.

One anomaly was discovered during excavation of the 005 Collection Trench. A hump in the sandstone was observed at about 87 to 90 feet North. Figure 2 is a picture taken of the hump and shows the irregular surface at this location. The hump in the sandstone surface dropped in elevation when moving in the north direction. Groundwater seepage was apparent at several locations along the east trench face. Most of the seepage appeared to be concentrated at locations where the composition of material appeared to be shale. Figure 3 shows one such location. The seepage locations also appeared to be elevated above the bottom of the trench at least one foot or more.

### Hydraulic Containment and Pump Back System

The geo-fabric and synthetic liner materials were draped over the west bank of the trench. The liner was extended onto the bottom of the trench about one foot and located immediately on top of the sandstone surface. Concrete was poured into the bottom of the trench to seal the liner to the sandstone. Figure 4 shows the concrete poured into the bottom of the trench. The concrete was thicker on the north end and sloped toward the south to provide drainage back to riser pipe.

After the concrete was poured a 15" perforated PVC riser pipe was placed at a location 58 feet north, which was the lowest elevation along the bottom of the trench. The riser was held in place with a backhoe until gravel was placed around the pipe for support. Figure 5 shows a picture of the riser pipe. Gravel was placed in the trench to a depth ranging from four to five feet deep. Holes had been drilled in the portion of the riser pipe where the gravel fill was placed to allow water to enter the pipe. The geo-fabric and liner were pulled over the top of the gravel. Backfill soil was placed in the trench above the liner and the area graded to match the topography.

Figure 6 shows a profile of the 005 Collection Trench. The layers from bottom to top consist of geo-fabric, synthetic liner, concrete, gravel, synthetic liner, geo-fabric and back fill soil. Figure 7 shows the placement of synthetic liner and geo-fabric over the gravel and around the riser pipe. The geo-fabric and liner were wrapped from the bottom along the west side of the trench and over the top of the gravel. The east side of the trench was left open to allow water to drain into and collect in the gravel contained in the trench. A pump placed into the riser pipe permits water to be pumped out of the containment system.

Figure 8 shows the area after final grading was completed. The riser pipe was located using GPS and found to be at 3930901N, 310921E (UTM NAD83, Zone 15). The coordinates were converted to State Plane Coordinates, NAD83, Oklahoma North 3501: 196380N, 2836112E. The elevation of the top of the riser is 531.74.

## Leak Detection Monitor Trench

A leak detection monitor trench (005 Monitor Trench) was installed downgradient from the 005 Collection Trench approximately 50 feet to the west. The 005 Monitor Trench was excavated down to bedrock in a location that was believed to be the bottom of the 005 drainage. The excavation began about 20 feet north of MW037 and continued for about 25 feet to the north. After digging for about 10 feet the sandstone surface ended and shale was encountered. The excavation was continued down several feet into the shale, below the depth of the sandstone, and no sandstone was encountered. The shale that had been excavated was therefore backfilled to the same elevation as the sandstone surface at the south end of the 005 Monitor Trench. The elevation at the bottom of the 005 Monitor Trench was about the same as the bottom of the 005 Collection Trench.

A sheet of synthetic liner was placed into the bottom of the 005 Monitor Trench. Two 10-foot sections of 4" perforated sewer pipe were placed on top of the synthetic liner and connected with a T to a 4" riser pipe in the center. Approximately two feet of gravel (river rock) was placed over the collection pipe in the trench. A sheet of synthetic liner was installed above the gravel before backfilling the trench with soil.

The 005 Monitor Trench riser pipe was located using GPS and found to be at 3930923N and 310909E (UTM NAD83, Zone 15). The coordinates were converted to State Plane Coordinates, NAD83, Oklahoma North 3501: 196450N, 2836069E. The elevation of the top of 005 Monitor Trench riser is 528.84. Figure 9 is a picture taken of the monitor trench during construction. Figure 10 shows the location of the collection and monitor trenches.

## Sample Location Identification

The old 005 Sump is designed as Sample ID 2224. The 005 Collection Trench and 005 Monitor Trench have been assigned Sample Location ID's 2224A and 2224B, respectively.

Figure 1. Open trench excavated to the top of sandstone. (Looking South)

Figure 2. Hump in sandstone surface between 87 and 90 feet north of bottom south end.

Figure 3. Seepage from east wall of trench - riser pipe placed at this location.

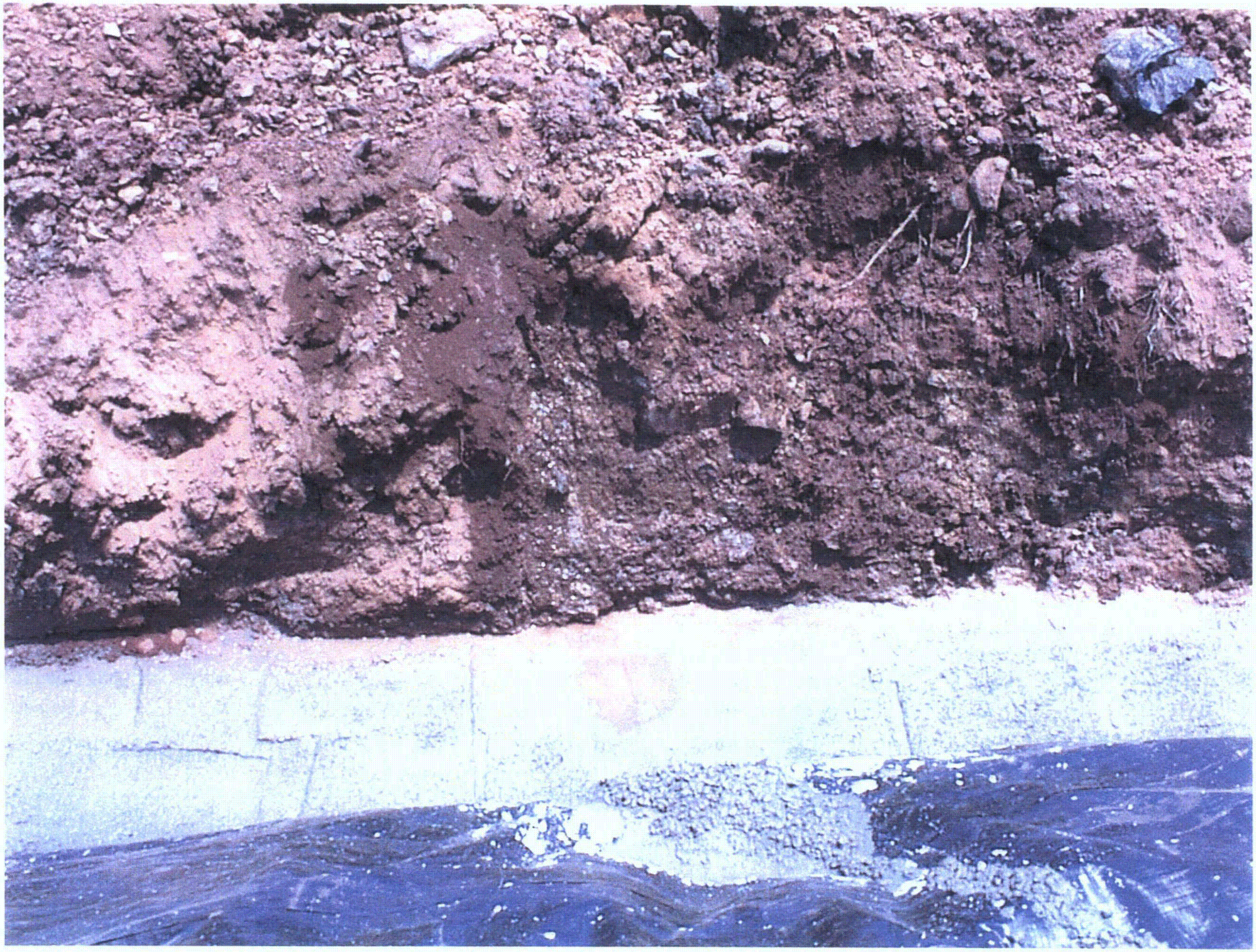
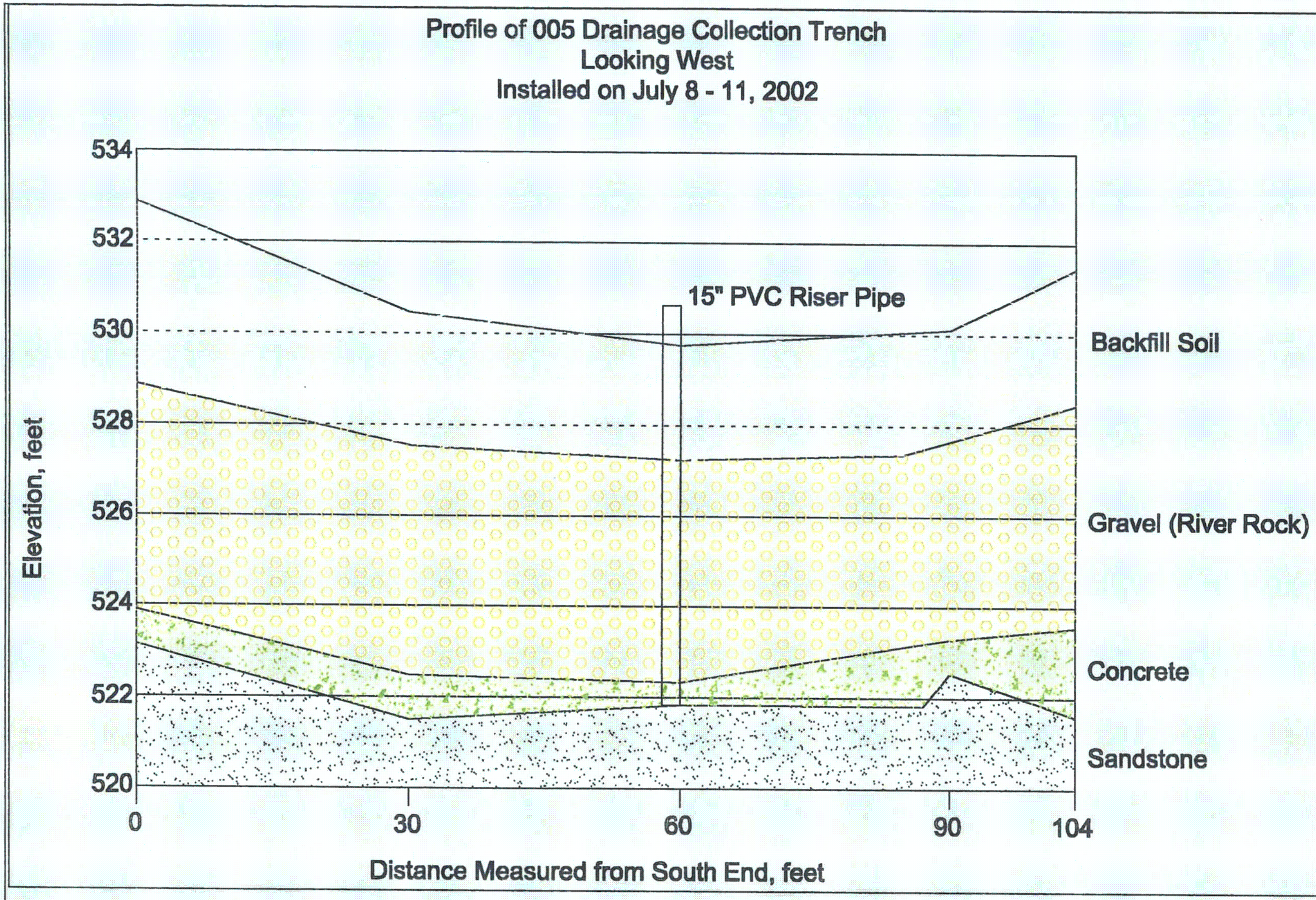


Figure 4. Concrete pour with liner along west bank. (Looking East)

Figure 5. Riser pipe positioned 58' from bottom south end. (Looking North)

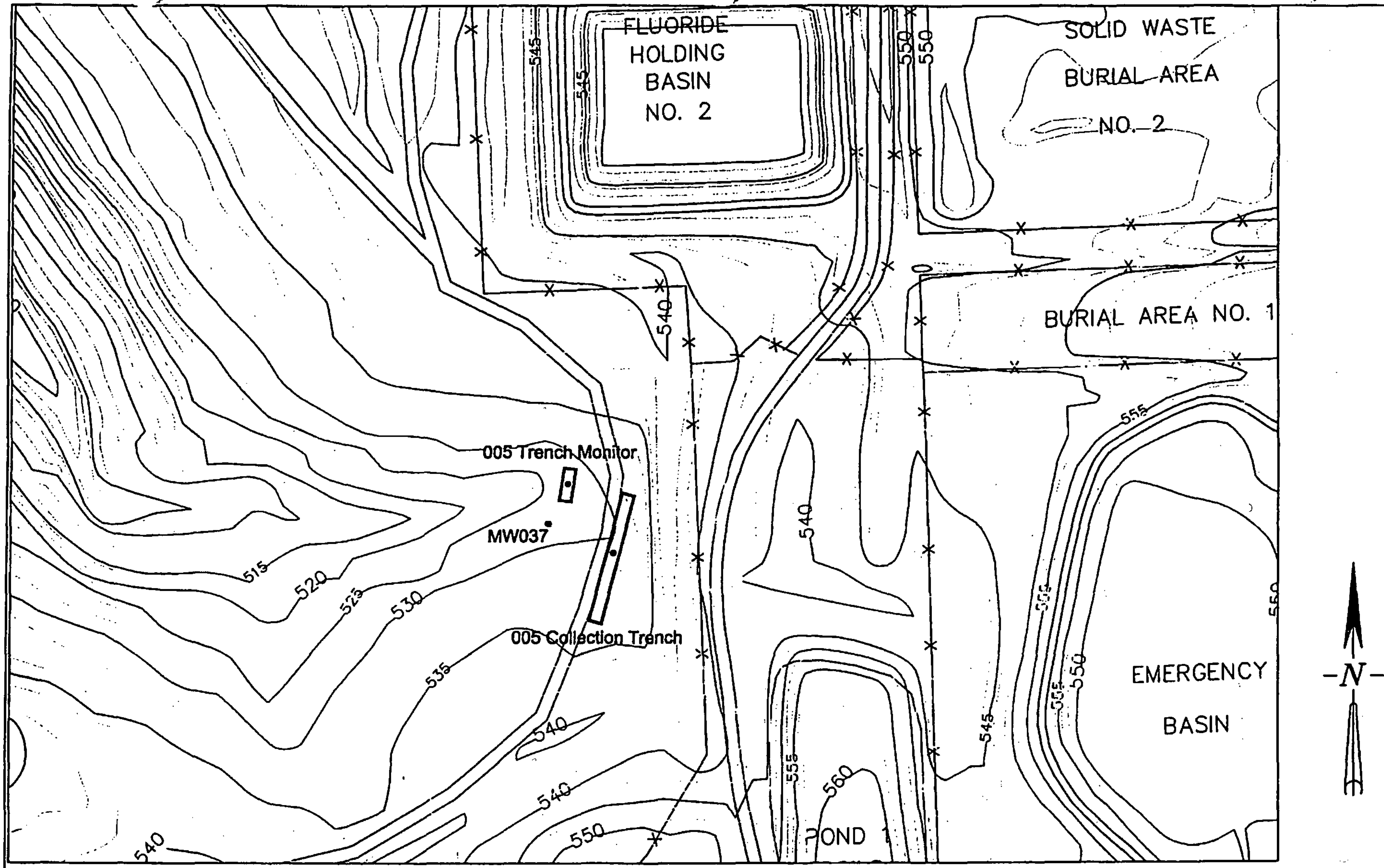



| SEQUOYAH FUELS CORPORATION<br>Installation of 005 Drainage Collection Trench | |
|---|---|
| Title: Profile of 005 Collection Trench | |
| PREPARED BY: SFC | Filename: 005TrenchProfile2 |
| Reviewed by: C Mooneyham | Figure No.6 |
| Date: 07/19/2002 | |

Figure 7. Placement of liner and geo-fabric over gravel. (Looking South)

Figure 8. Final grade of area with riser pipe showing. (Looking North)

Figure 9. Monitor trench construction. (Looking South)




| SEQUOYAH FUELS CORPORATION | |
|---|---|
| Installation of 005 Drainage Collection Trench | |
| Title: Location of 005 Collection Trench and 005 Monitor Trench | |
| PREPARED BY: SFC | Filename: 005TrenchRiserLoc |
| Reviewed by: C Mooneyham | Figure No.10 |
| Date: 07/18/2002 | |

## Installation of MW095A Collection Trench and Recovery Pit

### Introduction

Installation of a drainage collection trench and recovery pit between Pond 2 and Monitor Well MW095A was started in March and completed during the first part of April 2003. The collection trench and recovery pit were installed to intercept nitrate and arsenic impacted groundwater that is moving from the southwest corner of Pond 2 towards MW095A. Two investigation trenches had been excavated during November 2002 to identify possible groundwater pathways and to aid in design of a groundwater collection and recovery system. The Monitoring Well MW095A Trench Investigation report is included as Attachment 1.

### Trench Location and Excavation

The collection trench was installed at the location shown in Figure 1. This location is west of a sandstone ledge and spans the relative low point in the bedrock surface which appears to be the preferential flow path of groundwater from the Pond 2 area. Additionally, this location allowed excavation to a depth that should collect groundwater flow from east to west. The trench was extended southeast from the concrete riser in an uphill direction. This configuration should capture water that might be flowing downhill in this direction. Observations made during installation of the trench confirmed that the collection trench bottom elevation increased significantly between the concrete riser and the southeast end of the trench.

Excavation for the majority of the trench was into the top of the Unit 4 Shale. However, the trench was excavated to the top of Unit 4 Sandstone at the location of the concrete riser. This was also the deepest location as indicated on the profile of the trench provided on the bottom portion of Figure 1. The Unit 4 Shale could not be penetrated in the balance of the trench with a reasonable effort using excavation equipment. Therefore, the collection trench, with the exception of the concrete riser, was completed into the top of the Unit 4 Shale. Most of the water entering the collection trench was at or near the concrete riser.

There was also a significant amount of water identified at the western most end of the east-west investigation trench. SFC installed a recovery pit at this location. A significant amount of sandy soil was identified above Unit 4 Shale in the area near the concrete riser of the collection trench and near the recovery pit. Water levels taken from the collection trench and the recovery pit are at the same elevation, indicating that the sandy soil zone identified at each location is connected. The extent of the sand lens to the east of the collection trench was not determined but is believed to be the dominant flow feature from the Process Area. Pumping from these locations should significantly reduce the water in this area. The recovery pit should also provide a means for assessing the effectiveness of the collection trench.

A cross section has been prepared to show the geology of the area where the collection trench and recovery pit were installed. The location of this cross section (Cross Section A-A') is shown in Figure 1. The cross section has been included as Figure 2. Most of the water in this area appears to be contained in a silty sand layer above unit 4 shale. A picture take of the shale and silty sand near the location where the concrete riser was installed in the collection trench is included as Figure 3.

### Hydraulic Containment and Pump Back System

Because of the depth of the trench and the observed instability of the side walls a trench box with solid sides was utilized to construct the trench. This allowed laborers to assist in mechanically cleaning the bedrock surface and placement of a synthetic liner. The trench was excavated to the level at which the excavation equipment, track hoe, couldn't penetrate rock. In most of the trench, this was a hard silty shale immediately overlying a sandstone unit. The liner placement was started at the center of the trench bottom and extended up the downgradient side of the trench. Lateral line rock was used to "anchor" the liner to the top of the bedrock. The liner was not "sealed" to the bottom. Perforated sewer pipe was placed on top of the liner at the bottom of the trench and from five to six feet of lateral line rock placed above the pipe. The lateral line rock filled the width of the trench, which was approximately four feet. Holes were also drilled in the bottom five feet of the manhole to provide a pathway for any water collecting in the lateral line rock to flow directly into the manhole. The synthetic liner material was extended across the top of the lateral line rock prior to backfilling the trench to prevent sediment from entering the lateral line rock.

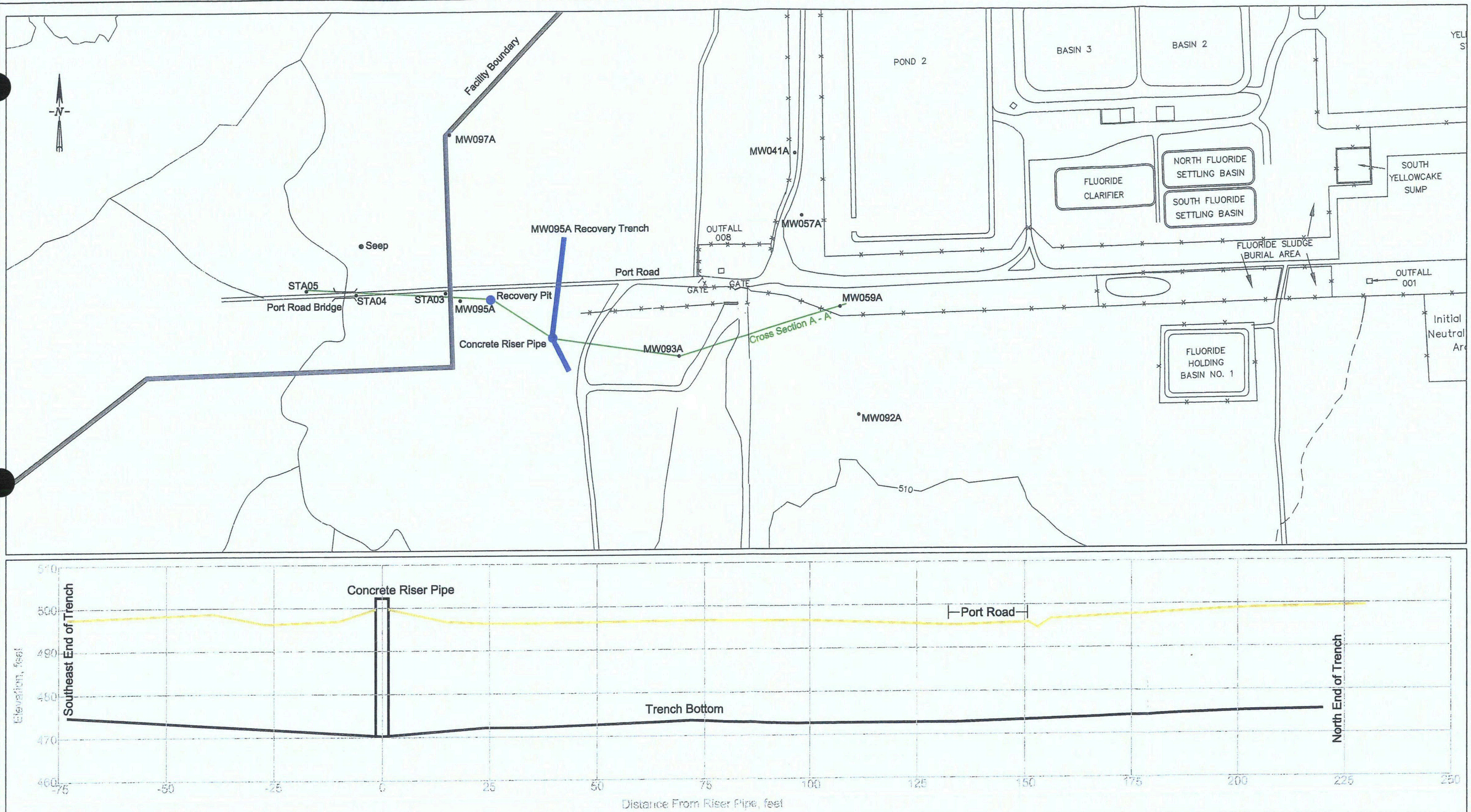
SFC plans to operate a pumping system for the MW095A recovery trench automatically. A timer module will be installed to turn the pump on at a predetermined frequency and shut off with a level switch. The frequency for the timer module will be adjusted depending on the groundwater recovery conditions encountered. SFC anticipates that a large volume of water will be recovered initially and should decrease with time. Appropriate adjustments will be made. Recovered groundwater will be pumped to a storage pond pending approval for land application of the material.

**Recovery Pit**

A recovery pit was excavated at the location shown in Figure 1. The pit is 11 feet in the north-south direction and 23 feet in the east-west direction. The total depth of the trench was about 18 feet. An 18 inch ID stand pipe with slots cut in the bottom part of the pipe was placed into the excavation and about nine feet of lateral line rock placed into the bottom around the stand pipe. A poly liner was placed on top of the lateral line rock prior to backfilling to prevent sediment from moving into the lateral line rock.

**Sample Location Identification**

The MW095A Collection Trench and Recovery Pit have been assigned location identification numbers 2247 and 2247A, respectively.

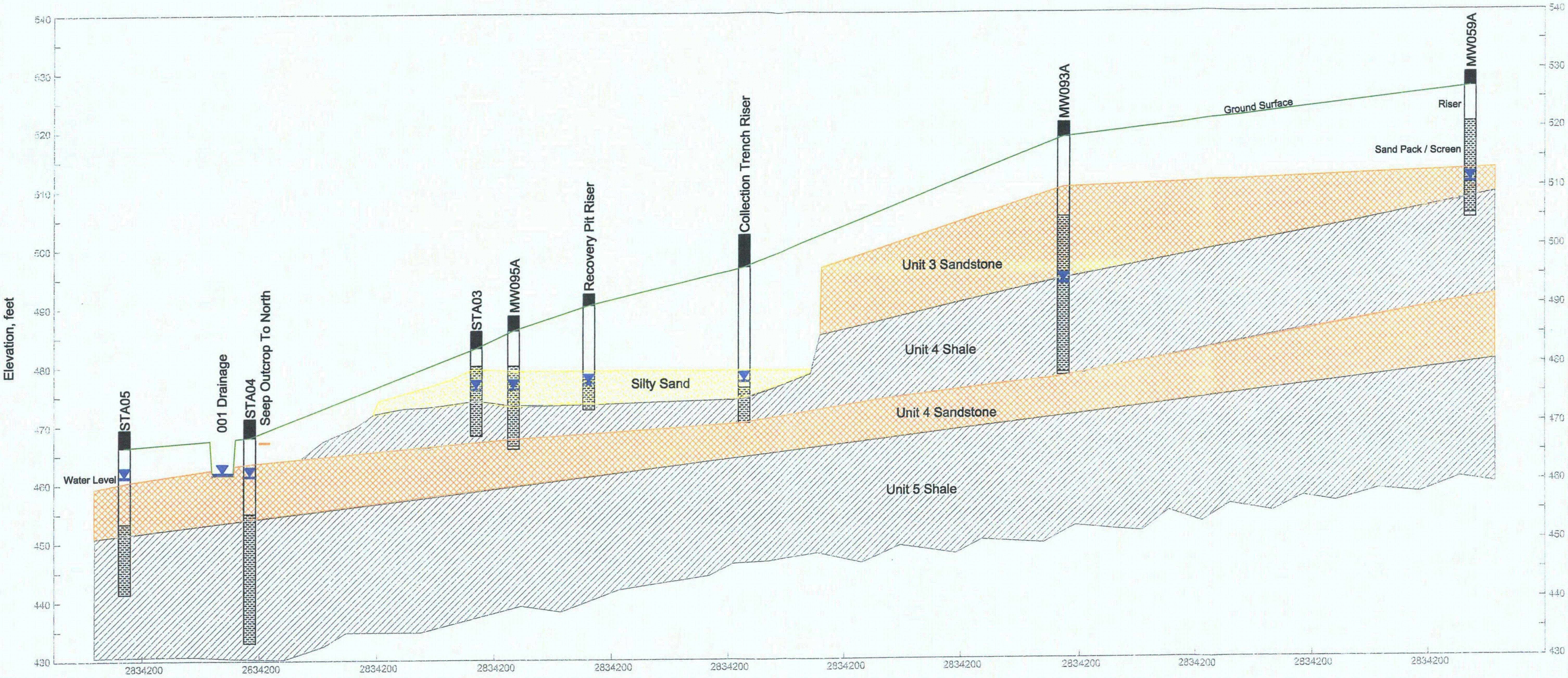



Profile of MW095A Recovery Trench - Looking West

Legend

- Trench Location
- Ground Surface
- Trench Bottom

| | |
|---|---|
| **SEQUOYAH FUELS CORPORATION**<br>Monitor Well MW095A Trench Installation | |
| Title: Trench Location and Profile | |
| Prepared By: SFC | Filename: Figure1B.dwg |
| Reviewed by: CM | Figure No. 1 |
| Date: 06/03/2003 | |




Cross Section Looking North

SEQUOYAH FUELS CORPORATION

Monitor Well MW095A Trench Installation

| | |
|---|---|
| Title: Cross Section A - A' | |
| Prepared By: SFC | Filename: Figure2C.dwg |
| Reviewed by: CM | Figure No. 2 |
| Date: 06/11/2003 | |

**Figure 3**. Water entering the excavation (concrete riser pipe location) at the interface of sandy soil and black shale.

# Attachment 1

## Monitoring Well MW095A Trench Investigation

## Monitoring Well MW095A Trench Investigation

### Introduction

Groundwater samples collected from Monitor Well MW095A, which is located just south of Port Road at the Facility west property boundary, have shown elevated concentrations of nitrate and arsenic. Elevated concentrations of nitrate and arsenic have also been observed at a seep located just north of Port Road Bridge. The source of the contamination in this area is most likely the impacts near the southwest corner of Pond 2 observed at Monitor Wells MW057A and MW059A. However, the pathway by which contamination is reaching groundwater near MW095A was not known. To better understand the possible pathways and to aid in designing a collection and recovery system SFC decided to excavate a trench to the top of bedrock in an effort to identify the groundwater unit that is transmitting water migrating towards MW095A. After completion of the first trench in an East-West direction, a second trench was completed in a North-South direction. This report describes the trench excavations and a proposed collection and recovery system.

### East-West Trench Excavation

On November 4, 2002 trenching began north of MW093A and proceeded west towards MW095A. The location of this trench is shown on Figure 1. The excavation was fairly shallow until moving west of the 008 Pipeline, where a significant depth change at WP09 as the edge of the sandstone was reached. Black shale was first encountered after dropping off the edge of the sandstone. Significant sandy seams that were several feet thick began to appear west of the 008 pipeline at WP11. The sandy seams observed near WP11 were dry. The first seepage and pooling of water was observed at WP12. At this location there was 8 to 10 feet of sandy soil above the bedrock surface. Significant amounts of sand continued to be observed west of WP12. Because of the amount of sand, the trench caved in several hours after excavation. The trench was stopped due to cave-in problems at WP15. Black shale was observed at the excavation near WP15. Significant water was flowing into the trench, including a significant amount from the west. The water was coming from the sand that was above the black shale layer. Rather than continuing the trench west a pit was excavated at WP16. The pit collected a significant amount of water, approximately 2 feet, within an hour after excavation. Water samples were collected from near WP12, WP15 and WP16. Analyses indicate that significantly elevated concentrations of nitrate and arsenic are present in the groundwater seeping into the trench. The results are included in Table 1.

Pictures taken of the East-West Trench during excavation are included in Appendix A. Figure 2 shows the location of the pictures. A description of the pictures is provided below:

Picture 1: Excavation of East-West Trench looking west at drop off (end of upper sandstone).

Picture 2: West end of East-West Trench. Note amount of sandy soil encountered.

Picture 3: Pit excavated at west end of East-West Trench. Water filling bottom from sandy type soil.

Picture 4: Pit excavated at west end of East-West Trench. Significant amount of water collected in a few hours.

Picture 5: Looking east a MW095A with Pit and East-West Trench in background.

The East-West Trench and pit at the west end of the trench were completed on November 6, 2002. GPS readings were taken at each way point (WP) and the distances measured between each way point. A cross-section of the East-West Trench showing the ground and bedrock surfaces in attached as Figure 3. Figure 3 also includes a summary of the lithology identified for several monitoring wells and the profile of the North-South Trench. The trench was back filled several days later. The pit was left open so that the water could be pumped out. Analysis of samples collected of water from the trench indicated the groundwater at the west end of the East-West Trench contains significantly elevated levels of nitrate and arsenic. The pathway connecting to the source of contamination with the impacted water near the west end of the East-West Trench was not identified. Therefore, a determination was made that an additional trench should be excavated in a North-South direction intersecting the East-West Trench.

North – South Trench Excavation

After completion of the East-West Trench it was determined that a North-South Trench should also be excavated to aid in identification of the pathway for movement of the contaminated groundwater from near the southwest corner of Pond 2 to the MW095A area. A North-South Trench was started on November 7, 2002 at WP17 shown in Figure 1. The trench was approximately 17 feet deep, with about 1 foot of black shale at the bottom. The depth to sandstone increased as the excavation continued to the south. A shallow layer of shaley sandstone was also encountered along with a very hard clay layer. Sandy soil was located below the clay and above the black shale. At WP 18 sandstone was hit at a depth of 20 feet. Sandstone was hit at a depth of 22 feet at WP19, with about 2.5 to 3 feet of black shale above the sandstone. At WP20 the trench was about 22 feet deep, with approximately 5 to 6 feet of shale above the sandstone. There is a 2 to 3 foot layer of sandy soil above the shale layer. This sandy layer was present the entire distance between WP17 and WP20. After several days a small amount of water was observed in a puddle at the bottom of the north end of the trench, 25 feet south of WP17. This location was designated as WP17A.

More water began to be observed at WP22. The black shale above the sandstone was getting thicker and several small puddles began to form in the trench bottom. The black shale layer was about 11 feet thick at WP22, with the total depth of the trench being approximately 22 feet. At WP 23 the black shale layer was 11 feet thick and the trench depth was 25 feet. At WP 24 a fairly hard layer of stone was hit at about 13 feet deep. After about 10 feet the sandstone was removed with the track-hoe. Discussions with the track-hoe operator indicated that this layer of fairly hard sandstone had been present for most of the excavation. The layer is about a foot thick. More water was observed as the excavation continued to the south. Standing water was present in the trench several hours after the excavation. The excavation continued to WP25 on November 13, 2002. The bottom of the excavation appears to be in the black shale and may not be on top of sandstone. The black shale could be slowly removed but was hard and difficult to excavate. A significant amount of water collected in the trench at WP25.

The excavation continued south across Port Road (WP26). Water was observed seeping into the trench as the excavation was in progress. About 1 foot of black shale is present at the bottom of the trench, however, the black shale is very hard and difficult to excavate. Water appears to be seeping in from the bottom of the trench. The total depth of the trench at WP26 is about 21 to 22 feet deep. As excavation continued south of Port Road a significant amount of water collected in the trench. At WP27, 30 feet south of Port Road, the trench bottomed out on a very hard surface that appears to be sandstone. At the intersection of the East-West Trench the North-South Trench (WP28) was about four feet deeper than the East-West Trench. The excavation continued to the south. At WP30 the depth to the bottom of the excavation was about 23 feet. The top of the black shale layer appears to have dropped and there is a layer of sandy soil above the black shale, the sandy layer is 8 to 10 feet thick. There is a thin sandstone layer at the top of the sandy layer. At this location the water appears to be coming from the black shale layer and not the sandy layer above the black shale. Trench continued to south after WP30 but curved to the southwest because of the location of the 008 Pipeline and ended near the 001 Pipeline. The 001 Pipeline was buried only 1 to 2 feet below the surface. The sandstone surface drops from the north to south end of the North-South Trench about 14 feet in elevation. A cross-section of the East-West Trench showing the ground and sandstone surfaces in attached as Figure 4. Water samples were collected at WP22, WP23, WP25, WP26, WP28, WP29, WP30 and WP31. The analyses for these samples are included in Table 1.

The North-South Trench was back filled to about five feet below the original ground surface so that the collection and recovery system trench can be excavated to the sandstone surface below the black shale. After the back filling was completed two pits were dug to confirm where the top of the sandstone surface was located. The first pit was dug at WP30. The elevation of the top of sandstone was determined to be at 471 feet. There was about 4 feet of black shale above the sandstone with water coming from the sandy layer that is above the black shale. There was a significant amount of water entering the pit. The pit was 150 feet south of the north edge of Port Road. A second pit was dug at the intersection of the East-West and North-South Trenches (WP28). The elevation of the top of the sandstone was determined to be at about 473 feet. There was about 2 feet of black shale above the sandstone. There was no water present and none appeared to be collecting in the pit. Elevations from the trench immediately north of this pit during excavation of the trench indicate that there may be a slight hump in the sandstone surface. However, all elevations and depths are approximate and therefore this may by attributed to measurement error. The second pit was located 55 feet south of the north edge of Port Road. Both pits were back filled shortly after excavation of the second pit was completed because rainfall was predicted.

Pictures taken of the North-South Trench during excavation are included in Appendix A. Figure 2 shows the location of the pictures. A description of the pictures is provided below:

Picture 6: North end of North-South Trench. Small amount of water but mostly dry. Note black shale layer approximately 2 feet thick at bottom of trench.

Picture 7: Looking north at north end of North-South Trench. Note that black shale layer becomes thicker and increases in thickness to about 5 feet. Excavation to top of very hard surface believed to be sandstone.

Picture 8: North-South Trench with no water present.

Picture 9: North-South Trench at about same location as Picture 8 showing water that collected in a few spots overnight.

Picture 10: North-South Trench north of Port Road. More water collecting at this location overnight.

Picture 11: North-South Trench at Port Road. Water seeping into trench shortly after excavation.

Picture 12: North-South Trench. Much more water collecting in trench. Water appears to be coming from black shale layer, not sandy soil above shale.

Picture 13: Looking at west bank of North-South Trench excavation. From bottom there is a black shale, sandy/gravel layer, thin sandstone layer, hard clay and topsoil.

Picture 14: North-South Trench at intersection with East-West Trench – looking north. North-South Trench is about 4 feet deeper than East-West Trench.

Picture 15: Looking south at North-South Trench excavation south of Port Road.

Picture 16: Looking south at the North-South Trench excavation, near curve to the southwest, at the south end of the trench.

Proposed Collection and Recovery System

Most of the water found during the trenching was located at the south end of the North-South Trench. Therefore, the collection trench should be located in this area. The south end of the investigation trench turned to the southwest between WP30 and WP31 in order to avoid the 008 Pipeline. The proposed location of the collection trench has been moved to extend southeast of WP30 in order to more effectively intercept groundwater flowing in this area. The proposed location of the collection trench is shown in Figure 5. The collection trench will be constructed by completing the excavation to the top of the sandstone surface. Liner material will be placed along the west side of the trench and extend out about half way across the trench bottom. Bentonite will be placed on the bottom of the trench to seal the liner material to the sandstone surface. Gravel should be placed into the trench to a depth of about six feet. The liner material should be cut off and draped over the top of the gravel to minimize infiltration of surface water. The trench will be back filled to the original ground surface.

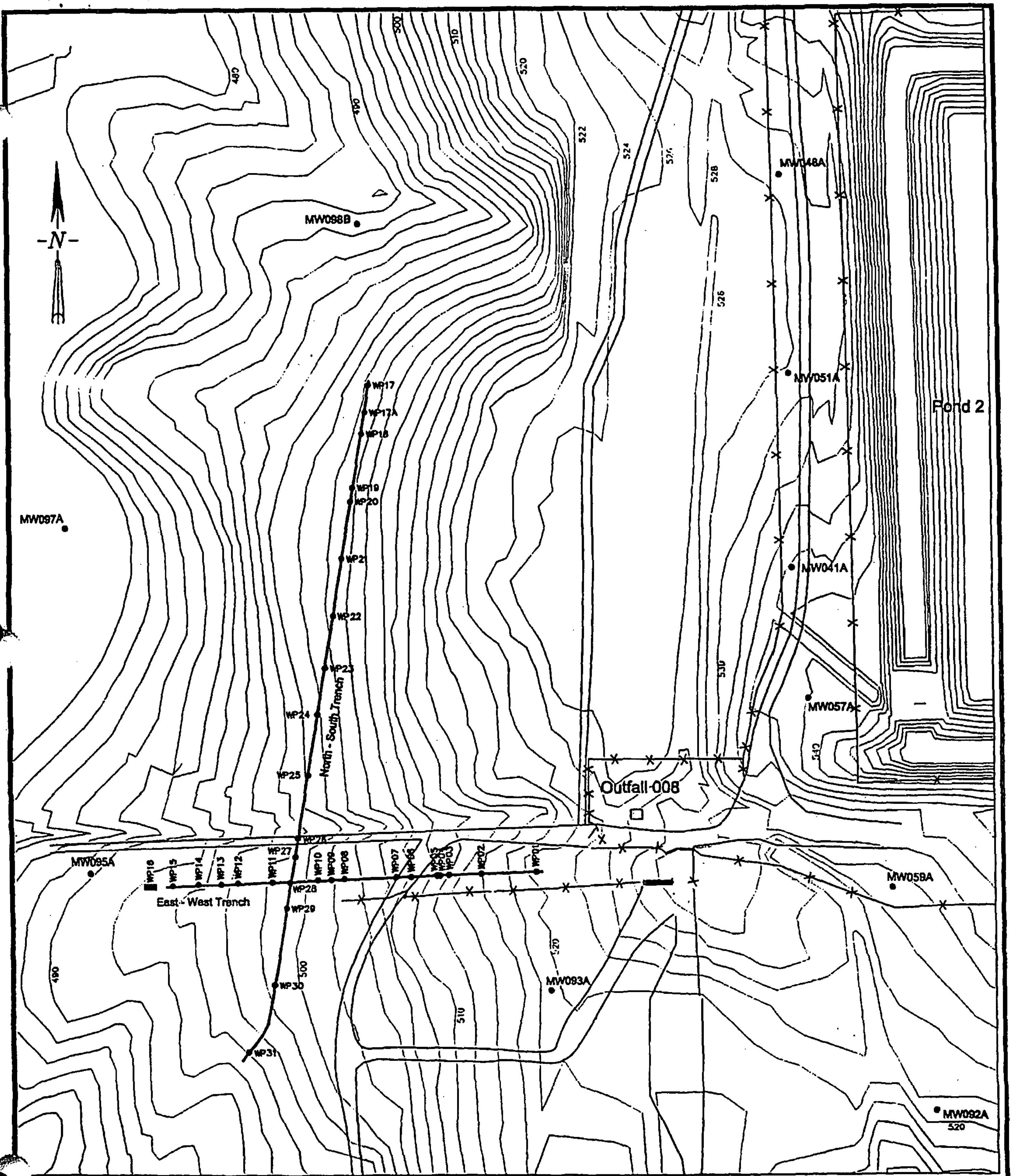
At the deepest location of the trench a collection sump will be installed. A concrete manhole with two ports cut in the bottom to receive pipes will be placed in the trench. A section of perforated pipe will be installed at the bottom of the trench coming out of each side of the concrete collection sump. The pipes will be placed on top of the liner material that is sealed to the bottom of the excavation and gravel installed in the trench as described above. The proposed collection system configuration is represented in Figure 6.

An estimate of the project cost for the collection and recovery system needs to be determined. A Request for Proposal has been prepared and will be sent to two contractors.

Table 1
Results for Samples Collected from Trench Investigation

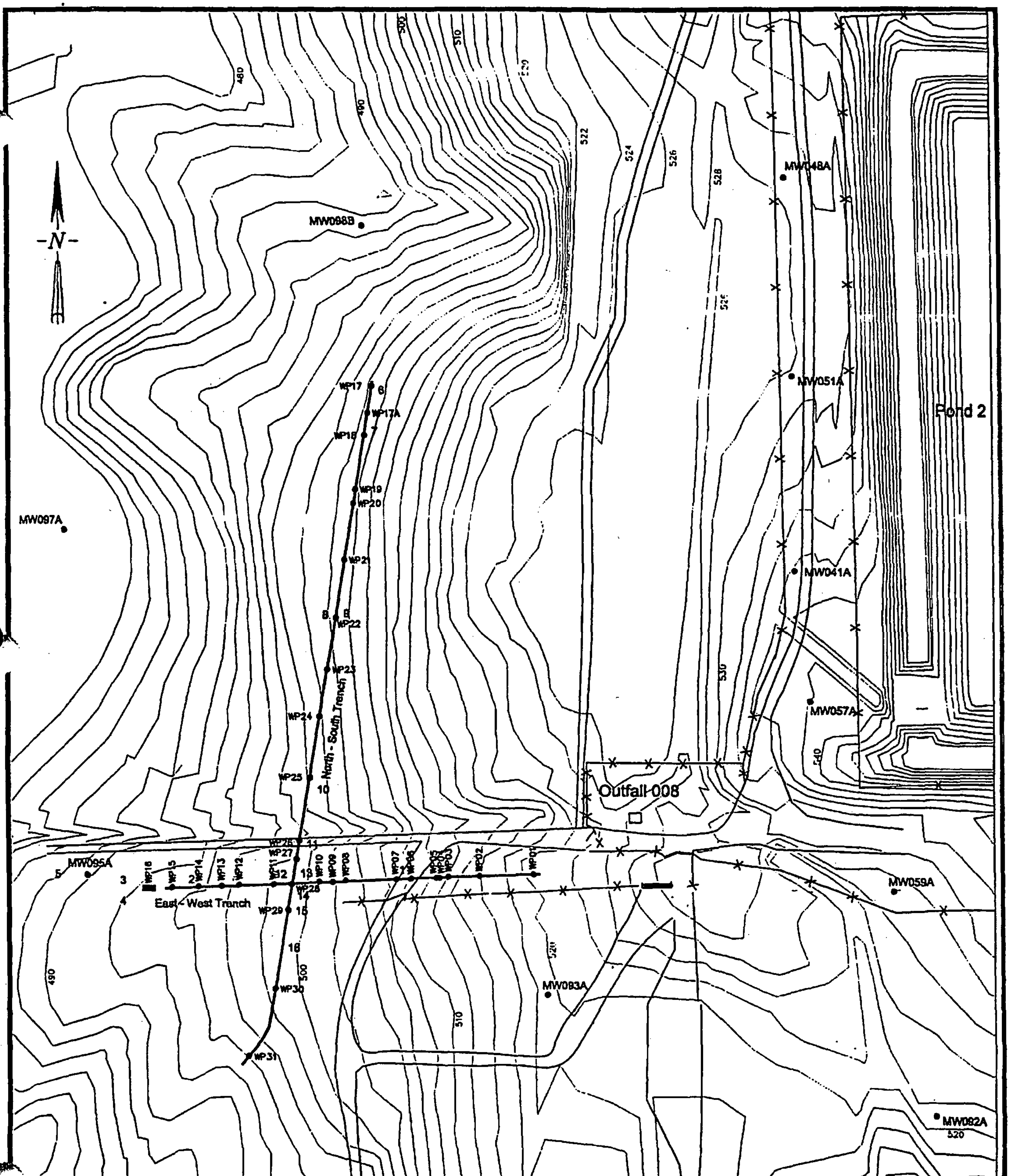
| Location | Date Sampled | Nitrate mg/l | Arsenic mg/l | Uranium µg/l |
|---|---|---|---|---|
| WP12 | 11/06/2002 | 2010 | 0.057 | 2.90 |
| WP15 | 11/06/2002 | 1750 | 0.120 | 2.39 |
| WP16 | 11/06/2002 | 1510 | 0.177 | 3.04 |
| WP22 | 11/15/2002 | 530 | 0.047 | 10.3 |
| WP23 | 11/13/2002 | 643 | 0.027 | 5.31 |
| WP25 | 11/14/2002 | 1410 | 0.024 | 7.30 |
| WP26 | 11/19/2002 | 1253 | 0.026 | 11.5 |
| WP28 | 11/20/2002 | 1230 | 0.026 | 3.30 |
| WP29 | 11/22/2002 | 1750 | 0.071 | 5.34 |
| WP30 | 11/22/2002 | 2710 | 0.176 | 5.67 |
| WP31 | 11/22/2002 | 1910 | 0.418 | 4.38 |

Note: For comparison the drinking water standards for nitrate, arsenic and uranium are 10 mg/l, 0.01 mg/l (effective January 23, 2006) and 30 µg/l (effective December 8, 2003), respectively. The current arsenic standard is 0.05 mg/l.




**SEQUOYAH FUELS CORPORATION**
*Monitor Well MW095A Trench Investigation*

| | |
|---|---|
| TITLE | *Trench and Wapoint Locations* |
| PREPARED BY: SFC | FILENAME: *Figure1* |
| REVIEWED BY: CM | FIGURE NO. 1 |
| DATE: 12/09/2002 | |




**SEQUOYAH FUELS CORPORATION**
**Monitor Well MW095A Trench Investigation**

| | |
|---|---|
| TITLE | Approximate Location of Pictures |
| PREPARED BY: SFC | FILENAME: Figure1 |
| REVIEWED BY: CM | FIGURE NO. 2 |
| DATE: 12/09/2002 | |

Figure 3
E-W Trench Excavated Nov2002

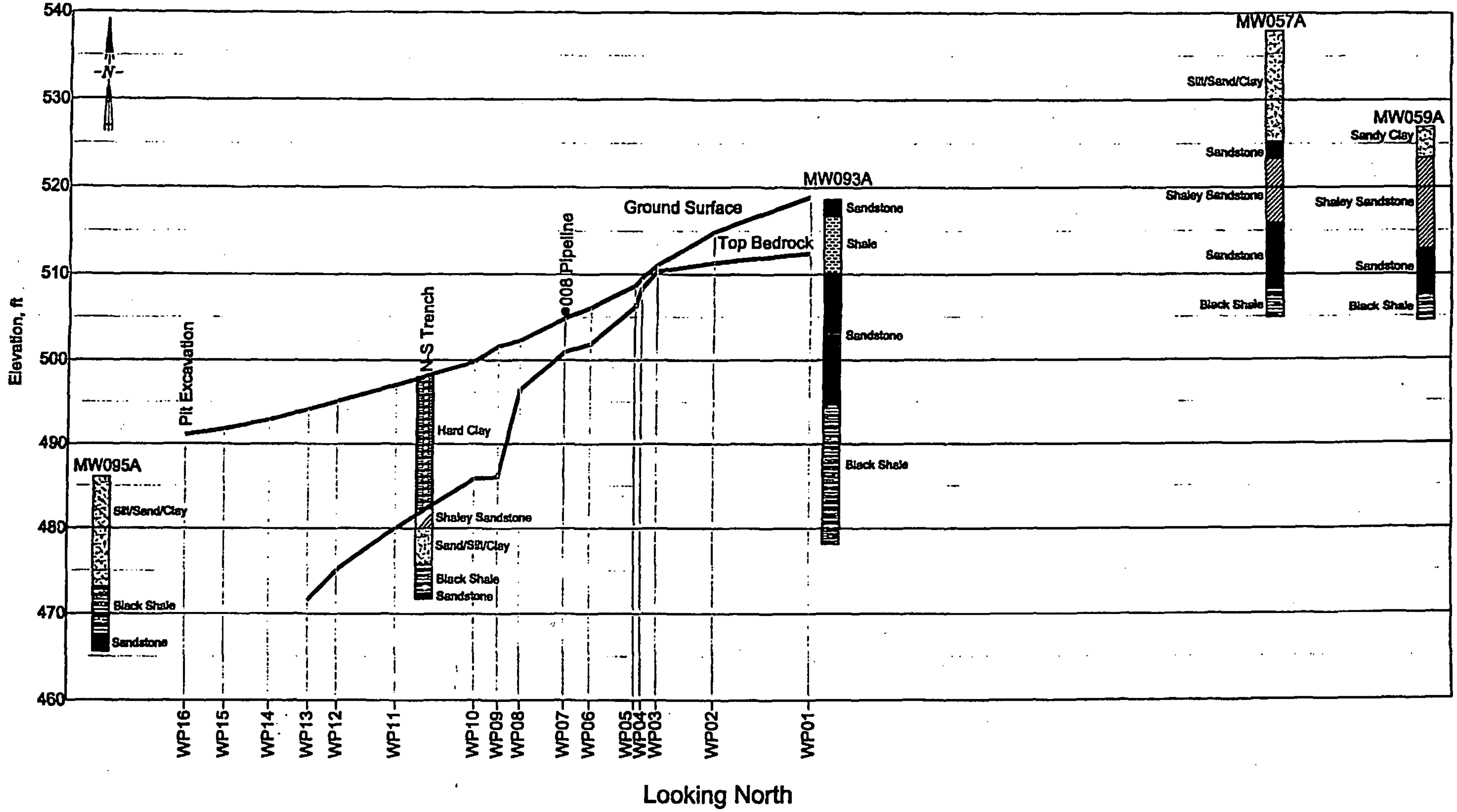
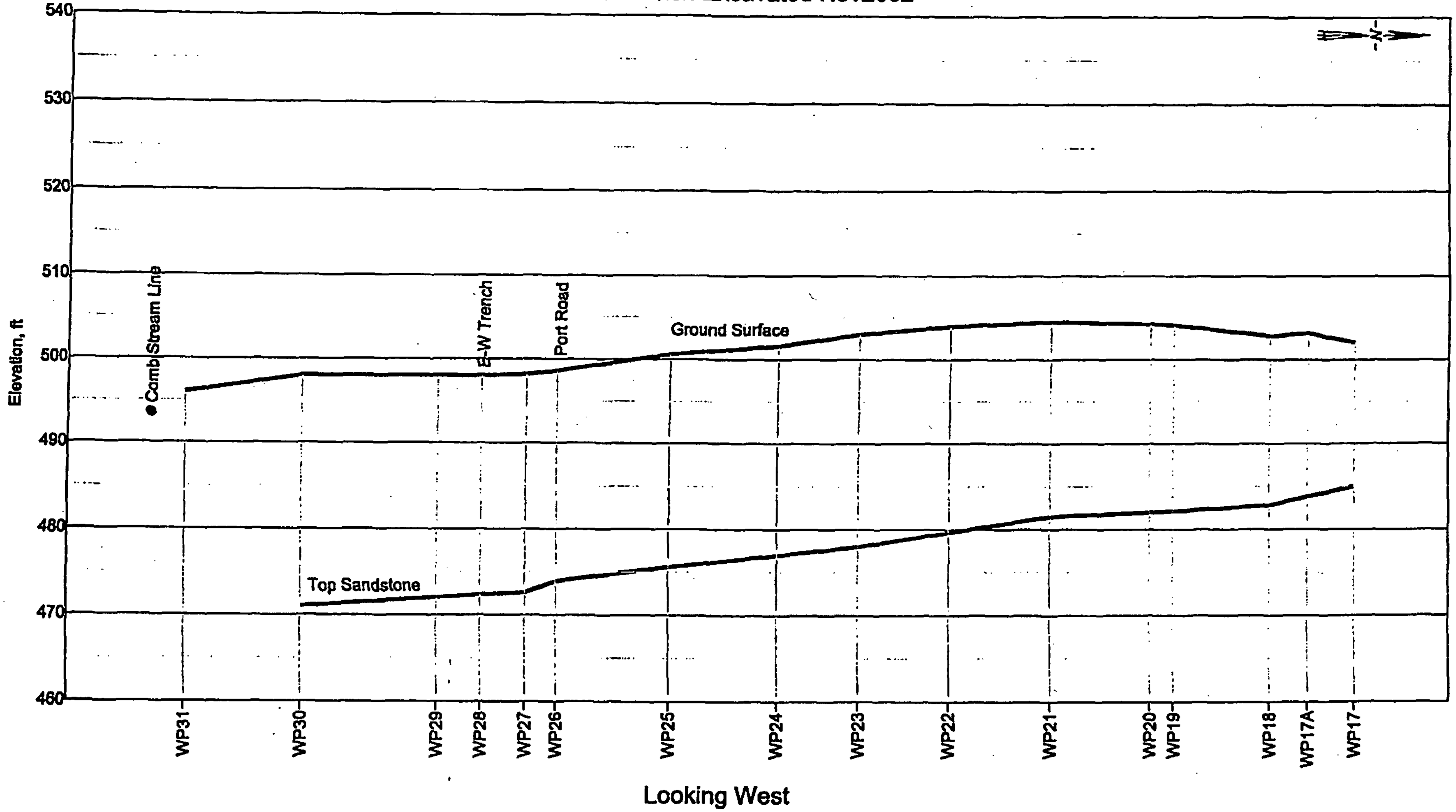
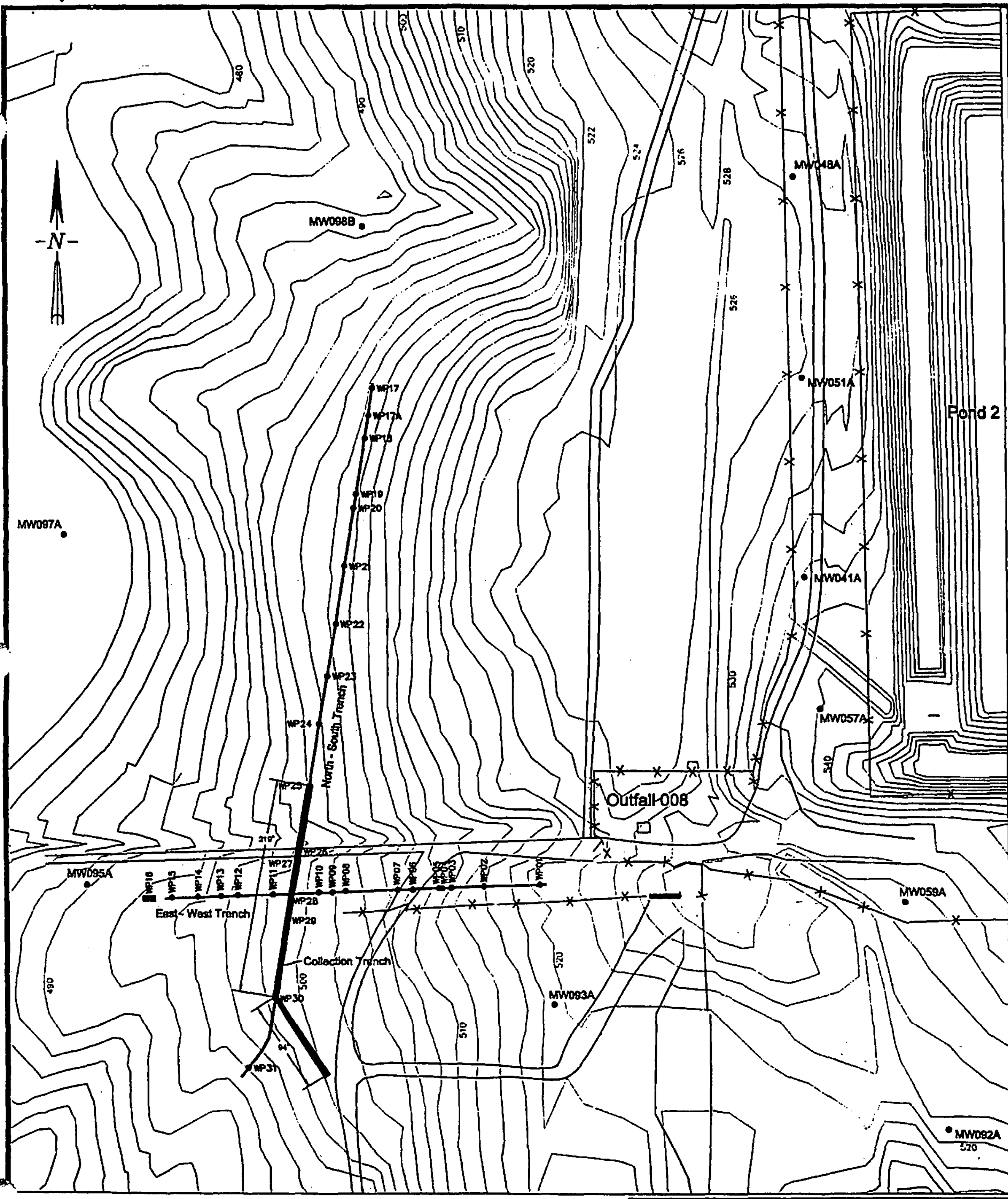


Figure 4
N-S Trench Excavated Nov2002

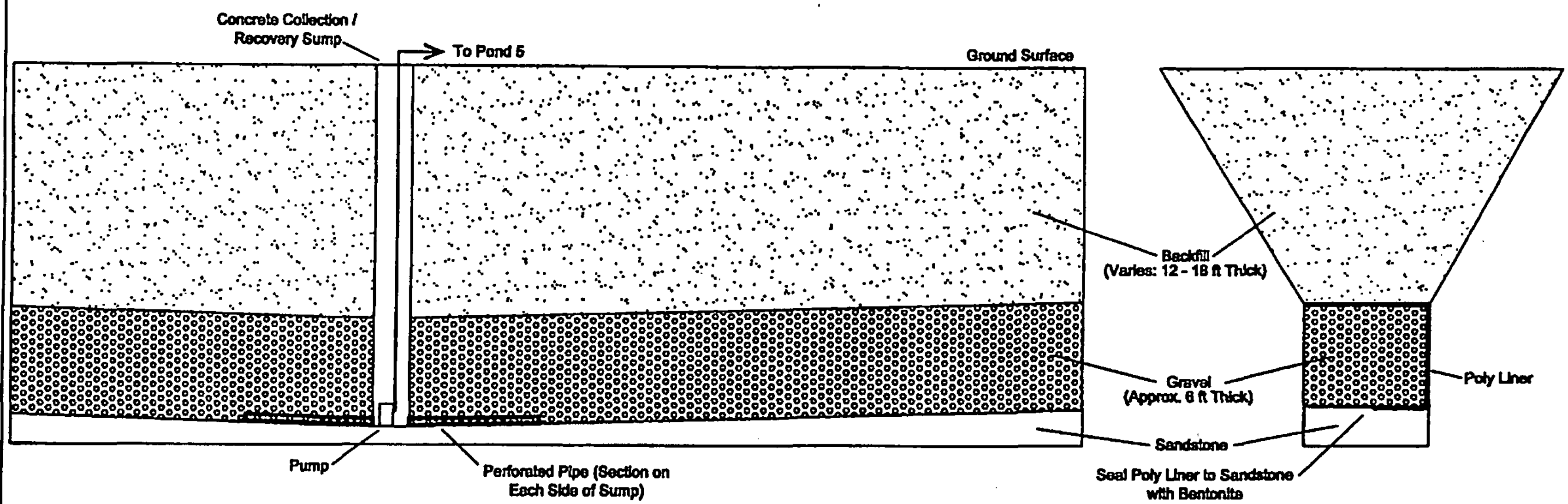





**SEQUOYAH FUELS CORPORATION**
**Monitor Well MW095A Trench Investigation**

| | | | |
|---|---|---|---|
| TITLE | Location of Proposed Collection Trench | | |
| PREPARED BY | SFC | FILENAME | Figure5 |
| REVIEWED BY | CM | FIGURE NO. 5 | |
| DATE | 12/09/2002 | | |

## Proposed Collection Trench
## N-S Trench Between Pond 2 and MW095A




Front View
View From East Side of Trench Looking West

Side View
View From North Side of Trench Looking South

SEQUOYAH FUELS CORPORATION
Monitor Well MW095A Trench Investigation

TITLE: Proposed Collection System Configuration

| | |
|---|---|
| PREPARED BY | SFC |
| REVIEWED BY | CM |
| DATE | 12/09/2002 |
| FILENAME | Figure6 |

FIGURE NO. 6

# Appendix A

## Pictures Taken During Trenching

# Pictures Taken During Trenching

Picture 1

Picture 2

Picture 3

Picture 4

Pictures Taken During Trenching

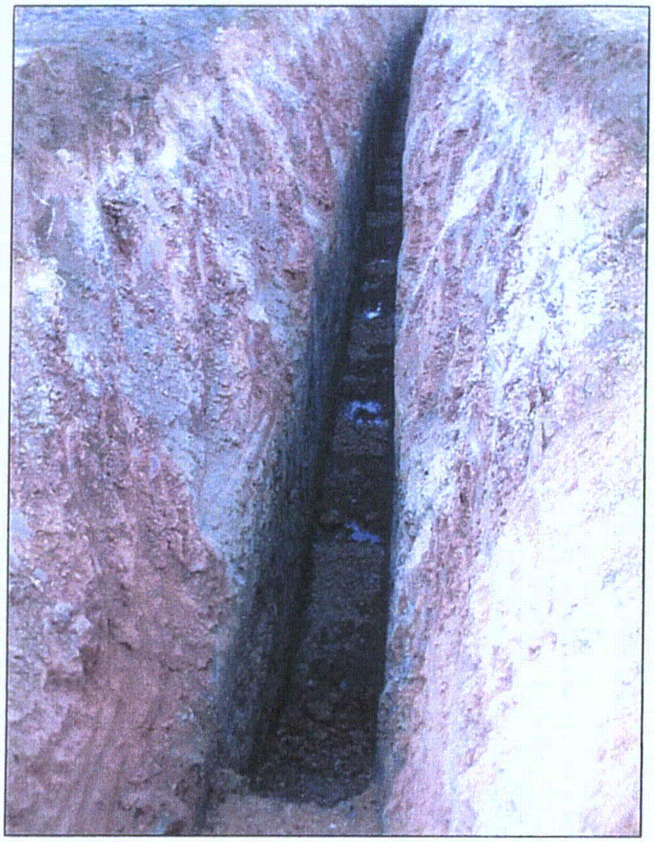
Picture 5

Picture 6

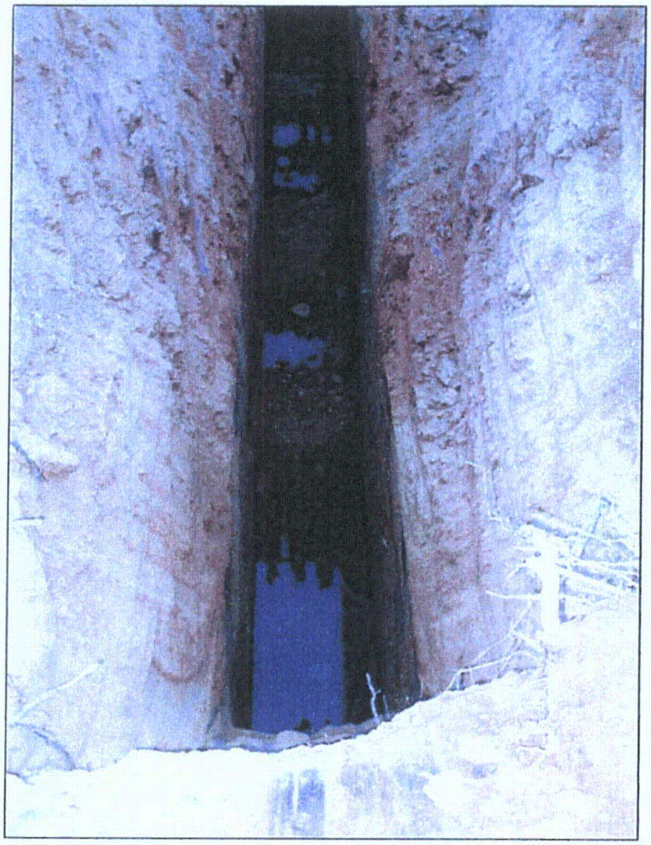
Picture 7

Picture 8

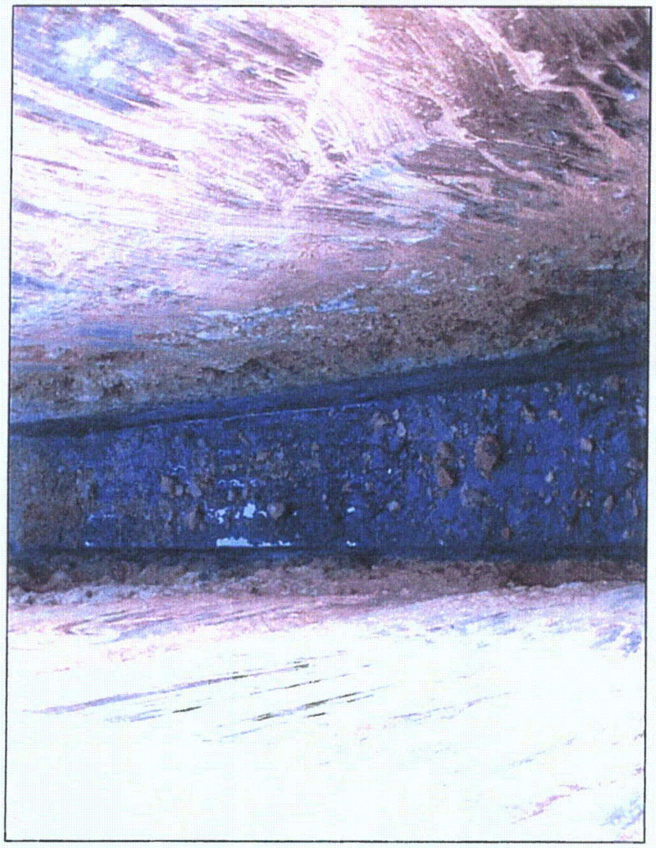
Pictures Taken During Trenching



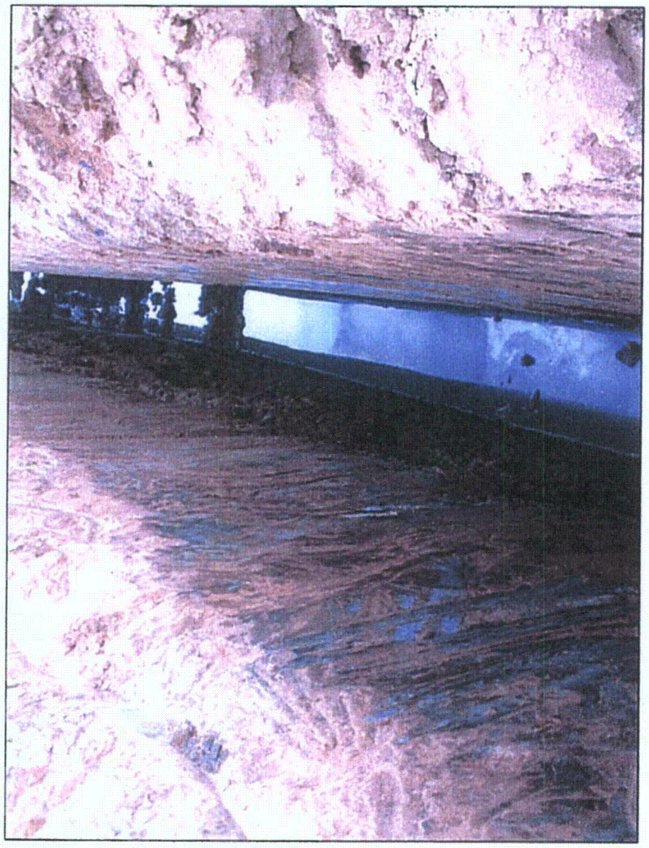
Picture 9



Picture 10



Picture 11

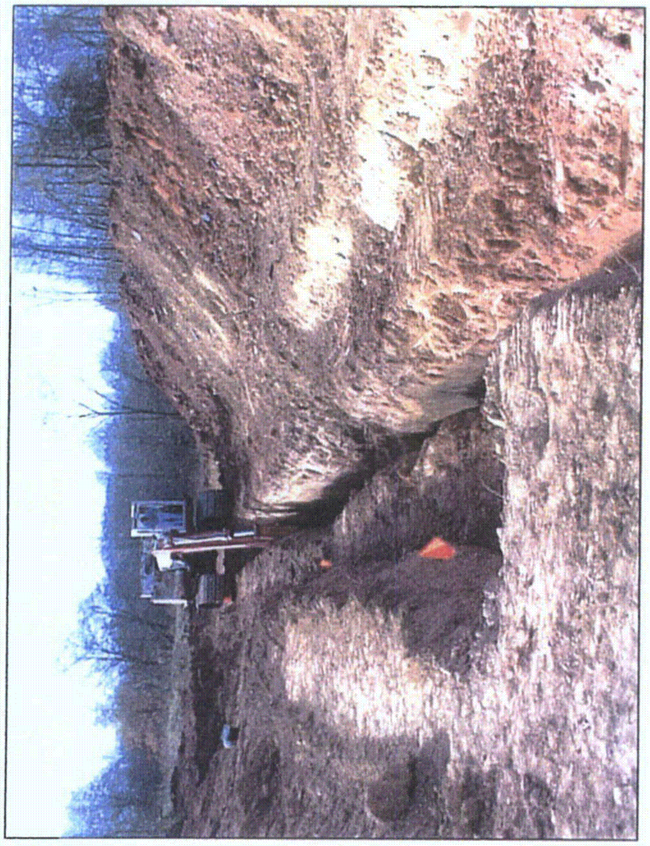


Picture 12

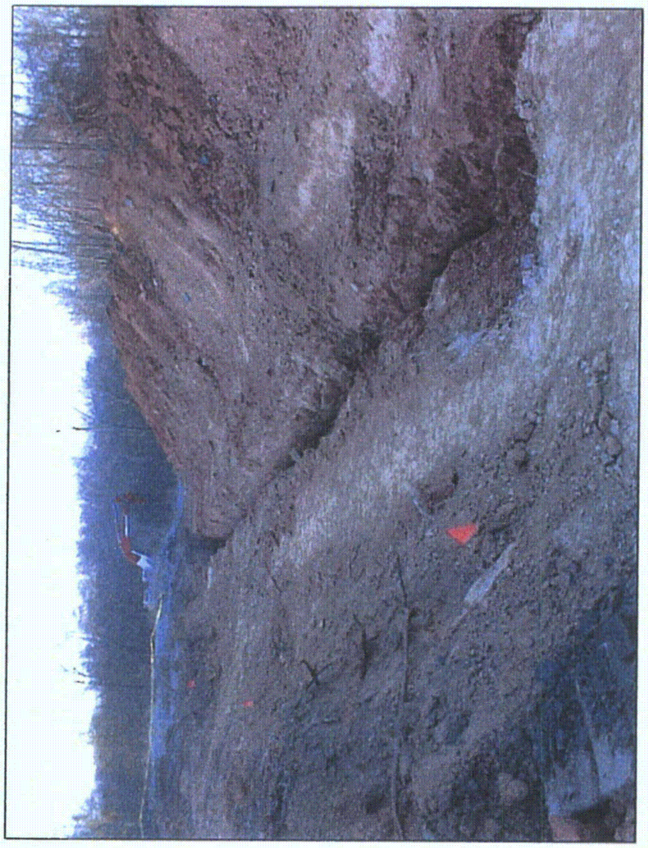
# Pictures Taken During Trenching

Picture 13

Picture 14

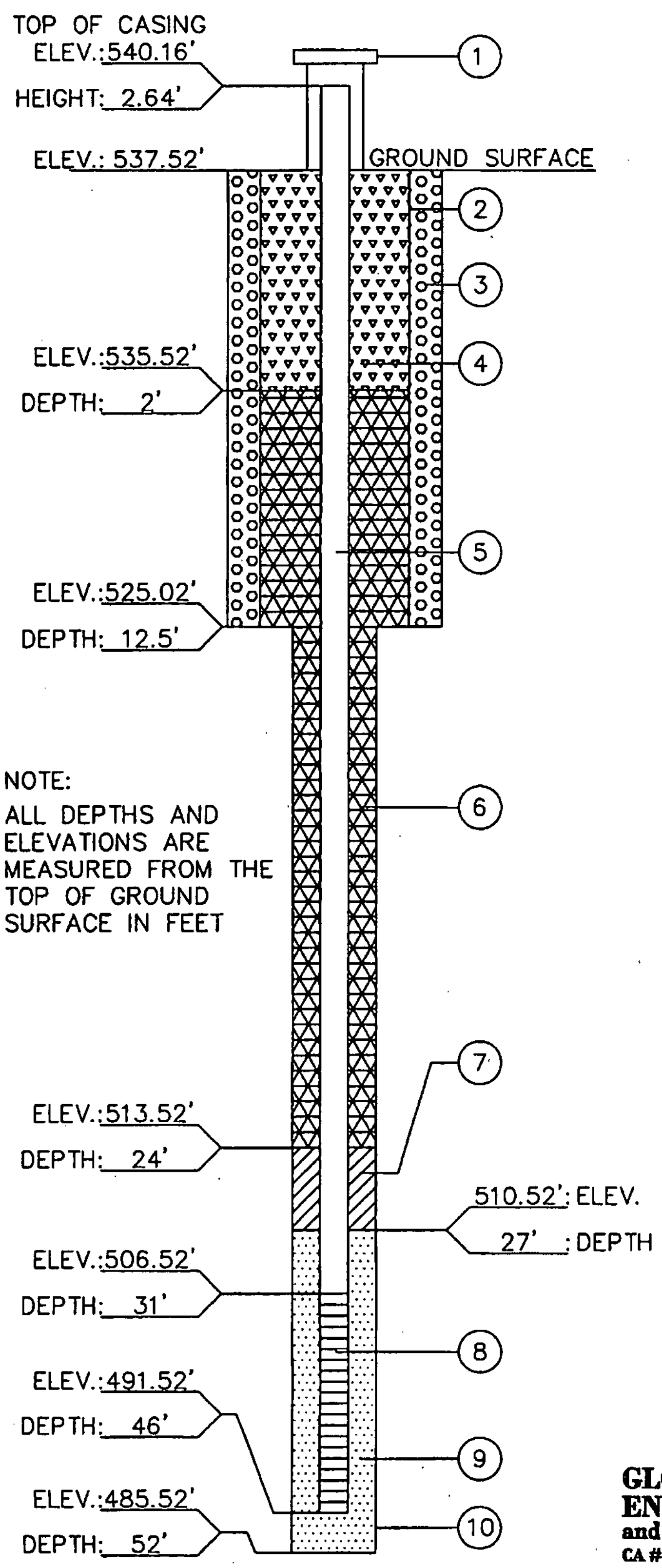


Picture 15



Picture 16

# APPENDIX C




## WELL CONSTRUCTION INFORMATION

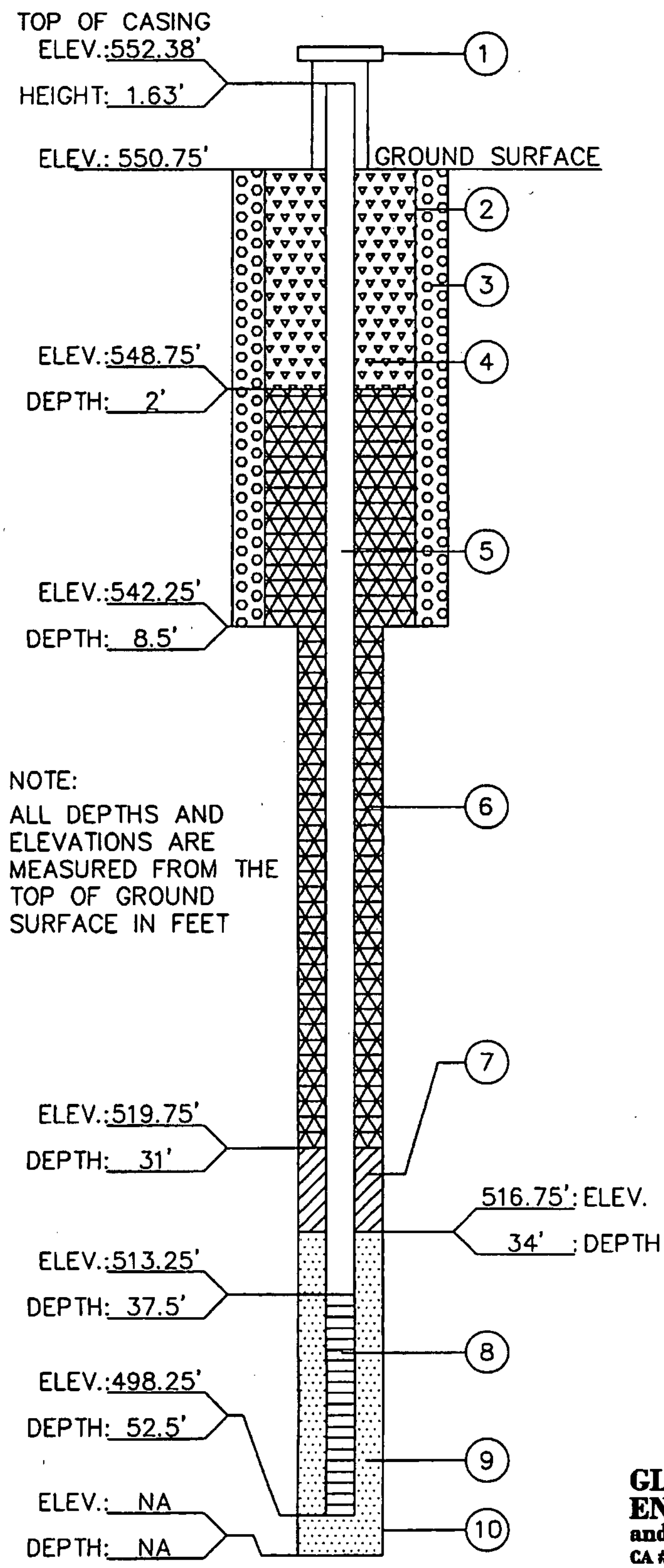
PROJECT: SEQUOYAH FUELS CORP.

WELL NO.: MWRW4

COMPLETION DATE: 1/25/06

1. PROTECTIVE CASING: NO
   LOCKING: YES
2. ISOLATOR PIPE TYPE:
   SCHEDULE 40 PVC, 12" ID
   SOLID PIPE LENGTH: 12.5 FT.
   JOINT TYPE: THREADED
3. TYPE OF BACKFILL:
   CEMENT BENTONITE GROUT
   HOW INSTALLED: TREMIE
4. TYPE OF SURFACE SEAL
   (IF INSTALLED): CONCRETE
5. SOLID PIPE TYPE:
   SCHEDULE 40 PVC, 8" ID
   SOLID PIPE LENGTH: 31
   JOINT TYPE: THREADED
6. TYPE OF BACKFILL:
   CEMENT BENTONITE GROUT
   HOW INSTALLED: TREMIE
7. TYPE OF LOWER SEAL
   (IF INSTALLED): BENTONITE CHIPS
8. SCREEN TYPE:
   SLOTTED, SCHEDULE 40 PVC
   SCREEN LENGTH: 14 FT.
   SCREEN SLOT SIZE: 0.01 IN.
   SCREEN DIAMETER: 8 IN.
   SUMP LENGTH
   (IF INSTALLED): 1 FT.
9. TYPE OF FILTER PACK:
   20/40 SILICA SAND
10. TYPE OF BACKFILL
   (IF INSTALLED): BENTONITE CHIPS
9. DRILLING METHOD: AIR ROTARY


**GLOBAL ENGINEERING and Surveying, Inc.**
CA # 3851 (expires 6-30-2006)
600 Emporia St., Ste."B"
Muskogee, Oklahoma 74401
(918) 681-2953
Fax (918) 681-2954




## WELL CONSTRUCTION INFORMATION

PROJECT: SEQUOYAH FUELS CORP.

WELL NO.: MWRW5

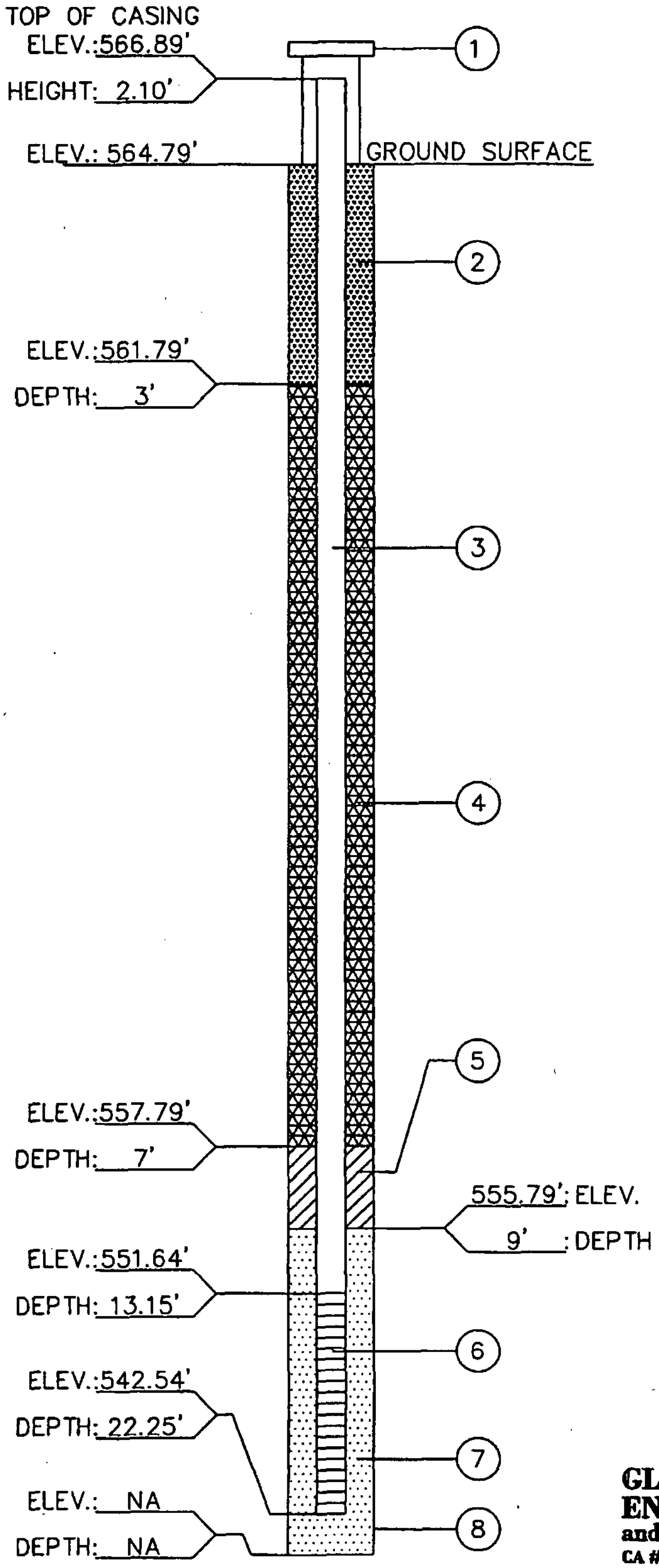
COMPLETION DATE: 1/30/06

1. PROTECTIVE CASING: NO
   LOCKING: YES
2. ISOLATOR PIPE TYPE:
   SCHEDULE 40 PVC, 12" ID
   SOLID PIPE LENGTH: 8.5 FT.
   JOINT TYPE: NA
3. TYPE OF BACKFILL:
   CEMENT BENTONITE GROUT
   HOW INSTALLED: TREMIE
4. TYPE OF SURFACE SEAL (IF INSTALLED): CONCRETE
5. SOLID PIPE TYPE:
   SCHEDULE 40 PVC, 8" ID
   SOLID PIPE LENGTH: 37.5
   JOINT TYPE: THREADED
6. TYPE OF BACKFILL:
   CEMENT BENTONITE GROUT
   HOW INSTALLED: TREMIE
7. TYPE OF LOWER SEAL (IF INSTALLED): BENTONITE CHIPS
8. SCREEN TYPE:
   SLOTTED, SCHEDULE 40 PVC
   SCREEN LENGTH: 14 FT.
   SCREEN SLOT SIZE: 0.01 IN.
   SCREEN DIAMETER: 8 IN.
   SUMP LENGTH (IF INSTALLED): 1 FT.
9. TYPE OF FILTER PACK:
   20/40 SILICA SAND
10. TYPE OF BACKFILL (IF INSTALLED): NA

9. DRILLING METHOD: AIR ROTARY

**GLOBAL ENGINEERING and Surveying, Inc.**
CA # 3851 (expires 6-30-2006)

600 Emporia St., Ste."B"
Muskogee, Oklahoma 74401
(918) 681-2953
Fax (918) 681-2954




WELL CONSTRUCTION INFORMATION

PROJECT: SEQUOYAH FUELS CORP.

WELL NO.: MWRW6

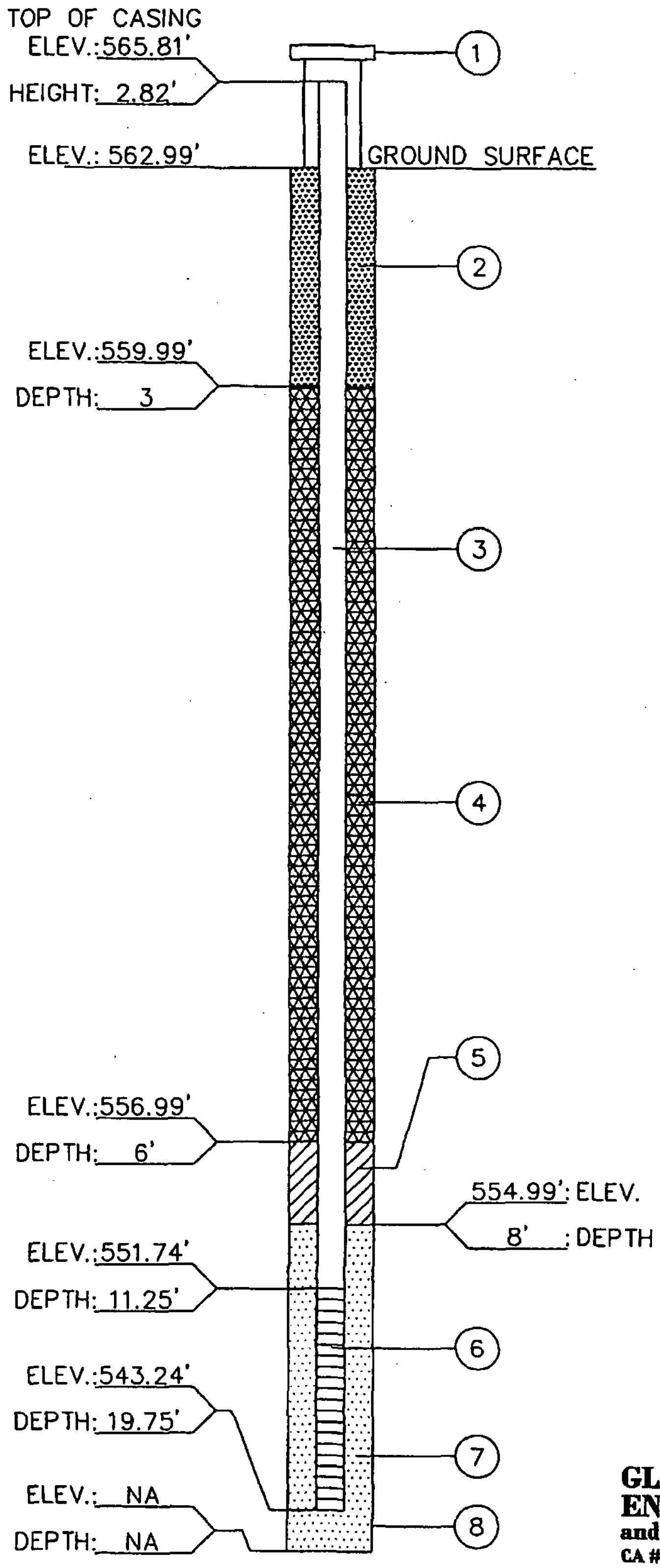
COMPLETION DATE: 1/19/06

1. PROTECTIVE CASING: NO
   LOCKING: YES
2. TYPE OF SURFACE SEAL (IF INSTALLED): CONCRETE
3. SOLID PIPE TYPE: SCHEDULE 40 PVC, 8" ID
   SOLID PIPE LENGTH: 13.15 FT.
   JOINT TYPE: THREADED
4. TYPE OF BACKFILL: CEMENT BENTONITE GROUT
   HOW INSTALLED: SURFACE
5. TYPE OF LOWER SEAL (IF INSTALLED): BENTONITE CHIPS
6. SCREEN TYPE: SLOTTED, SCHEDULE 40 PVC
   SCREEN LENGTH: 9.1 FT.
   SCREEN SLOT SIZE: 0.01 IN.
   SCREEN DIAMETER: 8 IN.
   SUMP LENGTH (IF INSTALLED): NA FT.
7. TYPE OF FILTER PACK: 20/40 SILICA SAND
8. TYPE OF BACKFILL (IF INSTALLED): NA
9. DRILLING METHOD: 10.25" ID HSA

NOTE: ALL DEPTHS AND ELEVATIONS ARE MEASURED FROM THE TOP OF GROUND SURFACE IN FEET

**GLOBAL ENGINEERING and Surveying, Inc.**
CA # 3851 (expires 6-30-2006)

600 Emporia St., Ste."B"
Muskogee, Oklahoma 74401
(918) 681-2953
Fax (918) 681-2954




## WELL CONSTRUCTION INFORMATION

PROJECT: SEQUOYAH FUELS CORP.

WELL NO.: MWRW7

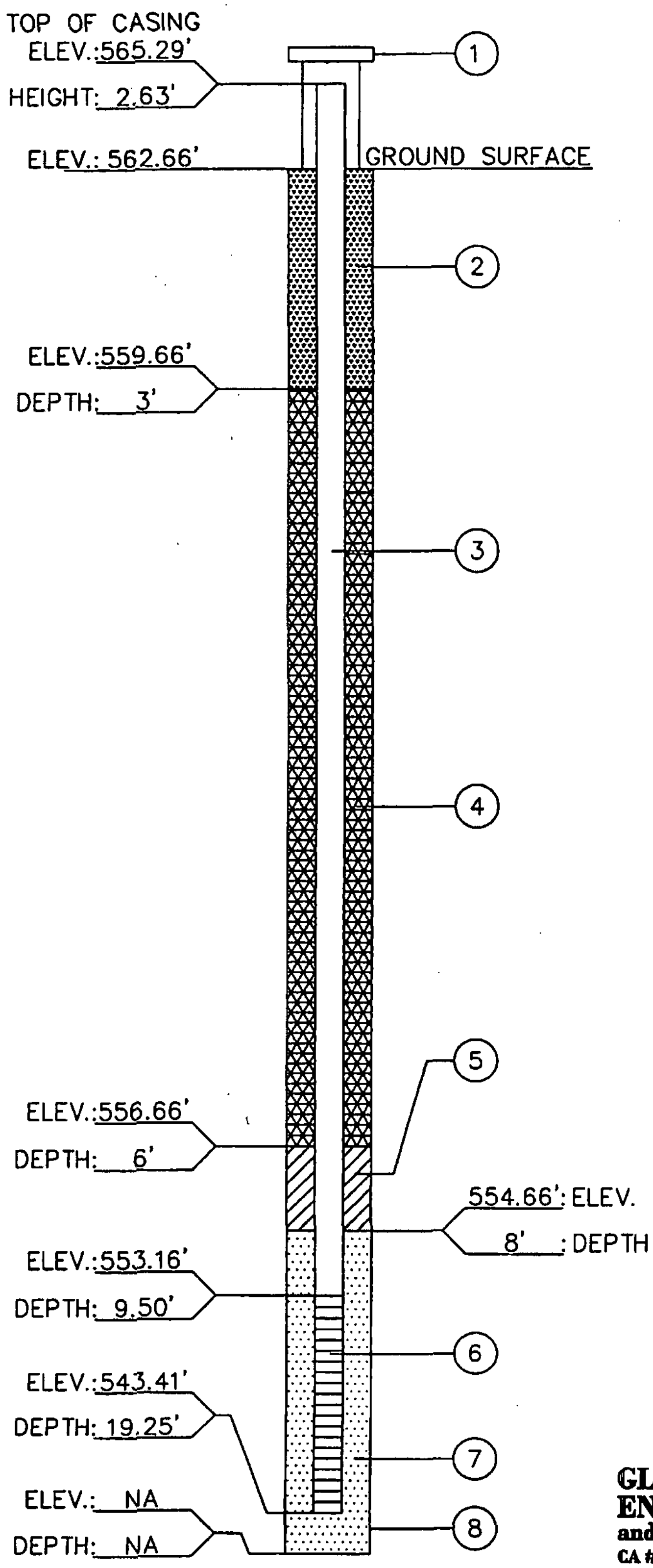
COMPLETION DATE: 1/19/06

1. PROTECTIVE CASING: NO
   LOCKING: YES
2. TYPE OF SURFACE SEAL (IF INSTALLED): CONCRETE
3. SOLID PIPE TYPE: SCHEDULE 40 PVC, 8" ID
   SOLID PIPE LENGTH: 11.25 FT.
   JOINT TYPE: THREADED
4. TYPE OF BACKFILL: CEMENT BENTONITE GROUT
   HOW INSTALLED: SURFACE
5. TYPE OF LOWER SEAL (IF INSTALLED): BENTONITE CHIPS
6. SCREEN TYPE: SLOTTED, SCHEDULE 40 PVC
   SCREEN LENGTH: 8.5 FT.
   SCREEN SLOT SIZE: 0.01 IN.
   SCREEN DIAMETER: 8 IN.
   SUMP LENGTH (IF INSTALLED): NA FT.
7. TYPE OF FILTER PACK: 20/40 SILICA SAND
8. TYPE OF BACKFILL (IF INSTALLED): NA
9. DRILLING METHOD: 10.25" ID HSA

NOTE: ALL DEPTHS AND ELEVATIONS ARE MEASURED FROM THE TOP OF GROUND SURFACE IN FEET


**GLOBAL ENGINEERING and Surveying, Inc.**
CA # 3851 (expires 6-30-2006)

600 Emporia St., Ste."B"
Muskogee, Oklahoma 74401
(918) 681-2953
Fax (918) 681-2954




## WELL CONSTRUCTION INFORMATION

PROJECT: SEQUOYAH FUELS CORP.

WELL NO.: MWRW8

COMPLETION DATE: 1/18/06

1. PROTECTIVE CASING: NO
   LOCKING: YES
2. TYPE OF SURFACE SEAL (IF INSTALLED): CONCRETE
3. SOLID PIPE TYPE: SCHEDULE 40 PVC, 8" ID
   SOLID PIPE LENGTH: 9.50 FT.
   JOINT TYPE: THREADED
4. TYPE OF BACKFILL: CEMENT BENTONITE GROUT
   HOW INSTALLED: SURFACE
5. TYPE OF LOWER SEAL (IF INSTALLED): BENTONITE CHIPS
6. SCREEN TYPE: SLOTTED, SCHEDULE 40 PVC
   SCREEN LENGTH: 9.75 FT.
   SCREEN SLOT SIZE: 0.01 IN.
   SCREEN DIAMETER: 8 IN.
   SUMP LENGTH (IF INSTALLED): NA FT.
7. TYPE OF FILTER PACK: 20/40 SILICA SAND
8. TYPE OF BACKFILL (IF INSTALLED): NA
9. DRILLING METHOD: 10.25" ID HSA

NOTE: ALL DEPTHS AND ELEVATIONS ARE MEASURED FROM THE TOP OF GROUND SURFACE IN FEET


**GLOBAL ENGINEERING and Surveying, Inc.**
CA # 3851 (expires 6-30-2006)

600 Emporia St., Ste."B"
Muskogee, Oklahoma 74401
(918) 681-2953
Fax (918) 681-2954