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WORK PLANS

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OIL CONSERVATION DIV.
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EVAPORATION POND 1
CORRECTIVE MEASURES STUDY WORKPLAN
(Revised)

prepared for

Navajo Refining Company
Artesia, New Mexico

December 1994

by

RE/SPEC INC.
RESEARCH SPECIALISTS

TELEPHONE
(505) 748-3311

EASYLINK
62905278

Navajo REFINING COMPANY

501 EAST MAIN STREET • P. O. BOX 159
ARTESIA, NEW MEXICO 88211-0159

FAX
(505) 746-6410 ACCTG
(505) 746-6155 EXEC
(505) 748-9077 ENGR
(505) 746-4438 P / L

December 15, 1994

Mr. William K. Honker, P.E.
Chief, RCRA Permit Branch
U.S. Environmental Protection Agency, Region 6
Suite 1200
1445 Ross Avenue
Dallas, Texas 75202

RE: Transmittal of the revised Corrective Measures Workplan Pond 1, Navajo Refinery, Artesia, New Mexico, December 1994.

Dear Mr. Honker:

Please find the revised Corrective Measures Workplan for the above referenced solid waste management unit. The original workplan was submitted to EPA in August 1994. The current version of the workplan has been extensively revised in response to EPA comments transmitted to Navajo in October 1994.

Among the EPA comments on the original workplan was the requirement to conduct an environmental risk assessment (RA) for soils and groundwater at the unit. The RA, intended to evaluate human health risk posed by direct oral ingestion of contaminated soil and groundwater under the premise of a residential exposure scenario, has been incorporated into the revised workplan.

The particular exposure assumptions specified for the RA suggest that EPA remains concerned about the potential for the site to pose a threat to human health. Navajo has consistently maintained that environmental conditions at the site do not pose a threat to human health, particularly since the potential for human exposure to site contaminants is extremely low. In order to address this concern in a definitive manner, Navajo has conducted a thorough evaluation of potential future alternate usage's for the site property as well as for properties in the vicinity of the site. The information obtained from that evaluation have also been incorporated into the revised workplan.

The findings of the site usage evaluation include the following facts and observations:

> Analysis of local demographic trends indicate that the population base for the city of Artesia has declined from a peak population achieved about 1960, and has since remained static for the past twenty years. There is no evidence to indicate that Artesia and surrounding areas either are, or will soon be, subject to the type of growth that would generate social and economic pressures for the subject property to be converted to residential or industrial land use.
>
> The naturally occurring quality of site groundwater is such that it is non-potable. Key water quality-related parameters such as total dissolved solids, sulfates, sodium, chlorides and magnesium indicate that the water would first be rejected as a source for human water consumption based upon aesthetic considerations. Also, there is considerable evidence in the scientific literature to indicate that prolonged consumption of such characteristically poor groundwater could lead directly to significant, if not severe, health effects for a large portion of an exposed population.
>
> The site is located in the 100-year flood plain of the Pecos River, and is subject to recurring inundation from Pecos River flooding events. Over the past thirty years, thirty distinct episodes of site flooding have been documented, five of which have occurred in the past ten years.

Upon consideration of the above-cited factors, it is apparent that the probability that the site of other adjacent properties will be used as a future area of human habitation is extremely remote. Further, the frequent flooding and typically poor agronomic characteristics of soils in the site vicinity indicate that it is highly unlikely that the area will ever be used for an agricultural purpose other than its current usage as open rangeland.

On the basis of new information and findings ensuing from the additional evaluations prompted by EPA review comments of the original Corrective Measures Workplan, Navajo has made a number of modifications to the proposed remediation program.

In response to EPA's request that Navajo evaluate water quality requirements of supplemental irrigation water to be used in the remediation effort, it has become apparent that the previously proposed use on Pond 5 as a water source in not feasible. An alternate source of acceptable irrigation water is not available. However, based on experience related to interim corrective actions conducted at the unit, Navajo remains confident that remediation of hydrocarbon contaminants in Pond 1 soils can be effectively accomplished using the land treatment technique proposed in the workplan.

The interaction of site soils, contaminants and climate indicate very low potential for subsurface contaminants at the unit to leach to the underlying water table. However, any concerns by EPA regarding the minimal leaching potential of residual contaminants remaining in the unit soils upon completion of remediation could be effectively discounted by adoption of the below proposed revegetation strategy. When established, this novel closure and post-closure revegetation program will serve as a highly effective means of ensuring that any residual risk posed by unit soils to human health and the environment will be effectively reduced to inconsequential levels.

Specifically, Navajo would establish a colony of saltcedar (Tamarix chemicals) at the Pond 1 unit. Saltcedar is a highly aggressive invader of species whose biological, physiological and ecological characteristics have been studied extensively by various federal agencies. Saltcedar trees possess prolific, deep root systems, utilize significant quantities of water through evapotranspiration processes, and exclusively displace competing vegetation. Saltcedar is highly adapted to prevailing environmental conditions at the site, and under appropriate establishment conditions can be expected to form a dense thicket over the unit. The saltcedar will stabilize the soils to an extent not otherwise achievable using adapted native vegetation, while maintaining a positive upward moisture gradient to essentially eliminate downward movement of residual contaminants.

On the basis of an overall assessment of site factors such as local demographics, the physical and ecological setting of the site, key features of the corrective measures strategy, and Navajo's commitment to retain ownership and control of the site property indefinitely, it has been concluded that a less stringent hydrocarbon target remediation goal can be established without incurring an increased risk to human health and the environment. Therefore, the proposed target remediation goal has been revised to reflect a clean-up standard of 10,000 mg/kg TPH.

Navajo remains prepared to initiate the corrective measures activities described in this revised version of the Corrective Measures Workplan in a prompt and timely manner. Should you have any questions, please do not hesitate to contact me or David Griffin, Manager of Environmental Affairs for Waste and Water, at (505) 748-3311

Sincerely,

Matthew P. Clifton
Senior Vice President

MPC/te

RESPONSE TO EPA COMMENTS ON THE NAVAJO REFINING POND 1 CORRECTIVE MEASURES STUDY PLAN

General Comment (third paragraph):

Response:

Estimated capital, operation and maintenance costs have been prepared and are presented in Section 4.3 of the revised CMS Workplan. The project schedule for implementation and completion of the proposed CMS workplan is discussed in Section 4.4.

General Comment:

Response:

Descriptions of the general operation and maintenance requirements for land treatment are described in Sections 4.1 (General Remediation Strategy) and 4.1.1 (Soil Amendment Applications).

Long-term monitoring requirements are discussed in Section 4.1.2. As discussed in that section, Navajo is currently awaiting the results of RFI Phase III data related to additional groundwater investigation at the evaporation ponds. As described in Section 4.1.2, Navajo proposes to prepare an addendum to the workplan, which will be submitted to EPA in March 1995, concurrent with the findings of the RFI Phase III. The addendum would define proposed interim groundwater monitoring (groundwater wells to be sampled, sampling frequency and analytical parameters). However, Navajo believes that a final long-term monitoring design should await the resolution of larger issues associated with the decommissioning of the active evaporation pond complex.

Page 3-1, Risk Evaluation of Pond Sampling:

Response:

The required risk evaluation for ingestion of Pond 1 soils under a residential scenario is presented in Section 3.4.2 of the revised CMS workplan.

Page 3-2, Determination of Limiting Exposure:

Response:

A description of the rationale, supporting information and methodology employed in the execution of the Part 503 soil comparisons is presented as Appendix D of the revised CMS workplan.

Page 3-4:

Response:

The requested risk assessment calculations for human ingestion of groundwater using data from the designated wells is presented in Section 3.4.3 of the revised CMS workplan.

A narrative discussion on Navajo's proposed groundwater concentration limits is presented at Section 3.7 of the revised workplan. While justification for the proposed alternate concentration limits for groundwater is provided in that section, comprehensive evaluation and discussion on that issue are also presented in Section 3.3 (Assessment of Potential for Future Site Usage).

Page 4-3, 2nd paragraph:

Response:

As discussed in Section 4.1 of the revised workplan, Navajo has been forced to abandon plans to include irrigation as part of the corrective measures program. Analysis of Pond 5 water yielded high values for TDS (greater than 4000 mg/kg) and sodium adsorption ratio (SAR greater than 35). Since no alternative irrigation source is feasible, discussion on water quality parameters and acceptable limits are no longer relevant.

EVAPORATION POND 1
CORRECTIVE MEASURES STUDY WORKPLAN
(Revised)

prepared for

Navajo Refining Company
Artesia, New Mexico

by

RE/SPEC, Inc.
4775 Indian School Road, NE #300
Albuquerque, New Mexico 87110

December 1994

David G. Boyer
David G. Boyer
Project Manager

Brian P. Sullivan
Brian P. Sullivan
Assistant Project Manager

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1.0 INTRODUCTION

Navajo Refining Company (Navajo) operates a petroleum refinery located in Artesia, New Mexico (EPA I.D. No. NMD 048918817). The facility is regulated under the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984. At the time that the U.S. Environmental Protection Agency (EPA) conducted a preliminary review (PR) of the facility, certain facility areas were identified as solid waste management units. Among these were:

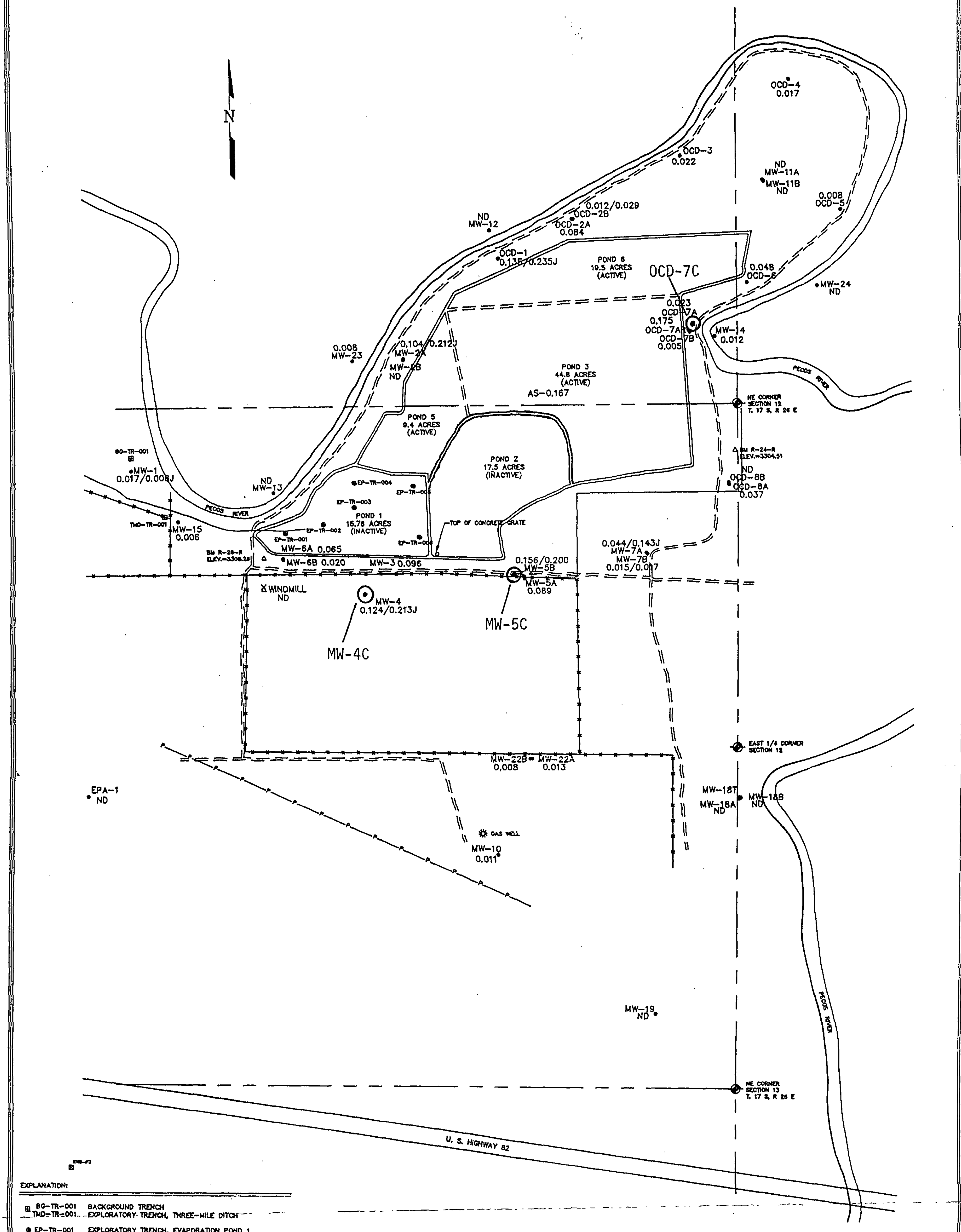
- An unlined wastewater conveyance unit known as Three-Mile Ditch (TMD) operated from the 1930s to 1987; and
- The facility evaporation pond system.

The evaporation pond system consists of now-inactive surface impoundments known as Evaporation Pond 1 and Evaporation Pond 2, which formerly received wastewater conveyed by the ditch, and a series of interconnected active evaporation ponds, which currently receive facility wastewater conveyed via an underground pipeline. A site plan for the facility evaporation ponds system is presented as Figure 1-1.

Under the technical framework of the RCRA corrective action program, EPA determined that a RCRA Facility Investigation (RFI) was required for these two facility units to characterize the nature and extent of releases of hazardous constituents. As a result, TMD and the evaporation ponds were the subject of RFI Phase I and Phase II investigations completed in 1990 and 1993, respectively.

As stated in May 19, 1994 correspondence from EPA to Navajo, EPA is now requiring that a RFI Phase III investigation be executed for TMD and the active evaporation ponds, together with the preparation of a Corrective Measures Workplan for Evaporation Pond 1. The draft RFI Phase III workplan for TMD and the active ponds, dated July 31, 1994, was previously submitted to EPA, and the Phase III investigation is in progress. The Corrective Measures Study (CMS) workplan was submitted to EPA on August 20, 1994. EPA comments, dated October 7, 1994, required the preparation of additional sections, including risk assessment for soils and groundwater.

The CMS approach envisions evaluation of various alternatives for corrective measures depending on the site specific conditions and characteristics of the released hazardous constituents. As discussed later in this document, conditions at Evaporation Pond 1 are conducive to on-site remediation efforts. Navajo began such efforts, such as dewatering and soil aeration, shortly after ceasing discharges in 1987. Therefore, based on previous RFI results showing minimal environmental risk, and in consideration of existing ongoing remediation activities, the CMS procedures have been modified to reflect the existing conditions and on-going activities at this unit.



EXPLANATION:

⊞ BG-TR-001	BACKGROUND TRENCH
TMD-TR-001	EXPLORATORY TRENCH, THREE-MILE DITCH
● EP-TR-001	EXPLORATORY TRENCH, EVAPORATION POND 1
● MW-4 0.124/0.213J	MONITOR WELL WITH TOTAL ARSENIC CONCENTRATION (mg/l), KWBES/PRC SPLIT SAMPLE (WHERE PERFORMED)
⊞	PIEZOMETER
J	ESTIMATED VALUE
ND	NOT DETECTED AT 0.005 (mg/l)
⊙	Proposed Deep Monitor Well Location

NOTE: MAP COMPILED FROM NAVAJO REFINERY AND USGS SPRING LAKE 7.5 MINUTE QUADRANGLE. WELL LOCATIONS AND ELEVATIONS FROM NAVAJO REFINERY CONTROL. WELL LOCATIONS SURVEYED 2/9: JAQUESS & ASSOCIATES.

LOCATION T 17 S, R 26 E, NMPM, EDDY COUNTY, NM

NOTE: KWBES ARSENIC CONCENTRATION SHOWN IS THE VERIFICATION ANALYSIS OR AVERAGE OF TWO VERIFICATION ANALYSES; IF NO VERIFICATION ANALYSIS WAS PERFORMED, VALUE SHOWN IS ORIGINAL CONCENTRATION.

800 0 800 2400 FEET

RE/SPEC INC.
RESEARCH SPECIALISTS

prepared for:
Navajo

Navajo Evaporation Ponds Site Plan

PROJECT: 318/2.1	
LOCATION: NAVAJO REFINERY, ARTESIA, NM	
APPR:	DATE: 11/23/93
DRAWN BY:	SCALE AS SHOWN
DATE: 4/27/93	FIGURE: 1-1

This CMS document presents the findings of a corrective measures alternatives evaluation for hydrocarbon-contaminated soils in Pond 1, and provides details of additional recommended corrective measures to be taken at the unit. This includes both routine monitoring of unit soils during remediation, and actions to be taken to comply with EPA-specified monitoring requirements for groundwater underlying the unit.

The workplan is organized into four sections. Section 1 summarizes the unit's regulatory history and introduces the CMS. Section 2 describes the status of current conditions and interim corrective measures being conducted at the unit. Section 3 provides a characterization of the types and levels of risk posed by contaminants contained in and released from the unit, identifies appropriate and attainable corrective measures objectives arrived at on the basis of the potential environmental risk, identifies the appropriate corrective measures alternative designed to obtain the stated objectives, and provides an evaluation of the effectiveness of the designated corrective measures alternative in achieving those objectives from the viewpoint of technological feasibility and potential short- and long-term effects on human health and the environment. Section 4 details design, operations and management criteria for the selected corrective alternatives measure, including specific details of operations and maintenance, remediation goals, program costs and scheduling, short and long-term monitoring requirements for unit soils and groundwater, proposed content and scheduling of routine inspections and progress reports, and proposed community relations activities.

2.0 CURRENT SITE CONDITIONS AND INTERIM CORRECTIVE MEASURES

The following sections summarize the existing information and data for Pond 1 soils and groundwater underlying and adjacent to the unit (Section 2.1), and a description of previous and current interim corrective actions activities conducted at the unit.

2.1 Current Soil and Groundwater Conditions

Detailed discussions of climate, soils, geology and groundwater in the vicinity of the refining process areas, TMD, and the facility evaporation ponds were presented in the November 1993 RFI Phase II report and summarized in the July 1994 RFI Phase III workplan. Therefore, only a summary discussion of soil and groundwater conditions, as they exist at evaporation Pond 1, is presented below with more complete and wide-ranging information available in cited reports.

2.1.1 Soils

Pond 1 soils were evaluated for hydrocarbon content and hazardous constituents during the course of the units' Phase II RFI (submitted to EPA in November, 1993). As part of the Phase II investigation, soil samples were obtained at various depths from six trackhoe-excavated trenches located within the unit.

The Phase II analytical data for the Pond 1 soils is summarized in Appendix A of this document. The data indicated that organic and inorganic contaminants were most heavily concentrated in the upper soils of the unit above a depth of 3 ft. The average percent oil and grease concentration reported in soil samples obtained at a one-foot sample depth was 10.4 % (Appendix A, Table 1). Oil and grease concentrations decreased markedly at sample intervals below the one-foot depth. At the three-foot sample interval, the average oil and grease concentration declined to 0.41%, with the average being skewed upwards by two samples collected at the trench locations completed proximal to the ditch influent point, which exhibited relatively elevated oil and grease concentrations (approximately 1%). At successive soil sample depth intervals below 3 ft., oil and grease concentrations became attenuated with depth (Appendix A, Table 1).

Sampling locations and analytical data for the November 1993 soil sampling event are presented in Appendix B. The laboratory analytical data from that sample event yielded average TPH values of 4,100 mg/kg, roughly equivalent to an oil and grease concentration of 4.1%.

The RFI Phase II analytical results for inorganic metal constituents in Pond 1 soils indicated that elevated metal concentrations were limited to the upper portion of the soil profile within a few ft. of the surface, with arsenic, chromium and lead being identified as potential metals of concern (Appendix A, Table 2). The apparent fixation of these three constituents in the upper soil profile was further confirmed by the results of TCLP testing, which failed to yield any TC exceedances.

Pond 1 is currently undergoing interim corrective measures actions (see Section 2.2) to remediate surface soils. As a result of the interim actions, the unit does not currently provide vegetative cover for wildlife, and neither supports or attracts vegetation-dependent populations of above-ground or subterranean vertebrate or invertebrate fauna. Consequently, there is little risk that contaminants contained in unit soils are entering the food chain or otherwise exerting a deleterious impact on the surrounding ecosystem.

The potential risk for further contamination to groundwater underlying the unit is considered to be minimal. Hazardous VOA and SVOA constituents are predominantly concentrated in the upper soil profile of Pond 1 soils, which are generally fine-textured, and the regional climate is semiarid. RFI Phase II data demonstrates that metal constituents are immobilized in the upper few ft. of the soil surface in Pond 1, and the very low leaching potential of these soils is further demonstrated by the failure of unit soil samples to yield TC exceedances for any metal constituents. Thus, with the inactivation and dewatering of Pond 1 in 1987, the potential for leaching of hazardous organic constituents to groundwater has been drastically reduced.

2.1.2 Groundwater

Groundwater monitoring in the vicinity of the evaporation ponds using monitoring wells constructed to RCRA specifications has been performed since 1986. Prior to that time several shallow wells were used to monitor for state required constituents. Constituent concentrations for organics, metals, and water chemistry inorganics were presented in the RFI Phase II report. Copies of these data are reproduced as Appendix C Table C-1 through C-4 and a summary of the more important findings is provided below.

Four monitor wells have been installed in the vicinity of Pond 1 at locations either downgradient or slightly off-gradient from the direction of groundwater flow. Three are shallow wells tapping the upper 10 ft. of saturated sediments while the remaining boring is a deeper well screened 32 to 41 ft. into the saturated zone at a depth of 39 to 48 ft. beneath the surface.

In the vicinity of the evaporation ponds, elevated levels of volatile organic constituents are found mainly south and downgradient of Pond 1. Monitor wells MW-3, 4, 6A and 6B had detectable levels of benzene, ethylbenzene, toluene, and xylene (BETX) volatiles, but benzene was the only constituent where samples exceeded the EPA MCL health based standard of 0.005 mg/l (ppm). The maximum benzene concentration was approximately 0.021 mg/l. Other than BETX, the only other volatile organics detected in the analyses were carbon disulfide and 2-butanone in one well (MW-6B). No identifiable semi-volatiles were detected in monitor wells surrounding Pond 1 at practical quantitation levels in the range of 0.025 to 0.030 mg/l.

Based on results obtained during the Phase I RFI, water samples were taken during the Phase II study for analysis of arsenic, chromium, lead and nickel. Samples for chromium, lead and nickel in the four monitor wells near Pond 1 were either not detected or found at levels less than EPA drinking water quality standards. Arsenic levels, as averaged from EPA method 7061 initial and verification analyses, ranged from 0.021 to 0.096 mg/l. These values exceeded the EPA drinking water standard of 0.05 mg/l in all but one well (MW-6B) in the vicinity of Pond 1, but were lower than the New Mexico ground water quality standard of 0.1 mg/l.

The analytical results of water quality sampling of the monitor wells must be evaluated in the overall context of groundwater quality in the vicinity of the ponds. As documented by U.S. Geological Survey (USGS) studies and reported in the RFI Phase II report, the area immediately adjacent to the Pecos River serves as a regional zone of groundwater discharge. Groundwater in an area from the river west to the Sacramento Mountains migrates eastward and discharges upwards into the river and shallow alluvium adjacent to the river channel. This effect was observed and documented during the Phase II work. Upward vertical gradients were recorded in paired monitor wells away from the immediate area of the ponds.

As water nears the surface, water quality markedly deteriorates due to the combined effect of evaporation of water and transpiration by phreatophytic salt cedar entrenched along the river channel. Total dissolved solids (TDS) of the river as measured during the Phase II study exceed 5100 mg/l and the USGS has documented values greater than 10,000 mg/l at their Artesia gauging station. During the Phase II RFI, water quality measurements from four monitor wells adjacent to the river and upgradient from the ponds, including three wells on the opposite side of the river from the ponds, resulted in an average TDS exceeding 10,000 mg/l. Groundwater in the alluvium a short distance to the west is of slightly better quality. The average of the TDS of the evaporation pond windmill and the EPA-1 monitor well on the western edge of the shallow alluvium is greater than 4200 mg/l. However, even this water greatly exceeds the EPA recommended drinking water standard of 500 mg/l. The quality of water for human consumption is further discussed in Section 3.3.2.2.

The exceedingly poor natural water quality in the alluvium immediately adjacent to the river and ponds prevents it from being used as a drinking water source for humans, and only marginally for livestock. The Phase II study documented that groundwater movement downgradient from the ponds is southeastward and the final discharge zone is a marshy area overgrown with salt cedar near the U.S. Highway 82 crossing of the Pecos River.

2.2 Interim Corrective Measures

Since approximately Fall 1989, Navajo has been engaged in interim corrective actions to facilitate complete access to all portions of the unit and to initiate biodegradation of the hydrocarbon-contaminated surface soils. In order to desiccate and solidify heavy waste solid deposits located around the periphery of the unit, initial activities employed a trackhoe to undertake bulk turning and mixing of waste solids and soils across the entire unit. From Summer 1990 through Summer 1994, Pond 1 surface soils have been tractor-disced at a frequency of approximately once a month, with the precise timing of tillage events dependent on the availability of sufficient soil moisture to minimize wind-induced soil erosion.

Based on the likelihood that EPA will, at least in broad principle, approve the proposed corrective measures alternative presented in this document, Navajo has initiated the excavation of hydrocarbon contaminated soils located along the easternmost end of Pond 1 to create an initial receiving/storage area for bioremediated soils (as described in Section 4.1 of this revised workplan document). Excavated soils are currently being surface-spread across adjacent areas of the unit to the west of the excavation, preparatory to the formal initiation of surface bioremediation activities.

3.0 ESTABLISHMENT OF CORRECTIVE MEASURES OBJECTIVES AND SELECTION OF CORRECTIVE MEASURES ALTERNATIVE

Appropriate corrective measures objectives are, in part, established on the basis of the potential risk posed to human health and the environment. Therefore, discussion of corrective measures objectives is preceded by the following sections, which provide evaluation and discussion of the overall risk posed by present and future environmental conditions at Pond 1 and its vicinity. Risks associated with the presence of contaminants in Pond 1 soils were evaluated in two ways: a comparison with Clean Water Act Part 503 standards (which pertain to the beneficial land application reuse of municipal wastewater sludge); and by development of a baseline risk assessment. Potential human health risks posed by groundwater underlying the unit were also evaluated on the basis of a baseline risk assessment. On the basis of the risk evaluation for the unit, appropriate and attainable corrective measures objectives are defined, and the correctives measures alternative which will achieve those objectives in the most effective manner has been identified.

3.1 General Risk-Related Considerations

Pursuant to EPA guidance, facility specific objectives are to be proposed to the administrative authority for corrective action. These objectives are based on public health and environmental criteria, information gathered during the RFI, EPA guidance, and the requirements of any applicable Federal statutes and regulations.

The available soil analytical data for Pond 1 indicates that unit soils contain hydrocarbon contaminants including trace concentrations of VOA and SVOA organic constituents, as well as levels of several metal constituents elevated significantly greater than background concentration values. While existing concentrations for some contaminants might be construed as posing a potential risk to human health, several factors serve to minimize the potential risk. The location of the unit (approximately three miles east of the city of Artesia in an area dedicated to open rangeland) is remote from areas of human occupation or intensive activity. Access to the unit is controlled by fences and locked gates, and by the adjacent physical barrier of the Pecos River. Further, the private property adjacent to State Highway 82, which must be entered to approach the unit, is kept under routine surveillance by local law enforcement agencies.

As reported in the Phase II RFI (and summarized in Section 2.1.2), impacts of any hazardous constituent releases from Pond 1 on groundwater having a current or potential use by humans, livestock, or for agricultural purposes are believed to be either minimal or non-existent. This is due to the naturally occurring poor water quality documented in the area and the hydrogeologic conditions at the location of the ponds.

3.2 Comparison of Pond 1 Soil Sampling Data to 40 CFR Part 503 Standards

Since organic hydrocarbon constituents present in Pond 1 soils will ultimately be degraded to simple non-hazardous carbon molecules, long-term environmental concerns associated with unit soils are related to the persistence of elevated concentrations of arsenic, chromium, and lead. At this time, it is apparent that Region 6 still considers nickel and zinc to be potential constituents of concern for Pond 1 soils, since the inclusion of those two constituents in a baseline risk assessment is being required by the agency. It is expected that the assessment discussions presented below will demonstrate that, with a high degree of confidence, nickel and zinc may be eliminated as constituents of concern in Pond 1 soils.

Because Pond 1 is situated in a relatively remote agricultural setting, an appropriate assessment of overall environmental risk posed by elevated metal constituents would entail a comparison of unit soils to risk-based standards developed for an agricultural/forest setting. A reliable comparative source to assist in defining risk-based limits for soils occurring in an agricultural setting is found in the EPA document entitled Technical Support Document for Land Application of Sewage Sludge. The technical support document was developed to provide justification for the promulgation of the final rule regulating the beneficial land application of municipal sewage sludge (40 CFR Part 503) under the authority of the Clean Water Act.

The EPA technical support effort entailed a comprehensive review of existing scientific data concerning the environmental effects of ten metal constituents. The data was assessed, summarized, and used to model or estimate the concentration-related risk levels posed by the constituents in the context of 14 agricultural and non-agricultural environmental exposure pathways. Risk-based pollutant limits were established for each constituent of concern at the level of the lowest risk-based number for any of the evaluated pathways.

In order to model the effects of the metal constituents in sewage sludge applications to land, EPA defined assumed values for soil mass and depth of sludge incorporation in order to obtain concentration-based exposure values (see Section 5.1.2.5.3 of the Technical Support Document). For the five Pond 1 metal constituents of concern, Table 3-1 presents the Part 503 risk-based pollutant limits and most limiting pathway that were used to establish each limit value. Employing the assumptions for depth of sludge incorporation and total soil mass specified by EPA in the Part 503 technical support document, Table 3-1 also presents calculated concentration-based soil values used by EPA in the establishment of the risk-based sludge application limits for these constituents. The derivation of the concentration-based soil limits is presented in Appendix D.

It is acknowledged that the contaminant profile for Pond 1 soils exhibits significant differences from the sludge application scenario employed by EPA for its development of the Part 503 soil standards. For instance, Part 503 rules assume an approximate 6-inch soil mixing depth for incorporated sludges. In contrast, RFI Phase II data for Pond 1 soils indicate that elevated metal concentrations in surface soils may extend from the surface to 1 to 3 ft. This distinction is most relevant for the Part 503 phtotoxicity exposure pathway, which assumes that metal constituents are primarily limited to the upper soil surface in a specified zone of incorporation. However, as discussed below, for Pond 1 metal constituents of concern for which phytotoxic effects constitute the most limiting exposure pathway, the concentrations of those constituents reported in Pond 1 soils are significantly lower than the derivable Part 503 pollutant limits.

Table 3-1. Comparision of Part 503 Risk-Based Pollutant Limits, Limiting Pathways, and Derived Concentration-Based Limits with Pond 1 Soil Metal Concentrations

Constituent	Range/Average for Pond 1 soils (mg/kg)$^{(1)}$	Primary Limiting Exposure Pathway and Risk-Based Limit	Derived Concentration Limit - Primary Exposure Pathway	Secondary Limiting Exposure Pathway and Risk-Based Limit	Derived Concentration Limit - Secondary Exposure Pathway
Arsenic	1.6-39.9 / 23.5	sludge to child via oral ingestion 41 kg/ha $^{(2)}$	41 mg/kg	sludge to groundwater to human via drinking 1,200 mg/kg $^{(3)}$	600 mg/kg
Chromium	32-1,011 / 386	phytotoxicity 3,000 kg/ha $^{(3)}$	1,500 mg/kg	sludge to groundwater to human via drinking 12,000 mg/kg $^{(3)}$	6,000 mg/kg
Lead	9-389 / 112	sludge to child via oral ingestion 300 kg/mg $^{(2)}$	300 mg/kg	sludge to soil to animal 1,200 kg/ha $^{(2)}$	1,200 mg/kg
Nickel	12-37/ 22.5	phytotoxicity 420 kg/ha $^{(3)}$	210 mg/kg	sludge to child via oral ingestion 820 kg/ha $^{(2)}$	820 mg/kg
Zinc	40-434 / 198	phytotoxicity 2,800 kg/ha $^{(3)}$	1,400 mg/kg	sludge to soil to plant to human via home garden 3,600 kg/ha $^{(3)}$	1,800 mg/kg

Notes:
(1) RFI Phase II soils data for 1 foot sample depth.
(2) Kg constituent per 1x10^{-6} kg dry weight sludge, as specified in U.S. EPA Part 503 Techical Support Document, p. 6-2.
(3) Kg constituent per 2x10^{-6} kg soil, as specified in U.S. EPA Part 503 Techical Support Document, p. 5-19.

In terms of the Pond 1 soil metal constituents of concern, the most limiting Part 503 exposure pathways for chromium, nickel and zinc are based on phytotoxic effects. The Part 503 risk assessment conducted for this pathway may be sensitive to variations in total contaminant depth in soils, since at least some of the technical data used to establish concentration limits for these constituents were based on field-test data for surface-applied sludge that was presumably not incorporated into deeper soil horizons. It is known that a major metal toxicity avoidance mechanism for plants involves the establishment of adequate root mass extending below metal-contaminated surface soils. Therefore, the Part 503 cumulative metal limits are likely to be less applicable for those situations in which elevated metals of concern extend to greater depths (e.g., deeper than six inches below the soil surface). However, as described below, when the Part 503 phytotoxicity pathway limits for chromium, nickel and zinc are converted to soil concentration-based values, the average concentrations of these metals in Pond 1 soils are many times lower than the permissible Part 503 application limits.

For the remaining Pond 1 metal constituents (arsenic and lead), the most limiting Part 503 exposure pathway is based on direct oral ingestion of contaminated sludge materials rather than sludge-incorporated soils, so that the Part 503 risk assessment conducted for this exposure pathway is independent of the depth to which soils have been impacted and is directly comparable with Pond 1 soils. In conclusion, the comparison of Pond 1 soils with the Part 503 sludge standards described below is considered to be generally valid and appropriate.

As shown in Table 3-1, the average soil concentration values obtained for arsenic, chromium, lead, nickel and zinc during the Pond 1 RFI Phase II are all below the derived Part 503 soil concentration limits for those constituents. A single Pond 1 soil sample obtained during the Phase II RFI from the one-foot sample depth yielded a concentration value in excess of the Part 503 limit for lead. However, the overall average concentration value for lead in Pond 1 soils was well below the Part 503 limit (Table 3-1).

The second most-limiting pathway for arsenic under the Part 503 rules is based on human ingestion of contaminated groundwater obtained from a well located immediately at the unit boundary. Based on a 6-in. sludge incorporation interval in surface soils, EPA has determined that an arsenic loading limit no greater than 1200 kg/ha is necessary to protect a generic shallow groundwater source underlying agricultural soils subjected to sludge applications. This represents a derived soil concentration value (600 mg/kg) approximately 25 times greater than the average concentration obtained for arsenic in surface soils at Pond 1. The risk-based limit for this pathway established by EPA employed extremely conservative assumptions regarding the environmental setting: soil texture in both the vadose zone and underlying saturated zone was assumed to consist of pure sand; and the water table under a site to which sewage sludge was applied was not greater than 1 meter from the treated surface.

For lead, the second most-limiting exposure pathway under the Part 503 rules is based on livestock consumption of sludge adhering to forage crops and/or sludge on the soil surface. For the conservative assumptions used by EPA in developing a risk-based limit for this pathway, EPA has determined that a limit of 1200 mg/kg is appropriate for lead. As was the case for the child sludge ingestion exposure pathway for lead, criteria for the livestock consumption pathway are independent of the depth to which the lead contaminant extends into the soil profile. Therefore, the comparison of Pond 1 soils with the Part 503 standards for these two most limiting lead exposure pathways is directly comparable and valid.

The average concentration of chromium in Pond 1 soils (386 mg/kg) is nearly four times less than the soil concentration-based phytotoxicity limit derived from the cumulative chromium loading limit established under the Part 503 regulations (1500 mg/kg). No Pond 1 soil sample concentrations exceeded the derived Part 503 limit. The second most limiting exposure pathway for chromium under the Part 503 regulations is based on human ingestion of contaminated groundwater obtained from a well located immediately at the unit boundary. The risk-based limit for that pathway is equivalent to a total soil concentration of 6000 mg/kg, which again was based on conservative assumptions of a sandy, saturated vadose zone, and a one-meter depth to groundwater.

The average concentration of nickel in Pond 1 soils (22.5 mg/kg) is more than nine times less than the derived soil concentration-based limit for the most limiting exposure pathway (210 mg/kg), based on plant phytotoxicity effects. The maximum nickel value obtained for Pond 1 soils (37 mg/kg) is also well below the derived Part 503 phytotoxicity pathway limit for this constituent. The second most limiting exposure pathway for nickel under the Part 503 regulations yields a derived concentration-based limit of 820 mg/kg, based on direct oral ingestion.

The average concentration of zinc in Pond 1 soils (197 mg/kg) is more than seven times lower than the derived concentration-based soil limit for the Part 503 rule (1400 mg/kg) (also based on phytotoxic effects). Furthermore, even the maximum zinc concentration value obtained from Pond 1 soils during the RFI Phase II investigation (434 mg/kg) is more than three times less than the Part 503 phytotoxicity pathway limit. The second most limiting exposure pathway for zinc under the Part 503 regulations yields a derived concentration-based limit of 1800 mg/kg, based on human consumption of vegetables grown in a sludge-amended home garden.

On the basis of the comparisons of Pond 1 soil metal concentrations with the specified criteria set forth under the 40 CFR Part 503 rules for allowable cumulative soil loading limits for metal constituents, none of the Pond 1 metals of concern can be construed as posing a threat to human health and the environment. In particular, this analysis indicates that Pond 1 soil concentrations for nickel and zinc are sufficiently low to eliminate these constituents from all future soil monitoring activities at the unit. In the case of nickel, Pond 1 soil concentrations are elevated approximately two to three times above local background levels. However, the average Pond 1 nickel soil concentration indicated by the RFI data (is only slightly above the nationwide average of 20 mg/kg for nickel concentration in surface soils (U.S. Geologic Survey, 1971). The average and maximum nickel soil concentrations reported for Pond 1 soils are well below established Part 503 standards specifying concentration exceedances that would constitute grounds for environmental concern in a general agricultural land use setting, and are many times less than relatively stringent residential health-based standards for this constituent that are widely employed by EPA for risk-based screening (U.S. EPA, 1993).

In contrast, reported maximum zinc values in Pond 1 soils represent concentrations which may be as high as twenty times above background levels. However, as was the case for nickel in Pond 1 soils, average and maximum zinc concentrations reported for Pond 1 soils are well below derivable Part 503 standards, and are also many times less than EPA residential health-based standards used for risk-based screening (U.S. EPA, 1993). Furthermore, zinc is not identified as a human carcinogen, and, as indicated by the Part 503 standards, its human noncarcinogenic toxicity is very low. In fact, zinc is an essential human nutrient. Based on a toddler's Recommended Daily Allowance (RDA) of 10 mg zinc (National Academy of Science, 1989), a standard soil ingestion rate of 200 mg/day for a 16 kg infant, and conservatively assuming chronic exposure to the maximum reported zinc concentration in Pond 1 soils (434 mg/kg), daily consumption of Pond 1 soils would supply only about 13% of the zinc RDA for an exposed toddler. In summary, it is overwhelmingly apparent that zinc levels in Pond 1 soils pose no threat to human health and the environment.

In development of the Part 503 standards, environmental fate of soil-applied metal constituents and consequent risk to human health and the environment posed by those constituents were conservatively assessed on the basis of sites situated in an agricultural/forest setting, and it is recognized that these rules were not formulated to generically address conditions associated with RCRA SWMUs. However, the Navajo evaporation ponds are situated in an environmental setting that, in terms of physical features, surrounding land usage and proximity to potentially exposed populations, is distinctly agricultural.

The Part 503 standards are intended to serve as sound environmental guidelines applicable to a broad spectrum of environmental settings encountered across the United States. As such, the development of the Part 503 standards has taken into account information obtained from exhaustive reviews of the scientific literature. In addition, numerous conservative assumptions are incorporated into the risk evaluation for the generic agricultural/forest setting, such as the presence of a coarse sandy soil exhibiting a low bulk density, a one-meter depth to groundwater, exposure to the most sensitive receptors (e.g., children, most sensitive crop species). For these reasons, the EPA Part 503 standards constitute a conservative basis of comparison that is valid for the assessment of potential environmental risks posed by the inorganic waste constituents contained in Pond 1 surface soils.

3.3 Assessment of Potential For Future Site Usage

As discussed above, the most comprehensive guidance currently available to EPA indicates that the Pond 1 soils pose no apparent threat to the surrounding environment, or to human health on the basis of reasonable exposure scenarios. Notwithstanding the level of contaminant concentrations in the soil, a key component of establishing the overall human health risk posed by environmental contamination is consideration of the potential for exposure to the various contaminated environmental media. In this regard, it is essential to evaluate the potential future land usage of the Navajo Evaporation Ponds system and adjoining properties.

3.3.1 Potential for Future Industrial Use

The property where Pond 1 is located is dedicated to a specific industrial purpose. In a larger context, the selection of that particular site location can be considered to have arisen as a result of: the history of oil exploration and production in the region; the random nature of human business dealings; and, most directly, the unique geography of the local Artesia area. As such, the use of the subject property for an industrial function represents a highly unique event. For this reason alone, it must be considered extremely improbable that this particular location will again be utilized as an industrial site. As discussed below, there are also other, more compelling reasons associated with the physical setting of the site which greatly reduce the possibility that an alternative industrial use for the site will occur. Subsequent to discontinuation of operations and final closure of the pond system, there is no reasonable likelihood that the property will result in significant human exposure via activities associated with industrial occupation.

3.3.2 Potential for Future Residential Use

In a residential land use scenario, potential exposure to environmental contaminants of concern associated with former operations at Pond 1 would occur primarily from direct exposure to contaminated soils and consumption of contaminated groundwater. However, due to factors described in the following sections, it is considered to be highly improbable that human exposure to contaminants at ingestion rates even remotely approaching those currently established for residential exposure scenarios will ever occur.

3.3.2.1 Local Demographics

The Navajo evaporation pond system is located several miles east of the city of Artesia. The population of the city of Artesia reached its current historical peak over thirty years ago around the time of the 1960 U.S. Population Census when the town recorded an official population of 12,000 inhabitants. Population trends since that time, as characterized by subsequent U.S. Census Bureau surveys, are as follows: 1970 - 10,315; 1980 - 10,385; 1990 - 10,610. It is evident that for the past 20 years, the city of Artesia has exhibited a relatively stable population base. While demographic data for the U.S. as a whole indicates significant population growth, no signifying demographic or economic trends or events have been identified to suggest that Artesia and surrounding areas either are, or will soon be, subject to rapid population expansion that would in turn generate social and economic pressures for the subject property to be converted to residential land use.

3.3.2.2 Groundwater Suitability for Human Consumption

As was demonstrated by the Phase I and Phase II RFI studies, groundwater unimpacted by the ponds is non-potable. For example, TDS for several off-gradient wells (EPA-1, Pond Windmill, and MW-24 east of the river) range from 3,570 to 11,600 mg/l (Table 3-2). Two downgradient wells believed unimpacted by pond seepage (MW-18A and MW-19) have TDS concentrations of 5,720 and 12,600 mg/l, respectively. These naturally occurring high-salt concentrations make groundwater unacceptable for human consumption without significant and costly treatment such as distillation and reverse osmosis.

Table 3-2. Major Constituent Ion Concentrations in Naturally Occurring Groundwater in the Vicinity of the Navajo Refinery Evaporation Ponds

Well ID	Sample Date	TDS (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Sulfate (mg/l)
EPA-1	10/90	3,570	N/A	N/A	950	1,220
EPA-1	11/92	3,750	176	480	989	1,420
Pond Windmill	10/90	4,800	N/A	N/A	1,240	1,010
Pond Windmill	11/92	4,740	180	872	1,190	1,780
MW-18A	11/92	12,600	664	2,420	3,930	3,950
MW-19	11/92	5,720	226	718	1,370	1,950
MW-24	11/92	11,600	240	2,500	4,170	2,910
Pecos River	11/92	5,110	186	733	1,470	1,660

Water Quality Standards and Notes:

1. TDS: 500 mg/l (SMCL), 1,000 mg/l (NMWQCC)
2. Magnesium: 100 mg/l @ 5 liter/day (USAMRDC), 150 mg/l (WHO)
3. Sodium: 20 mg/l (DWEL), 100 mg/l (NAS)
4. Chloride: 250 mg/l (SMCL, NMWQCC), 600 mg/l (USAMRDC)
5. Sulfate: 250 mg/l (SMCL), 300 mg/l @ 5 liter/day (USAMRDC), 600 mg/l (NMWQCC), 630 mg/l (LOAEL)
6. Abbreviations: DWEL - EPA Drinking Water Equivalent Level; LOAEL - EPA Lowest Observable Adverse Effects Level; N/A - No analysis; NAS - National Academy of Sciences; NMWQCC - New Mexico Water Quality Control Commission; SMCL - EPA Secondary Maximum Contaminant Level; TDS - Total Dissolved Solids; USAMRDC - U.S. Army Medical Research and Development Command; WHO - World Health Organization.
7. Table data is from Navajo Phase I and Phase II RFI Reports

Several constituents naturally occurring in groundwater in the vicinity of the evaporation ponds contribute to the unsuitability of untreated water for domestic consumption. Additionally, the total of these dissolved constituents, or TDS, produce adverse health effects by contributing to dehydration of body tissues either directly through osmotic effects after ingestion, or by refusal of individuals to drink the water because of the salty taste. The effects of the individual constituents and total salt concentrations on human health are discussed individually below.

Magnesium

Health effects of elevated concentrations of magnesium include catharsis and voluntary and involuntary dehydration. In clinical medicine, a dose of 480 mg is recommended to induce laxative effects (USAMRDC, 1988). Above 100 mg/l, there is increasing susceptibility to dehydration due to increasing laxative effects with water intake. Also, voluntary dehydration may occur as a result of rejection of water due to taste. Although the World Health Organization's recommended limit is 150 mg/l, magnesium at concentrations less than that value impart astringent taste that make water less palatable (NAS, 1977).

Sodium

Excessive sodium intake is linked to the development of hypertension. However, sodium in water usually provides only a small portion of sodium found in the diet. Commonly, for taste reasons, sodium is added to foods during processing, in home cooking, and at the table. Habitual intake bears no relationship to physiological need, but can be detrimental to individuals susceptible to hypertension through genetics, hormones, diet, or stress. An estimated 15 to 20 percent of the healthy American population is at risk of developing hypertension while about 3 percent is on a sodium restricted diet. A small portion of the population is on a severely restrictive diet that limits sodium content in water to 20 mg/l (NAS, 1977). A more important limitation on use of sodium rich water is its impact on potability due to taste when, combined with the anions chloride and sulfate, elevated levels lead to rejection due to taste or possible dehydration due to internal osmotic effects of salt fluids on the human body.

Chloride

The major impacts of ingestion of high chloride water are its laxative effects and hypertension at higher concentrations, voluntary dehydration resulting from rejection of water due to taste, and involuntary dehydration resulting from loss of body fluids due to the process of osmoregulation in the digestive tract. At increasing concentrations above 600 mg/l, a greater proportion of the population is likely to refuse to drink the water because of taste. At concentrations above 1,200 mg/l, the water was judged so objectionable that it would be rejected leading to voluntary dehydration (USAMRDC, 1988). Laxative effects and osmoregulation effects are reported to occur at concentration levels three to four times higher than concentrations which lead to voluntary dehydration. Hypertension effects have been reported when sodium is the cation ion in solution with chloride.

Sulfate

Elevated concentrations of sulfate, in combination with either sodium or magnesium, lead to increased laxative effects in water which may be used for drinking. Medical studies report that a 15-gram dose of Epsom salt ($MgSO_4 \cdot 7H_2O$) or Glauber's salt ($NaSO_4 \cdot 10H_2O$) will produce a cathartic response within three hours or less. A single five-gram dose of Epsom salt or Glauber's salt was reported to produce a significant laxative effect (USAMRDC, 1988). The latter level of Epsom or Glauber's salt (i.e., 1,950- or 1,450-mg dose of sulfate, respectively) are equivalent to the ingestion of two liters of water per day with sulfate concentrations ranging from about 700 to 1,000 mg/l. By comparison, the minimum concentration of sulfate in groundwater in the vicinity of the ponds is about 1,200 to 1,400 mg/l in EPA-1. More recently, in soliciting comments relating to a proposed maximum concentration limit goal (MCLG) for sulfate, EPA reported a concentration of 630 mg/l as the lowest observable adverse effect level in humans, in this case infant diarrhea (55 FR 30383, July 25, 1990).

Total Dissolved Solids

Collectively, the sum of the individual salt constituents dissolved in water is referred to as total dissolved solids (TDS). Various authors have categorized waters above 1,000 mg/l as either brackish or saline. Davis and DeWiest (1966) categorize waters between 1,000 and 10,000 mg/l as brackish. Hem (1992) classifies water between 3,000 and 10,000 mg/l as moderately saline. Either classification is appropriate for the naturally occurring water found in the vicinity of the evaporation ponds.

The health impact of individual cations and anions has been presented above. Health risks due to elevated concentrations of TDS similarly occur in two general categories: the risk of dehydration caused by refusal to drink water and the possibility of laxative effects. Although some populations can tolerate TDS levels exceeding 2,000 mg/l if acclimated, one study estimates that 18 percent of the population will reject water as objectionable due to taste at that concentration. Although increasingly higher percentages of the population reject water with TDS above 2,000 mg/l due to taste, dehydration due to laxative effects becomes an increasing concern. At a concentration of 3,600 to 3,800 mg/l TDS, well EPA-1 contains sufficient sulfate and other ion concentrations to cause laxative effects which could lead to dehydration due to loss of body fluids.

To summarize, the concentration of natural salts in the groundwater in the vicinity of the evaporation ponds are above all current acceptable standards. At a minimum, this renders the water non-potable due to taste. Additionally, the untreated water contains elevated levels of naturally occurring constituents that can lead to serious health effects such as dehydration which results from the loss of bodily fluids as a result of laxative action of the water. Because the water is non-potable, extensive treatment would need to be performed by a potential user to remove elevated levels of salts prior to human consumption. Such point-of-use treatment would also act to remove any contaminants introduced into the groundwater by the evaporation ponds.

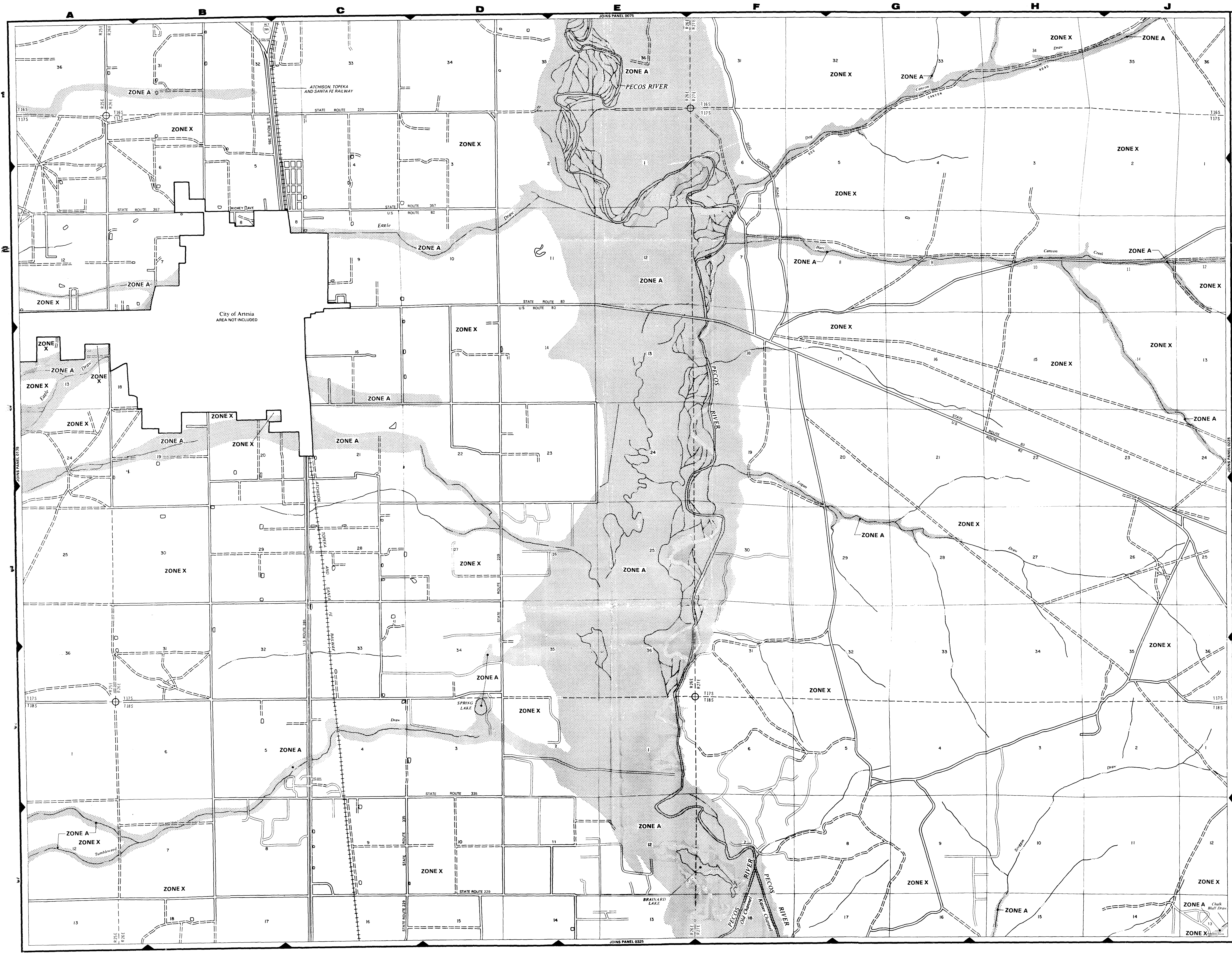
3.3.2.3 Site Suitability for Residential Habitation

The land area adjacent to and downgradient from the evaporation ponds, including inactive Pond 1, is subject to relatively frequent flooding by the Pecos River. Though the ponds themselves are protected by dikes from inundation by the 100-year flood, surrounding agricultural grazing land has no such protection. The Pecos River is deeply incised in a meander channel in the vicinity of the ponds and is somewhat restricted from changes in direction during flood events by thick growths of saltcedar along each bank. When the river floods, it overtops the restrictive channel in the vicinity of the northwest corner of Pond 1 and flows southerly via overland flow and exits the area via large box culverts beneath U.S. Highway 82 (Figure 1-1).

The Federal Emergency Management Agency (FEMA) has published flood insurance maps for much of the United States to use in administrating the National Flood Insurance Program. Among other features, the maps show areas of special flood hazards including the area subject to an 100-year flood. The maps, together with a review of other related information, should be used prior to purchase of property or construction. Map 350120 0200B (Eddy County, unincorporated areas) effective February, 1991, shows the Navajo evaporation ponds to be within an area inundated by at least an 100-year flood. The map shows the pond system lying in the approximate center of the 100-year flood zone (Figure 3-1), with the western boundary of the zone lying approximately 4000 ft. west of Pond 1.

Additional information was obtained from U.S. government records to determine the frequency of flooding in the immediate proximity of the ponds. From 1905 through the present, the U.S. Geological Survey (USGS) has maintained a water discharge gauge at the Highway 82 crossing of the Pecos River (Station 08396500). This location is approximately 6000 ft. southeast of Pond 1. The station documents flow and water quality for a 15,300 square-mile drainage area. Yearly water discharge records list average daily flow, and maximum and minimum flow for the year together with water level elevations (gage heights). The published data (Cruz et. al, 1994) also includes dates, discharge and elevations of base floods above 2000 cubic ft. per second (cfs) for each water year (October 1 to September 30).

In 1981 the gage was moved upstream 250 ft. and the stage-discharge relationship recalculated by the USGS. For the CMS, information in published records and received from the agency's Carlsbad office were used to evaluate at what elevation and flow the river overtopped its incised channel. River stage was graphically plotted versus discharge. An abrupt change in slope was noted at a river stage of about 11.1 to 11.2 ft. and at a flow of approximately 2000 cfs (Figure 3-2). This change in slope is interpreted as the height at which the river overtops the channel and water moves via overland flow over a much broader area. The graph shows that the 2000 cfs value, chosen by the USGS after evaluation of earlier flood events, continues to be a valid lower limit above which flooding occurs in the vicinity of the evaporation ponds.



LEGEND

▨	**SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD**	
	ZONE A	No base flood elevations determined.
	ZONE AE	Base flood elevations determined.
	ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.
	ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding; velocities also determined.
	ZONE A99	To be protected from 100-year flood by Federal flood protection system under construction; no base flood elevations determined.
	ZONE V	Coastal flood with velocity hazard (wave action); no base flood elevations determined.
	ZONE VE	Coastal flood with velocity hazard (wave action); base flood elevations determined.
▨	**OTHER FLOOD AREAS**	
	ZONE X	Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.
☐	**OTHER AREAS**	
	ZONE X	Areas determined to be outside 500-year floodplain.
	ZONE D	Areas in which flood hazards are undetermined.
———		Floodplain Boundary
— — —		Floodway Boundary
- — -		Zone D Boundary
▨		Boundary Dividing Special Flood Hazard Zones.
~~513~~~		Base Flood Elevation Line; Elevation in Feet*
(D)——(D)		Cross Section Line
(EL 987)		Base Flood Elevation in Feet Where Uniform Within Zone*
RM 7_x		Elevation Reference Mark
•M1.5		River Mile

*Referenced to the National Geodetic Vertical Datum of 1929

NOTES

This map is for use in administering the National Flood Insurance Program; it does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size, or all planimetric features outside Special Flood Hazard Areas. The community map repository should be consulted for possible updated flood hazard information prior to use of this map for property purchase or construction purposes.

Coastal base flood elevations apply only landward of 0.0 NGVD, and include the effects of wave action; these elevations may also differ significantly from those developed by the National Weather Service for hurricane evacuation planning.

Areas of special flood hazard (100-year flood) include Zones A, AE, AH, AO, A99, V, and VE.

Certain areas not in Special Flood Hazard Areas may be protected by flood control structures.

Boundaries of the floodways were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the Federal Emergency Management Agency.

Floodway widths in some areas may be too narrow to show to scale. Floodway widths are provided in the Flood Insurance Study Report.

Elevation reference marks are described in the Flood Insurance Study Report.

For adjoining map panels see separately printed Map Index

MAP REPOSITORY

Eddy County Courthouse, Carlsbad, New Mexico 88221-1139 (Maps available for reference only, not for distribution).

INITIAL IDENTIFICATION:

FEBRUARY 7, 1978

FLOOD HAZARD BOUNDARY MAP REVISIONS:

NONE

FLOOD INSURANCE RATE MAP EFFECTIVE:

FEBRUARY 6, 1991

FLOOD INSURANCE RATE MAP REVISIONS:

Refer to the Flood Insurance Rate Map Effective date shown on this map to determine when actuarial rates apply to structures in the zones where elevations or depths have been established.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at (800) 638-6620.

APPROXIMATE SCALE

2000 0 2000 FEET

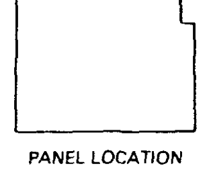
NATIONAL FLOOD INSURANCE PROGRAM

C71

FIRM
FLOOD INSURANCE RATE MAP

EDDY COUNTY,
NEW MEXICO
UNINCORPORATED AREAS

PANEL 200 OF 1125
(SEE MAP INDEX FOR PANELS NOT PRINTED)


PANEL LOCATION

COMMUNITY-PANEL NUMBER
350120 0200 B

EFFECTIVE DATE:
FEBRUARY 6, 1991

Federal Emergency Management Agency

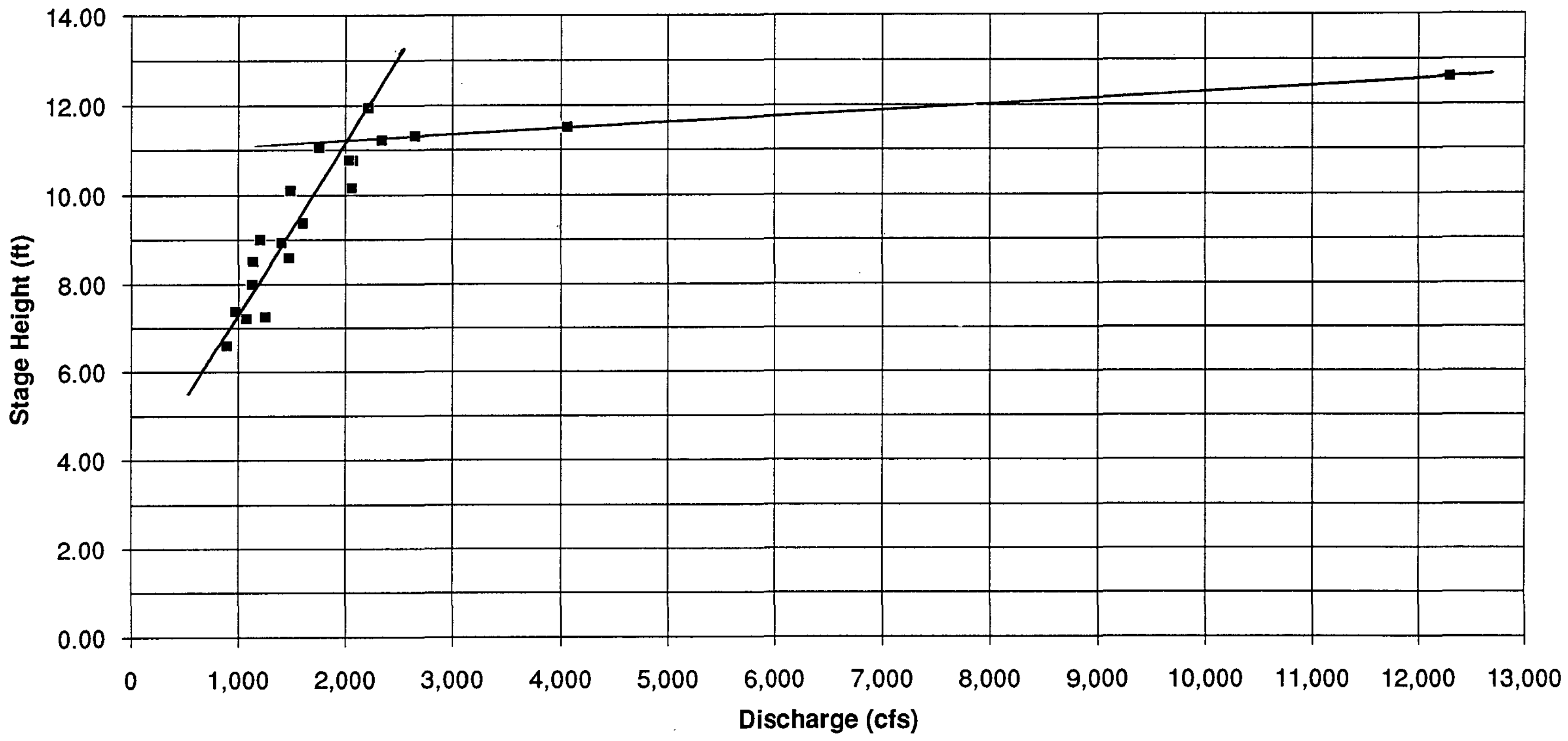


Figure 3-2. Stage-Discharge Relationship, 1981-1993

Records for water years 1964 through 1993 were researched and examined to determine the frequency and severity of flooding along this reach of the river. Records for earlier years provide historical perspective, but upstream dams have been constructed for flood control. The most recent major project completed was the Two Rivers Reservoir on tributary arroyos southwest of Roswell in July of 1963. Table 3-3 provides information on yearly maximum discharge and floods greater than 2000 cfs at the Artesia gage for water years subsequent to completion of the Two Rivers Reservoir.

Figure 3-3 is a chart showing maximum annual river discharge at the station and floods discharging greater than 2000 cfs. During the 30-year time period under discussion, 30 flood events with a peak discharge greater than 2000 cfs were recorded at the gauging station. During the past ten years, five events greater than 2000 cfs were recorded. Even with increased flood control construction on river tributaries, the June 1986 flood at 12,300 cfs was the largest flood in the period of record researched for this report.

In summary, the historical hydrologic evidence demonstrates that the area downgradient from the evaporation ponds is prone to frequent and significant flooding even subsequent to flood control measures. No further flood control efforts are known to be planned in the vicinity of the ponds. No residential housing (including farm and ranch structures) are currently located downgradient from the ponds. Because of the documented frequent flooding potential, it is extremely unlikely that any residential housing will be constructed, and no domestic use of the groundwater will occur, irrespective of its natural quality. Therefore, there is no potential future human exposure to any water contaminants that may be present in groundwater due to seepage from Navajo's evaporation pond, and no risk to human population by this exposure pathway.

3.3.3 Potential for Future Agricultural Use

The Navajo evaporation pond system and surrounding property is situated inside a large west-to-south running bend of the Pecos River and is contained within the boundaries of the 100-year floodplain. Soils in this area are too saline for commercial-scale agricultural crop production and quality irrigation water is unavailable. Furthermore, the area is prone to periods of frequent and prolonged inundation from river overflow, which would severely disrupt any form of agricultural crop production (Section 3.3.2.3). Due to these factors, the property surrounding the Navajo ponds is utilized exclusively as open rangeland for livestock grazing. Should the Pond 1 unit ever be used for purposes of human enterprise at some distant future date, it is realistic to assume that open rangeland represents the only feasible usage of this site.

3.4 Human Health Risk Assessment for Pond 1 Soils and Groundwater

For this CMS plan, EPA has required that a human health risk assessment (RA) be conducted for organic and inorganic constituents contained in Pond 1 soils and groundwater. Specifically, EPA has specified a RA based on a residential exposure scenario involving human ingestion of contaminated surface soils, using RFI Phase II trench soil sample data obtained from the 0-1 ft. sample interval at four trenches (EP-TR-01, 02, 03, and 06).

Table 3-3. Maximum Discharge Records and Floods Greater Than 2000 Cubic Feet Per Second (cfs), Artesia Gage, Water Years 1964 - 1993

Water Year	Discharge (cfs)	Gage Height (ft)	Date	USGS Comment
1964	5,200	6.80	14-Jun-64	Flow bypassed gage
1965	4,700	12.34	30-Jul-65	Flow bypassed gage
1966	2,200	8.94	20-Jun-66	
1966	7,000	12.42	24-Aug-66	Flow bypassed gage
1967	2,300	9.48	30-May-67	
1967	2,060	8.80	17-Aug-67	
1968	4,000	12.30	7-Jul-68	
1969	3,360	12.26	12-Sep-69	
1969	3,580	12.31	19-Sep-69	
1970	2,050	- -	26-Jul-70	
1970	3,050	11.93	18-Sep-70	
1971	1,690	8.57	13-Aug-71	
1972	2,780	11.11	21-Jul-72	
1972	3,100	11.82	30-Aug-72	
1972	2,300	10.38	3-Sep-72	
1972	3,800	12.25	10-Sep-72	
1972	2,290	10.90	14-Sep-72	
1972	2,260	10.85	16-Sep-72	
1973	2,060	9.62	18-May-73	
1974	6,500	12.40	24-Sep-74	Flow bypassed gage
1974	4,300	- -	24-Oct-74	Flow bypassed gage
1976	4,300	12.20	24-Oct-75	Flow bypassed gage
1976	931	6.54	5-Aug-76	
1977	2,380	11.34	1-Sep-77	
1978	2,930	11.85	29-Jun-78	
1979	1,180	7.57	14-Jun-79	
1980	1,670	9.00	12-Sep-80	
1981	1,080	7.21	13-Aug-81	
1982	2,070	10.15	15-Sep-82	
1983	895	6.59	16-May-83	
1984	2,080	10.76	4-Nov-83	
1984	2,220	11.94	13-Aug-84	
1985	1,480	8.59	19-Jun-85	
1986	12,300	12.61	27-Jun-86	
1987	1,210	9.00	25-May-87	
1988	1,130	7.99	24-Sep-88	
1989	1,140	8.51	14-May-89	
1990	975	7.38	17-Aug-90	
1991	2,347	11.22	17-Jul-91	
1991	4,060	11.50	18-Jul-91	
1991	2,040	10.77	16-Aug-91	
1992	1,250	7.26	2-Jun-92	
1993	1,490	10.10	22-Jul-93	

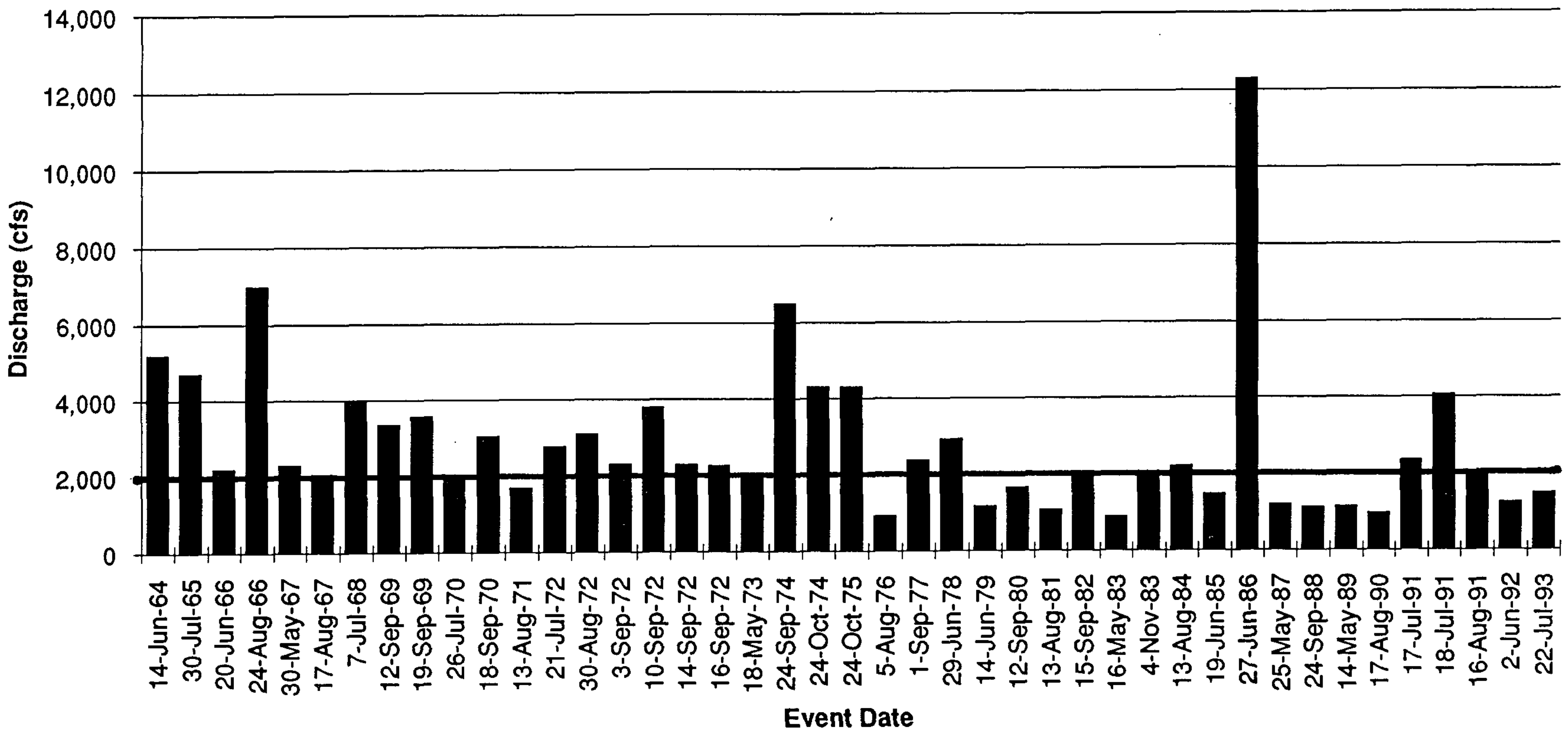


Figure 3-3. Maximum Annual Discharge and Floods Greater than 2000 Cubic Feet Per Second, Artesia Gage, Water Years 1964-1993

The baseline RA described in the following sections has been conducted in general accordance with the guidance and methods described in the document entitled Risk Assessment Guidance for Superfund: Vol. I, Human Health Evaluation Manual (Part A).

3.4.1 Data Collection and Evaluation

Data reviewed for use in the RA for Pond 1 soils was obtained from the RCRA Facility Investigation TMD and Evaporation Ponds, Phase II, (Revised) report (KWBES, 1993). Data reviewed for use in the RA for groundwater in the vicinity of the unit came from the RFI Phase I Report (Second Submittal), Mariah Associates, Inc., December, 1990 as well as the Phase II report.

Pond 1 soil analytical data for inorganic and organic constituents obtained from the from the RFI Phase II is presented in Tables 3-4 and 3-5. Four of the five inorganic constituents of concern (arsenic, chromium, nickel, and zinc), were included in the RA evaluation. For volatile organic constituents, only those constituents detected at one or more of the designated soil sample location intervals were included for evaluation.

Lead was not considered in the RA, since EPA currently considers it inappropriate to develop numerical estimates for either the RfD or oral slope factor parameters for this constituent. However, potential environmental risk posed by lead in Pond 1 soils was discussed in detail in Section 3.2, and the maximum soil concentration value for lead in Pond 1 soil samples obtained from the 0-1 ft. interval for the four sample locations of interest was 389 mg/kg, and the average value was 177 mg/kg. EPA's integrated uptake model (IUBK) uses a lead blood level not to exceed 10 ug/deciliter and a 95th-percentile population distribution to protect the most sensitive exposed individuals to establish a permissible soil lead concentration of 500 mg/kg. Consequently, the exclusion of lead from the current RA is not considered to be crucial to the evaluation.

Due to the limited size of the data set, calculation of a 95% Upper Confidence Level for the arithmetic average of sample constituent concentrations was not appropriate. Considering the limited nature of the data set and the general inability to derive valid statistics for use in the RA, it was decided that the maximum values obtained for each inorganic and organic constituent would be used for the RA.

Assessment of semivolatile constituents was hampered by an absence of appropriate data. For the most part, semivolatile data presented in the final RFI Phase II report had sample detection limits which were too high to determine whether those constituents were present at levels of potential concern. In their review of the original submittal of the Pond 1 CMS Work Plan, EPA requested that the analytical results for split samples obtained by EPA contractors during the RFI Phase II field activities be used in the soils RA. However, it was subsequently discovered that split samples were not obtained for the locations of interest at the 0-1 foot sample interval. To address this shortcoming, it was decided to devise a conservative worst-case approach. For the sample locations of interest, all hazardous semivolatile constituents reported at any sample interval were compiled, including those reported in both total semivolatile analyses

Table 3-4. Summary of Pond 1 Soil Sampling Data for Total Metals (mg/kg)

Location	Arsenic	Chromium	Lead	Nickel	Zinc
EP-1	26.1	74	389	21	54
EP-2	38.6	1011	93	37	303
EP-3	22.6	633	73	14	434
EP-6	39.9	235	153	37	161

Table 3-5. Summary of Pond-1 Soil Sampling Data for Organic Constituents (mg/kg)

Constituent	Sample Location				
	EP-TR-01	EP-TR-02	EP-TR-03	EP-TR-06	
Volatile Organics[1]					**Maximum Value:**
Acetone	0.387	<0.391	<0.061	<0.263	0.387
Benzene	0.030	<0.196	<0.031	<0.132	0.030
Ethylbenzene	0.443	0.590	0.101	<0.132	0.590
Methylene chloride	<0.028	<0.196	0.076	<0.132	0.076
Toluene	0.622	0.376	0.114	0.147	0.622
Xylenes (total)	2.050	1.570	0.264	<0.132	2.050
Semivolatile Organics[2]					half - average[3]
Benzo(g,h,i)perylene	<80	<890	<6.0	<220	150
Benzo(a)pyrene	<80	<890	<6.0	<220	150
Chrysene	<80	<890	<6.0	<220	150
Dibenzofuran	<80	<890	<6.0	<220	150
2,4-Dimethylphenol	<80	<890	<6.0	<220	150
Fluorene	<80	<890	<6.0	<220	150
Naphthalene	<80	<890	<6.0	<220	150
2-Methylnaphthalene	<80	<890	<6.0	<220	150
Phenanthrene	<80	<890	8.0	<220	150
Pyrene	<80	<890	<6.0	<220	150

Notes:

(1) Only constituents detected in one or more samples are reported.

(2) Includes all constituents detected at any depth for total semivolatile and TCLP-semivolatile analyses.

(3) Average of 1/2 detection limit values.

and TCLP-semivolatile analyses. For each constituent, the average value of one-half the reported detection limit was calculated for use in the RA.

Groundwater data for monitor wells selected by EPA for inclusion in the RA are presented in Table 3-6. Sample concentration data from the RFI Phase I and Phase II for the four metals of concern, and for all volatile and semivolatile constituents for which detection events were reported are summarized in Table 3-6.

The sample analytical data used in the RA was obtained during the course of the Pond 1 RFI Phase I and Phase II. The data in question was collected under the auspices of the RFI quality assurance/quality control program, and has previously been reviewed by EPA. Therefore, the quality and reliability of the data is presumed to be acceptable for purposes of the RA.

Toxicity data used in the RA was obtained primarily from the Integrated Risk Information System (IRIS), an on-line EPA database carried on the National Library of Medicine on-line database system. The data obtained from IRIS at the time of the RA was current as of December, 1994.

Data obtained from IRIS consisted of reference dose (RfD) and oral slope factor data for the various constituents. For several constituents, information was lacking on these parameters on IRIS, and secondary sources of information were used to fill the information gaps as necessary. When alternate information sources were employed (e.g., Health Effects Summary Table, other EPA documents), the source of the information is cited in the summary tables.

3.4.2 Risk Assessment for Pond 1 Soils

For purposes of the RA, EPA has stipulated that potential human health risks posed by Pond 1 soils be assessed on the basis of an oral ingestion exposure pathway under a residential occupation scenario. Calculation of the residential ingestion of soil contaminants was accomplished according to the residential soil ingestion equation presented in Exhibit 6-14 of the EPA Human Health Evaluation Manual, Part A (EPA, 1989). Standard default exposure assumptions typically employed in a residential exposure assessment were used in the current RA. For the evaluation of non-carcinogenic of soil-borne constituents, the following assumptions were employed:

- exposed individual is a child, age 1-5 years;
- body weight is 16 kg;
- fraction of soil ingested from the contaminated source is 100 percent; and
- ingestion rate of contaminated soil is 200 mg per day.

In addition, the product of the exposure frequency times duration were set to be equivalent to the averaging time, so that these terms canceled, and the oral ingestion exposure term was expressed in mg contaminant /kg body weight/day.

Table 3-6. RFI Phase I and Phase II Groundwater Contaminant Concentrations

	RFI PHASE I			RFI PHASE II				EPA MCL(3)
Well ID:	**MW-3**	**MW-4**	**MW-6**	**MW-3**	**MW-4**	**MW-6A**	**MW-6B**	
Constituent (1)								
Arsenic	0.11	0.22	0.056	0.078	0.080	0.065	0.021	0.05
Chromium	0.01	0.02	0.01	0.03	<0.02	0.05	<0.02	0.1
Lead	<0.01	<0.01	<0.01	<0.02	<0.02	<0.02	<0.02	0.015(4)
Nickel	0.01	0.07	<0.01	0.12	<0.11	0.11	<0.01	0.1
Benzene	0.041	ND(2)	ND	0.017	0.021	<0.005	0.009	0.005
Ethylbenzene	ND	0.032	0.011	0.016	0.019	0.007	<0.005	0.7
Toluene	ND	ND	0.013	0.021	0.009	0.006	0.006	1.0
Xylene	ND	0.023	0.019	0.025	0.032	0.014	<0.005	10
2-hexanone	0.014	ND	0.023	<0.005	<0.005	<0.005	<0.005	- -
2-butanone	ND	ND	ND	<0.010	<0.010	<0.005	0.048	- -
carbon disulfide	ND	ND	ND	<0.005	<0.005	<0.005	0.117	- -
bis(2-chloro isopropyl) ether	ND	ND	0.022	<0.030	<0.050	<0.010	<0.010	- -

Notes:

(1) All constituent concentrations are milligrams per liter (mg/l).
(2) ND - Not Detected; detection limits not available for RFI Phase I groundwater data.
(3) Maximum Contaminant Level
(4) Action level for domestic water at the tap

For the soil contaminant non-carcinogenic health effects segment of the RA, maximum soil concentration values for the various constituents, calculated soil ingestion rates, reference doses for the various constituents, and the resulting hazard quotients and the cumulative hazard index are presented in Table 3-7.

For the evaluation of lifetime carcinogenic effects, the following standard assumptions were employed:

- exposed individual is an adult;
- body weight is 70 kg;
- fraction of soil ingested from the contaminated source is 100 percent; and
- ingestion rate of contaminated soil is 100 mg per day.

Again, the product of the exposure frequency times duration were set to be equivalent to the averaging time, so that these terms canceled, and the oral ingestion exposure term was expressed in mg contaminant /kg body weight/day.

For the lifetime cancer risk portion of the RA, maximum soil concentration values for the various constituents, calculated soil ingestion rates, oral slope factors for the various constituents, and the resulting individual and cumulative cancer risks are presented in Table 3-8.

EPA typically considers a hazard index greater than 1 to be indicative of potentially unacceptable risk, while the results of the acute human health risk assessment for Pond 1 soils presented in Table 3-7 reveal an overall hazard index calculation of 2.03. However, there is ample reason to consider the derived hazard index to be an overestimate of the overall non-carcinogenic risk posed by Pond 1 soils. First, in the absence of a sufficient soil sample database from which to draw an estimate, maximum soil concentrations for each constituent were employed in the evaluation. More than 80 percent of the total contribution to the hazard index resulted from the hazard quotient of 1.66 obtained for arsenic. However, should the average arsenic value for Pond 1 soils actually be similar to the overall average for the six Pond 1 surface samples obtained during the RFI Phase II (25 mg/kg) the overall contribution of arsenic to the hazard index is reduced by nearly 40 percent. Furthermore, there is no evidence to support the extremely conservative concentration values assumed for the semivolatile constituents. The conservatively assumed maximum concentrations for these constituents contributed approximately 16 percent of the total hazard index.

Finally, while the residential exposure assumptions used in the non-carcinogenic evaluation (based on child exposure) were mandated by EPA, there is abundant reason to doubt that such an exposure scenario could ever occur at the site, as was discussed in preceding sections of this document If the exposure assumptions are modified to a more reasonable adult exposure scenario, using an ingestion rate of 100 mg/kg soil/day and a 70 kg adult body weight, the overall hazard index is reduced to a value of 0.232, which is nearly one tenth of the current value of 2.03, and also less than one-fourth of a hazard index value of 1.0.

Table 3-7. Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Non-carcinogenic Health Effects for Pond 1 Soils

Constituent	Maximum Concentration (mg/kg)	Calculated Soil Intake (mg/kg/day)(1)	Reference Dose (mg/kg/day)(2)	Calculated Hazard Quotient
Arsenic	39.9	4.99E-04	3.00E-04	1.66E+00
Chromium	1011	1.26E-02	1.00E+00	1.26E-02
Nickel	37	4.63E-04	2.00E-02	2.32E-02
Zinc	434	5.43E-03	3.00E-01	1.81E-02
Acetone	0.387	4.84E-06	1.00E-01	4.84E-05
Benzene	0.03	3.75E-07	NA	NA
Ethylbenzene	0.59	7.38E-07	1.00E-01	7.38E-05
Methylene chloride	0.076	9.50E-07	6.00E-02	1.58E-05
Toluene	0.622	7.78E-06	2.00E-01	3.89E-05
Xylenes	2.05	2.56E-05	2.00E+00	1.28E-05
Benzo(g,h,i)perylene	150(3)	1.88E-03	NA	NA
Benzo(a)pyrene	150(3)	1.88E-03	NA	NA
Chrysene	150(3)	1.88E-03	NA	NA
Dibenzofuran	150(3)	1.88E-03	NA	NA
2,4-Dimethylphenol	150(3)	1.88E-03	2.00E-02	9.40E-02
Fluorene	150(3)	1.88E-03	4.00E-02	4.70E-02
Naphthalene (4)	150(3)	1.88E-03	4.00E-02	4.70E-02
2-Methylnaphthalene	150(3)	1.88E-03	NA	NA
Phenanthrene (5)	150(3)	1.88E-03	2.90E-02	6.48E-02
Pyrene	150(3)	1.88E-03	3.00E-02	6.27E-02
			Hazard Index	**2.03E+00**

Notes:

(1) Assumptions: 200 mg soil intake/day; 16 kg body weight (ingestion by child)
(2) Based on 12/94 Integrated Risk Information System (IRIS) data.
(3) Based on average of one-half of constituent detection limits.
(4) RfD data obtained from HEAST.
(5) RfD data obtained from Region 3 risk-based screening guidance (EPA, 1993).
NA Not Available.

Table 3-8. Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Lifetime Cancer Risks for Pond 1 Soils

Constituent	Maximum Concentration (mg/kg)	Calculated Soil Intake (mg/kg/day)(1)	Oral Slope Factor (mg/kg/day)(2)	Calculated Cancer Risk
Arsenic	39.9	5.70E-05	1.75	9.98E-05
Chromium	1011	1.43E-04	NA	NA
Nickel	37	5.29E-05	NA	NA
Zinc	434	6.20E-04	NA	NA
Acetone	0.387	5.53E-07	NA	NA
Benzene	0.03	4.29E-08	2.90E-02	1.24E-09
Ethylbenzene	0.59	8.43E-07	NA	NA
Methylene chloride	0.076	1.09E-07	7.50E-03	8.18E-10
Toluene	0.622	8.89E-07	NA	NA
Xylenes	2.05	2.93E-06	NA	NA
Benzo(g,h,i)perylene (3)	150(4)	2.14E-04	1.55E-01	3.32E-05
Benzo(a)pyrene	150(4)	2.14E-04	7.30E+00	1.56E-03
Chrysene	150(4)	2.14E-04	NA	NA
Dibenzofuran	150(4)	2.14E-04	NA	NA
2,4-Dimethylphenol	150(4)	2.14E-04	NA	NA
Fluorene	150(4)	2.14E-04	NA	NA
Naphthalene	150(4)	2.14E-04	NA	NA
2-Methylnaphthalene	150(4)	2.14E-04	NA	NA
Phenanthrene	150(4)	2.14E-04	NA	NA
Pyrene	150(4)	2.14E-04	NA	NA
Total Cancer Risk				**1.70E-03**

(1) Assumptions: 100 mg soil intake/day; 70 kg body weight (ingestion by adults).

(2) Based on 12/94 Integrated Risk Information System (IRIS) data.

(3) Oral slope factor data obtained from Region 3 risk-based screening guidance (EPA, 1993).

(4) Based on average of one-half of constituent detection limits.

For the carcinogenic risk assessment summarized in Table 3-8, an overall cumulative cancer risk of 1.7 x 10^{-3} was calculated. Again, the derived value is very likely to be a gross overestimate. Two semivolatile constituents, benzo(g,h,i)perylene and benzo(a)pyrene, contribute approximately 94 percent of the total estimated cumulative carcinogenic risk posed by the Pond 1 soils. There is no evidence to believe that these assumed values provide a realistic estimate of the true soil concentration values for these constituents. The assumed soil concentration for arsenic (39.9 mg/kg), which essentially contributes the remainder of the cancer risk, falls within an acceptable risk range of 10^{-4} to 10^{-6}, particularly when the extremely minimal potential for residential occupation of the site is taken into account.

3.4.3 Risk Assessment for Pond 1 Groundwater

For the Pond 1 groundwater RA, EPA also stipulated that potential human health risks posed by groundwater in the vicinity of the unit be assessed on the basis of an oral ingestion exposure pathway under a residential occupation scenario. Calculation of the residential ingestion of groundwater contaminants was determined according to the residential groundwater ingestion equation presented in Exhibit 6-11 of the EPA Human Health Evaluation Manual, Part A (EPA, 1989). Again, standard default exposure assumptions typically employed in a residential exposure assessment were used in the current RA. For the evaluation of both non-carcinogenic and carcinogenic effects, the following assumptions were employed:

- exposed individual is an adult;
- body weight is 70 kg; and
- ingestion rate of contaminated groundwater is 1.4 liters/day.

As was the case for the soils assessment, the product of the exposure frequency times duration were set to be equivalent to the averaging time, so that these terms canceled, and the oral ingestion exposure term was expressed in mg contaminant /kg body weight/day.

Results of the assessment of non-carcinogenic effects of groundwater-ingestion are summarized in Table 3-9. The estimated hazard index for residential ingestion of groundwater was 14.8, with arsenic contributing 99 percent of the total. Since arsenic has been reported in site monitoring well samples at concentrations exceeding the arsenic MCL, it is reasonable to expect that a hazard index greater than 1.0 would be obtained. Similarly, while arsenic and benzene both contributed to the calculated cancer risk of 7.72 x 10^{-3} (Table 3-10), the total cancer risk was dominated by the estimated effects of arsenic.

Although the non-carcinogenic and carcinogenic risk parameter calculations described above might appear to indicate significant potential risk, scarce significance should be attached to these findings. Preceding sections of this document have provided ample demonstration that human occupation of land overlying the groundwater in the vicinity of Pond 1 will not occur, and that, even if such occupation were to occur, the natural quality of the groundwater causes it to be grossly unsuitable for human consumption. Indeed, in providing guidance for characterizing the potential for human exposure to environmental contaminants, EPA has explicitly recognized that "an assumption of future residential land use may not be justifiable if the probability that the site will support residential land use in the future is exceedingly small" (EPA, 1989).

Table 3-9. Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Non-carcinogenic Risks for Exposure to Pond 1 Groundwater

Constituent	Maximum Concentration (mg/l)	Calculated Ground-water Intake (mg/kg/day)(1)	Oral Reference Dose (2)	Hazard Quotient
Arsenic	0.22	4.40E-03	3.00E-04	1.47E+01
Chromium	0.05	1.00E-03	1.00E+00	1.00E-03
Nickel	0.12	2.40E-03	2.00E-02	1.20E-01
Benzene	0.041	8.00E-04	NA	NA
Ethylbenzene	0.032	6.00E-04	1.00E-01	6.00E-03
Toluene	0.021	4.00E-04	2.00E-01	2.00E-03
Xylene	0.032	6.40E-04	2.00E+00	3.20E-04
2-Hexanone	0.023	2.80E-04	NA	NA
2-Butanone	0.048	9.60E-04	6.00E-01	1.60E-03
Carbon disulfide	0.117	2.34E-03	1.00E-01	2.34E-02
Bis(2-chloro isopropyl)ether	0.022	4.40E-04	4.00E-02	1.10E-02
			Hazard Index	**1.48E+01**

Notes:

(1) Assumptions: 1.4 liter intake/day; 70 kg adult body weight.

(2) Based on 12/94 Integrated Risk Information System (IRIS) data.

Table 3-10. Summary of Exposure Calculations, Toxicity Data and Risk Assessment Calculations for the Assessment of Carcinogenic Effects for Exposure to Pond 1 Groundwater

Constituent	Maximum Concentration (mg/l)	Calculated Groundwater Intake (mg/kg/day)(1)	Oral Slope Factor (mg/kg/day)(2)	Calculated Cancer Risk
Arsenic	0.22	4.40E-03	1.75E+00	7.70E-03
Chromium	0.05	1.00E-03	NA	NA
Nickel	0.12	2.40E-03	NA	NA
Benzene	0.041	8.00E-04	2.90E-02	2.32E-05
Ethylbenzene	0.032	6.00E-04	NA	NA
Toluene	0.021	4.00E-04	NA	NA
Xylene	0.032	6.40E-04	NA	NA
2-Hexanone	0.023	2.80E-04	NA	NA
2-Butanone	0.048	9.60E-04	NA	NA
Carbon disulfide	0.117	2.34E-03	NA	NA
Bis(2-chloro isopropyl) ether	0.022	4.40E-04	NA	NA
				7.72E-03

Notes:

(1) Assumptions: 1.4 liter intake/day; 70 kg adult body weight.

(2) Based on 12/94 Integrated Risk Information System (IRIS) data.

3.5 Corrective Measures Objectives

On the basis of a thorough evaluation of the overall environmental risk posed by contaminant in Pond 1 soils the following conclusions have been reached. The location and environmental setting of the Navajo Evaporation Ponds is such that the probability that the site will be subject to future industrial use or human residential occupation, in either the immediate or distant future, must be considered to be extremely remote. Furthermore, based on the nature and magnitude of contamination and the existing scientific literature database (as reflected in the 40 CFR Part 503 sludge rules), there is no evidence indicating that the site does or will pose a threat of ecological harm to the surrounding environment.

Navajo has no intention of selling the property of which the subject site is a part. Upon final closure of the unit, Navajo will submit documentation to establish that a legally binding covenant will be placed upon the property deed to the effect that any future use of the property will be expressly limited to agricultural purposes.

Given the flood-prone nature of the site and the lack of potential for alternative agricultural usages, it is clear that open rangeland represents the only feasible future agricultural use of the property. Therefore, an appropriate corrective measures remediation goal will consist of reducing soil hydrocarbon concentrations to levels that will permit the establishment of a permanent vegetative cover over the unit. A target remediation goal of 10,000 mg/kg TPH for Pond 1 soils is hereby proposed.

The 10,000 mg/kg TPH standard for surface soils is intended to ensure that the minimal levels of volatile and semivolatile hazardous organic constituents present in Pond 1 soils are further reduced to the point of non-detection or otherwise sufficiently reduced to further minimize any reasonably postulated residual risk to human health and the environment. In addition, the proposed standard will be adequate to permit the establishment of the specialized vegetative cover described in Section 4.1.3. From a functional agronomic viewpoint, the hydrocarbon wastes present in Pond 1 soils are similar to the residual products which might result from the release of a weathered crude oil. Considerable documentation exists to support the fact that vegetation can establish itself, and in some instances even benefit, from soil hydrocarbon concentrations (typically in the form of refinery sludge or crude oil) as high as 10,000-20,000 mg/kg TPH when the hydrocarbons are derived from refinery wastewater sludge or crude oil.

Finally, as part of the unit closure, Navajo intends to employ a long-term phytoremediation-oriented approach that is expected to be highly effective and appropriate for the particular environmental setting of this site. As described in Section 4.1.3, final unit reclamation will be designed to essentially eliminate the possibility that the Pond 1 soils will pose even the most minimal threat of contaminant release to underlying groundwater, and to ensure that unit soils will remain stable until natural processes have completed the biodegradation of residual hydrocarbon materials.

3.6 Identification of Corrective Measures Alternative

As discussed in Section 3.5, the corrective measures objectives for Pond 1 are intended to reduce soil hydrocarbon concentrations to levels that will permit the establishment of a specialized vegetative cover on the unit. Based on all sources of available information, there is no evidence to indicate an immediate threat to human health and the environment resulting from the presence of the Pond 1 soil contaminants, so that excavation and offsite removal of the hydrocarbon contaminated soils is not warranted. Therefore, off-site remediation and/or disposal options for Pond 1 soils are not considered further in this document.

Various on-site remediation technologies appropriate for the treatment of the hydrocarbon-contaminated soils, such as thermal desorption or incineration, would achieve an adequate remediation of hydrocarbon-contaminated soils in Pond 1 in the minimum possible amount of time. However, such alternative options would require highly intensive efforts in terms of planning, design, testing, energy, time and cost expenditures. Use of such technology-intensive remediation methods is not considered consistent with the overall level of environmental risk presently posed by unit soils.

In view of the low overall level of environmental risk posed by the unit, it is concluded that traditional land treatment bioremediation technology will afford the most appropriate and cost-effective means to remediate Pond 1 soils. Land treatment is a proven bioremediation method that produces consistent and reliable results while utilizing low-technology equipment and a relatively simple level of expertise in a highly cost-effective manner.

Navajo possesses a high level of preparedness to proceed with the proposed corrective measures land treatment alternative. Based on knowledge of the soil contaminant profile in Pond 1 and experience with the interim corrective actions previously undertaken at the unit, it is anticipated that bioremediation of the unit to the target clean-up standard of 10,000 mg/kg TPH can be completed in approximately 2 years.

3.7 Proposed Alternate Concentration Limits for Groundwater

Phase I and Phase II RFI studies have characterized groundwater constituent concentrations downgradient from Pond 1. Sample results for the RFI Phase III work have not yet been validated and are not available for inclusion with this report. The Phase I and Phase II results for metals, volatiles and semivolatiles together with EPA maximum contaminant levels (MCL's) are shown in Table 3-6. Most sample results are at or less than the corresponding MCL for that constituent. However for some wells arsenic and benzene exceed the MCL by a factor of between 4 and 5 times the MCL.

As has been discussed above, at the current site, groundwater is non-potable for drinking without extensive treatment which would remove both inorganic and organic contaminants. Also, the physical location is subject to frequent flooding rendering it unsuitable for human residential use. Therefore, the use of alternate lower constituent concentration limits for groundwater downgradient from Pond 1 is appropriate.

Accordingly, groundwater concentration levels 20 times the established MCL's have been selected as alternate concentration limits (ACLs) for all constituents. Since the maximum exceedance for any constituent currently does not exceed five times the MCL, a level of 20 provides a buffer range that allows for laboratory variability in analyses. This is especially important in the analysis of arsenic in groundwater since matrix interference can commonly cause reported concentrations to be higher than are actually present (RFI Phase II report, p. 138). If concentrations greater than 20 times the MCL are observed during the period of post-closure monitoring, such occurrence will trigger a re-evaluation of the health risks that may be present at the site.

4.0 CORRECTIVE MEASURE DESIGN, OPERATION AND MANAGEMENT

The following sections describe the proposed bioremediation program for Pond 1 soils. Section 4.1 describes the general remediation strategy and basic features of operation and maintenance, specific requirements for soil amendment applications, environmental monitoring, and post-remediation revegetation of the unit. Corrective Measures Program documentation and reporting are described in Section 4.2, and estimated program costs and scheduling are discussed in Sections 4.3 and 4.4, respectively.

Details of further environmental investigation and monitoring of new and existing wells adjacent to the unit are included as Section 4.5. This information was previously presented in the original submittal of the Evaporation Pond 1 Corrective Measures Study Workplan (August, 1994). As EPA had no modifying comments regarding the proposed approach for the additional groundwater investigation, the initial phase of the work (measurement and monitoring of existing wells at Pond 1) was conducted in November 1994 in conjunction with field activities related to the TMD/Active Evaporation Pond RFI Phase III. However, for the sake of completeness, the details of the additional groundwater investigation are again presented in their entirety in this revised submittal of the CMS workplan.

4.1 General Remediation Strategy

The general strategy of the proposed bioremediation program is presented in Figure 4-1. Based on knowledge of existing site conditions, the middle of the unit is underlain by a relatively shallow layer of hydrocarbon contamination which typically extends to an average depth not greater than 1.5 ft. from the soil surface. This central area is estimated to encompass approximately 13 acres of the 15 total acres of the unit. For purposes of project cost estimations, it is also conservatively assumed that the remaining periphery areas of the unit (approximately 2 acres) exhibits hydrocarbon contamination to an average depth of 9 ft. from the existing surface grade.

At the eastern end of the unit, immediately adjacent to the dike dividing Pond 1 from Pond 2, an initial excavation of all hydrocarbon-contaminated soils will be conducted with the depth of excavation not too exceed the depth of groundwater. The excavated area will subsequently be used as an interim stockpile area for remediated soils, as described below. Soils which are initially removed from the eastern excavation will be surface applied across the unit to the west of the excavation, and standard land treatment methods, including tillage and soil amendment applications will be initiated. When these excavated soils have been remediated to target clean-up levels, the treated soils will be scraped from the treatment area and into the eastern excavation. Subsequently, surface treatment will be continued on the next lower segment of soils (if contamination is evident). When the initial excavation area has been backfilled, other surface-treated soils from the central part of the unit will be scraped from the active treatment area in the center of the unit and accumulated above the backfilled excavation area at the east end of the unit.

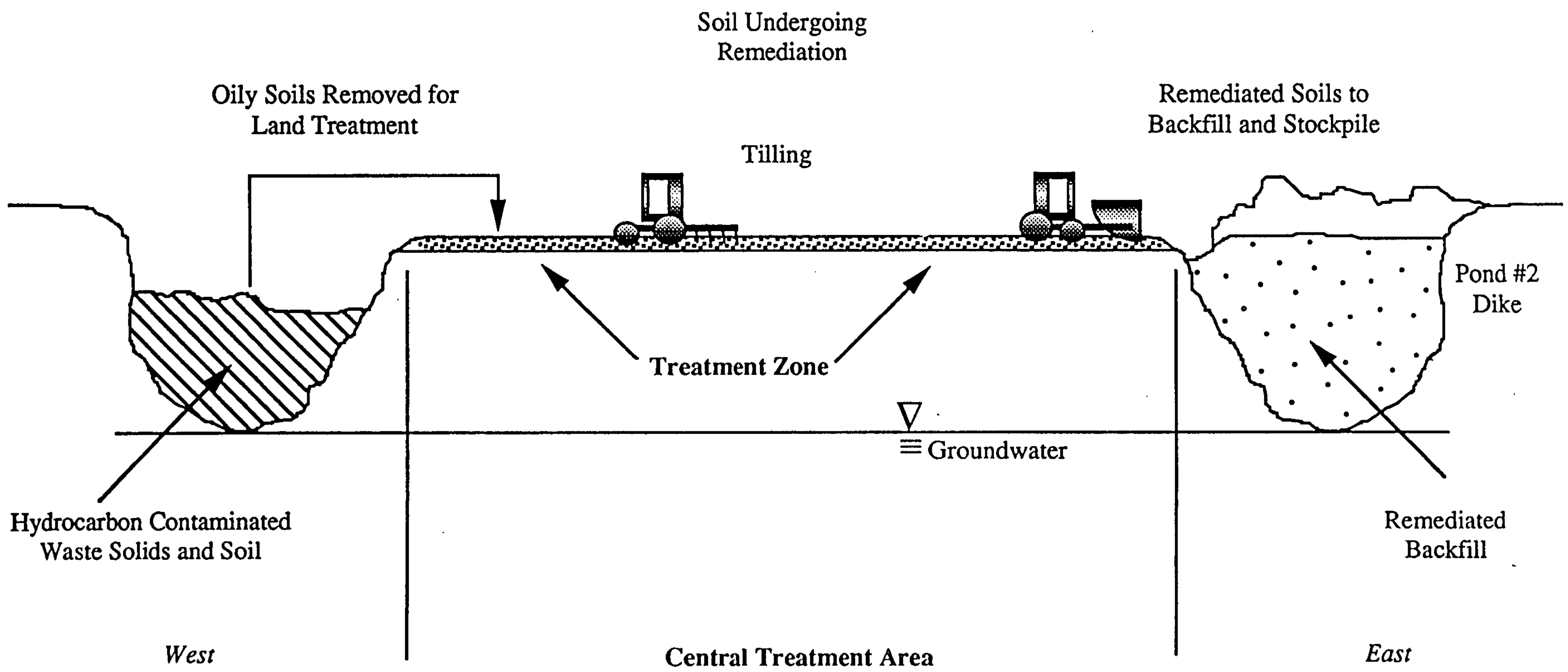


Figure 4-1 Schematic Diagram of Proposed Pond 1 Biotreatment Program

As the treat-and-peel process proceeds and the initial excavation is backfilled to surface grade, additional surface-treated soils will be deposited above the backfill area until an elevation slightly less than the level of the existing dike separating Pond 1 from Pond 2 is achieved. In this manner, contaminated soils in the treatment area will be remediated, removed and stockpiled in a process that gradually extends westwards across the Pond 1 area until a sufficient volume of soils has been removed from the central unit area to reveal a clean (hydrocarbon content at or less than target remediation standard) base for a delineated central treatment area.

When the treat-and-peel process has achieved a "clean" soil base in the central area of the unit, this area will be delineated as the final treatment area. Excavation work will then proceed around the unit periphery, as well as those areas extending out from the narrow western end of the unit (where hydrocarbon-contaminated soils are known to extend to the greatest depth). Contaminated soils from deep peripheral zones of contamination will be systematically excavated and applied to the central treatment area. Once a clean base for the active central treatment area has been achieved, the volume of excavated soils placed on the active treatment area will not exceed a total applied depth of approximately 8 to 12 inches. Excavation, treatment, and subsequent backfilling of these deep peripheral soils will continue until all unit soils extending from the surface to groundwater have been remediated to the target clean-up standard.

Navajo has previously proposed that surface water from the adjacent Pond 5 unit might serve as a source of irrigation water to be applied to the Pond 1 remediation cell. In order to assess the potential for the use of Pond 5 for that purpose, a composite sample obtained at various locations within the pond was analyzed for relevant parameters, including TDS, EC, and total cations). The sample analysis revealed that Pond 5 water quality was not suitable to serve as an irrigation supply, even for the relatively short-term utilization purpose envisioned for the Pond 1 remediation program.

An investigation of alternative water resources has failed to identify a feasible alternative irrigation supply. Water rights to subsurface water in the surrounding area are not obtainable, and treated municipal wastewater generated by the city of Artesia, which would also be likely to be a suitable source, is already allocated by the city for various post-treatment municipal usage.

Despite the fact that a suitable source of supplementary irrigation water is unavailable for use in the Pond 1 corrective measures program, Navajo has no reason to believe that the remediation effort will be significantly impacted. Ongoing interim corrective measures activities have demonstrated that heavily hydrocarbon-impacted soils excavated from the unit periphery are readily amenable to land treatment techniques in the absence of supplementary irrigation water. Navajo is confident that applied land treatment practices will facilitate the level of biodegradation necessary to remediate hydrocarbon-contaminated soils, augmented by sunlight-mediated photolysis and oxidation.

The Navajo project manager will be responsible for determining the extent to which excavation of deep-contaminated peripheral areas is required and for assessing the adequacy and completeness of land-treated soil remediation in meeting target cleanup standards prior to their removal to either the initial eastern excavation area or the subsequent overlying stockpile area.

The project manager will use best professional judgment in determining the extent and adequacy of excavation of peripheral areas, with the understanding that deep soils left in place will be able to meet the target cleanup standard. Prior to movement of surface-treated soils to excavation backfill, preliminary confirmation soil sampling will be conducted (as described in Section 4.1.2) to verify that backfilled soils meet or exceed the target cleanup standard. Preliminary confirmation sampling for surface-treated soils to be stockpiled at the eastern end of the unit will be conducted at the discretion of the project manager.

4.1.1 Soil Amendment Applications

At the initiation of remediation operations, surface soils will be evaluated for physical and chemical parameters relevant to their capacity to sustain microbial biodegradation. Soil tests will be conducted to ascertain the nutrient status of unit soils. On the basis of those test results, soil amendments will be applied to the soil as needed to establish optimal chemical conditions for biodegradation of hydrocarbon materials. Specifically, commercial fertilizer will be added to adjust the soil carbon: phosphorous ratio to 50:1 (Brown et. al, 1983). In the case of nitrogen, a carbon:nitrogen ration of 25:1 is recommended (Brown et. al, 1983). However, the existing carbon concentrations in Pond 1 soils are generally elevated to levels which, should the optimal ratio be attempted, would greatly exceed the soil microbial populations capacity to assimilate the applied nitrogen, with the great majority of excess nitrogen being lost via ammonia volatilization. Therefore, nitrogen fertilizer will be applied at an annual loading rate of nitrogen as pure N of 200 lbs/acre/year, which shall be split into two 100 lbs of N/acre applications occurring in mid-spring, and late summer.

The existing Pond 1 data generated by the RFI Phase II yields an average soil EC value of approximately 5.3 mmhos/cm, a value indicative of moderately saline soil conditions. However, existing circumstances are not conducive to adjustment of soil salinity conditions by application of a sodium-displacing amendment such as gypsum. In the absence of an abundant supply of high-quality irrigation water, insufficient moisture would be available to solubilize an applied sodium-displacing amendments, such as gypsum or to subsequently leach displaced sodium salts to lower levels of the soil profile.

Despite the lack of feasibility for effective use of applied sodium-displacing amendments, Navajo's experience to-date with interim corrective measures at the unit indicates that remediation of oily soils can be successfully accomplished under existing soil conditions. Based on these considerations, management of soil salinity by application of sodium-displacing amendments would be deemed to be both ineffective and unnecessary for the success of the remediation effort.

Unit soils will be tilled at least twice a month to a depth of approximately 8 to 12 in. Tillage operations may be occasionally delayed when periods of excessive soil wetness deny site access to equipment, or when excessively windy conditions occur.

Prior to the completion of remediation activities at the unit, Navajo will submit a unit closure plan to EPA. The closure plan will include a description of final soil verification sampling and materials and methods to be used for the establishment of a final vegetative cover.

4.1.2 Soil and Groundwater Monitoring

For surface-treated soils to be returned to excavated areas (e.g., areas which have been excavated to a depth greater than 3 ft. below surface grade) soil sampling and analyses will be conducted. These samples will provide preliminary verification to confirm that soil batches have been sufficiently treated to meet the target remediation standard.

When the Navajo project manager believes that soil materials contained within the designated treatment cell have been adequately remediated, treatment cell areas containing surface soils designated for return to open excavations will be physically defined by means of flagged stakes, and an approximate areal estimate of the demarcated area will be determined by simple survey measurements (transit and rod). The delineated area will be subdivided into approximate 2-acre subplots, which will also be flagged as described above. Maximum x and y axis coordinate values will be determined for each subplot on the basis of their dimensions, and sample locations will be identified by random selection of x and y distances along the axes.

For each 2-acre subplot, a total of 5 soil samples will be collected. Each sample will be comprised of five subsamples, which will be collected as follows. Using the original sample location as a center point, two subsamples will be collected along a line extending through the center and at distances of 50 ft. to each side of the center location. Two subsamples will be collected at identical distance from the center along a line which is oriented perpendicular to the initial subsample axis. The fifth subsample will be obtained at the original central location.

Subsamples will be thoroughly mixed with a clean trowel and a representative sample will be collected in an appropriate sample container in accordance with standard SW-846 guidance and recommendations. Samples will be assigned an identifying number, and the sample number, location, and time of collection (date, time of day) will be recorded in a field notebook which will be subsequently relinquished to the project manager. Samples will be stored on ice and shipped to the analytical laboratory with appropriate chain-of-custody documentation. The preliminary verification samples will be analyzed for TPH.

Groundwater monitoring is currently being performed in the area of the evaporation ponds pursuant to a schedule authorized by the NMOCD as a condition of ground water discharge plan approval. This monitoring will be continued at least through the time that Pond 1 is undergoing soils remediation with the possible addition of several constituents to monitor impacts, if any, of remediation activities on groundwater. Decisions involving changes to water quality constituent monitoring and frequency will be detailed in an addendum to the CMS Workplan, which will be submitted in March 1995 subsequent to evaluation of groundwater data generated by the RFI Phase III (see Section 4.5, Interim Groundwater Monitoring). Decisions involving long term monitoring of groundwater in the area of the evaporation ponds must await resolution of the larger issues of wastewater disposal location and active evaporation pond decommissioning which are under discussion between Navajo and the EPA.

4.1.3 Post-Remediation Revegetation Strategy

Navajo proposes to pursue a unit revegetation program that will further contribute to the elimination of any residual risks to human health and the environment that might conceivably be posed by residual surface and subsurface soils at the unit. Navajo proposes to revegetate the unit with saltcedar (Tamarix chinensis) subsequent to attaining the target hydrocarbon remediation goal for Pond 1 soils. As described below, the use of saltcedar as a vegetative cover at Pond 1 will confer several distinct advantages uniquely related to its physiological characteristics and its anticipated interactions with key environmental features of the Navajo evaporation ponds.

Saltcedar is one of a class of phreatophyte-type plants that is capable of obtaining a continuous supply of water by extending its roots to considerable soil depths until the water table or capillary fringe of the water table is encountered. Saltcedar is a rapid-growing, prolifically reproducing plant that can permanently displace native vegetation. It has the potential ability to absorb and transpire very large quantities of groundwater, is well adapted to arid environments, and can utilize highly saline water sources. Saltcedar is currently established along the Pecos River channel adjacent to the ponds, where natural groundwater concentrations in excess of 10,000 mg/l have been observed.

In a suitable environment, saltcedar will spread to form dense thickets that provide 100 percent canopy coverage across colonized areas. Because of these features, saltcedar is widely considered to be a nuisance species, and it has been the subject of many technical studies conducted by academics and government agencies. Consequently, saltcedar is well characterized in terms of its impact on the environment.

Saltcedar possesses a deep rooting system that permits it to withdraw groundwater from depths as great as 30 ft.. Numerous researchers have derived estimates for annual saltcedar groundwater uptake rates. These utilization estimates are typically based on the assumed presence of a saltcedar stand possessing maximum canopy density (site-specific studies) or as general estimates over extensive land areas (regional averages), and are either expressed directly in units of acre-ft./year, or can otherwise be readily converted to acre-ft./year from the existing data. A range of published estimates obtained from various government reports are presented in Table 4-1. The capacity of saltcedar to withdraw prodigious quantities of groundwater is not in question. Reports of significant diurnal variation in groundwater elevation levels corresponding to daily rhythms in saltcedar transpirational activity are common in the scientific literature.

In addition to the estimates provided above, at least one study has also demonstrated that the evapotranspirational potential of saltcedar remains considerable even when grown in relatively saline conditions. Under experimental conditions, Hylckma (1980) documented a water consumption rate equivalent to approximately 3.3 ac-ft/yr for saltcedar grown in contact with groundwater exhibiting an EC of 35,000 umhos/cm.

Table 4-1. Summary of Saltcedar Water Consumption Estimates Identified in the Literature

Estimated Groundwater Consumption Rate Per Acre of Saltcedar	Study Type	Reference
3.8 ac-ft/yr	Generic Average-17 Western States	Robinson, 1965
6.0 ac-ft/yr	Pecos River between Acme and Artesia, NM	Mower, et. al., 1964
3.3 ac-ft/yr to 7.05 ac-ft/yr	Gila River, South Central AZ	Hylckama, 1974
1.3 ac-ft/mo (April to May)	Gila River, South Central AZ	Hylckama, 1980
9 ac-ft/yr	Estimated Physiological Maximum	Kerpex and Smith, 1987

Establishment of a saltcedar stand at Pond 1 would serve to improve overall site conditions in a number of significant ways, to the extent that this approach will constitute an important feature of the overall corrective measures strategy. Advantages associated with the proposed revegetation approach include the following:

1) *Drastic reduction of future potential leaching of residual organic and inorganic constituents to groundwater.*

Based on the results of TCLP analyses, the available data from the RFI Phase II found little evidence to indicate that residual organic or inorganic contaminants present in Pond 1 soils possessed a serious leaching potential. This inherent lack of a physical potential for leaching is further reduced by the fact that the unit is located in an arid environment where cumulative evaporation potential exceeds cumulative precipitation by a wide margin. The establishment of a saltcedar colony at Pond 1 can be expected to further reduce the existing minimal leaching potential to the point of inconsequentiality.

The available scientific literature supports a conservative assumption that an established saltcedar colony at Pond 1 would withdraw groundwater from beneath the unit at a rate of at least 2 acre-ft./year per acre of saltcedar. Considered over the entire area of the 15 acre unit, this is equivalent to a water withdrawal rate of approximately 9,776,000 gallons. per year. This volume of water is comparable to that which would be withdrawn on an annual basis by four groundwater recovery wells pumping at a constant rate of just under 5 gallons per minute.

It is possible that groundwater withdrawal rates could be double or even triple the conservatively assumed water consumption rate. When considered in combination with the overwhelming deficit between precipitation and evaporation, it is clear that the proposed revegetation strategy would vastly minimize the rate of downward water percolation through the water column.

2) *Minimization of potential exposure of ecological receptors*

Saltcedar thickets represent extremely poor wildlife habitat. Existing literature on the biology and ecology of this species reveals no known insect or animal species which utilize saltcedar vegetation as a significant food source, and the thickets are highly effective at establishing homogeneous stands that exclude all competing native plant species. As a result, areas predominated by saltcedar attract very little wildlife, with the exception of some species that intermittently utilize the thicket canopy as nesting habitat or as protective cover. Even though the 40 CFR Par 503 municipal sludge guidance used to assess the unit indicates little apparent risk posed by unit soils to the environment, the establishment of a saltcedar colony at Pond 1 will serve as an additional conservative measure to ensure that the ecological health of the surrounding environment is fully protected.

As a final note on this issue, the native environment in the vicinity of the pond system can by no means be considered to be ecologically sensitive. The surrounding environment of the Pecos River flood plain of which the unit is part consists of many hundred of thousands of acres dedicated almost exclusively to use as open rangeland for cattle grazing (unless otherwise relinquished to saltcedar thickets). There can be no reasonable expectation that the long-term removal of the unit area as grassland habitat will impact the ecological health of the surrounding environment.

3) *Enhanced passive bioremediation of subsurface hydrocarbon contaminants*

Along with the deliberate recruitment of plant transpiration to manipulate groundwater hydraulic gradients, the capacity for plant roots to create subsurface conditions that significantly facilitate the biodegradation of organic contaminants is now scientifically established. Experimental studies and remediation projects aimed at evaluating or exploiting these plant system capabilities are generally encompassed under the topic of phytoremediation.

Phytoremediation is regarded as a legitimate area of study for environmental restoration. Topics and issues in this field are now the subject of academic research at major universities and corporations, and phytoremediation discussion sections are now included at major international symposia sponsored or supported by organizations such as Batelle, Gas Research Institute, U.S. EPA, U.S. DOE, Environment Canada, U.S. Air Force, among other government and industry groups.

The subsurface environment occupied by the root zone of plants is known as the rhizosphere. For numerous diverse plant species, it has now been demonstrated that the degradation of many subsurface organic contaminants is significantly accelerated when they exist in proximity to the plant rhizosphere. While the context of the current workplan document is not deemed appropriate as a forum for detailed review and discussion of this issue, Anderson et.al (1993) is recommended as an excellent current review of the field. A partial list of organic contaminants documented to undergo enhanced biodegradation in the zone of rhizosphere influence includes: parathion, diazinon, crude oil, oil residues, mixed VOCs, mixed SVOCs, various surfactants, 2,4-D, carbofuran, and TCE. Reports of rhizosphere-enhanced biodegradation rates in excess of one or two orders of magnitude in excess of those found in soils void of living root mass are not uncommon in the scientific literature.

Mechanisms to account for the enhancing effects of plant roots on organic contaminant biodegradation are not always well understood, although delivery by root systems of substances such as oxygen and/or co-metabolite exudates to subsurface microbial populations have been identified as significant contributing factors in some studies. In keeping with an extensive scientific database pertaining to the positive influence of plant roots in creating a favorable microhabitat for vigorous and diverse microbial populations, observation of enhanced phytoremediation effects are typically associated with the presence of significantly higher microbial populations in root-abundant soil, and/or the presence of specific microbial populations that are otherwise less abundant in root-free soil.

While it is not possible to provide an estimate of the extent to which passive bioremediation of residual hydrocarbon contaminants could be accelerated by the presence and influence of a dense saltcedar rhizosphere in Pond 1 subsurface soils, the existing state of research in this field indicates that the phytoremediation effect on subsurface organic contaminants is common to many, if not most or all, plant species. Since saltcedar exhibits prolific root growth, it is reasonable to assume that an established saltcedar colony at Pond 1 will likely exert an additional beneficial effect on the rate of naturally occurring passive biodegradation of residual hydrocarbon contaminants in Pond 1 subsurface soils.

The proposed revegetation approach for Pond 1 represents a unique and potentially highly effective site reclamation strategy which will contribute an additional level of stringency to the proposed corrective action measures program. Should EPA approve the proposed approach, Navajo will prepare a detailed description for revegetation of the site as part of the final unit closure plan.

4.2 Corrective Measures Documentation and Reporting

All personnel engaged in corrective measures activities will report to the Navajo project manager prior to, and at the completion of all site activities associated with the corrective measures program. A standard reporting form will be used to record and track all site activities. At a minimum, the following activities will be recorded:

- date and extent of tillage events;
- date of application, type, and quantities of soil amendments;
- dates on which preliminary verification soil samples are collected (including sample identification and corresponding collection locations); and
- dates or date intervals during which unit soils are either applied to, or removed from, active treatment cell areas.

Within 15 months of the approval and initiation of the Pond 1 Corrective Measures Program an annual report will be submitted to EPA Region 6 which will include documentation and presentation of all corrective measures activities and environmental monitoring data. Thereafter, subsequent annual reports will be submitted until unit soils are fully remediated. As stated previously, Navajo anticipates that, subsequent to the initiation of the Corrective Measures Program for Pond 1, remediation of unit soils is expected to be completed in approximately 18 to 24 months.

4.3 Estimated Program Costs

Costs for labor, equipment and materials associated with the execution of the corrective measures program will be incurred from the following activities:

- earth moving activities associated with the proposed "treat and peel" land treatment bioremediation process;
- acquisition and application of nutrient materials;
- labor associated with routine tillage, inspection, and soil monitoring activities;
- laboratory analysis of soil monitoring samples; and
- post-remediation land contouring.

Costs associated with the various aspects of the corrective measures program are detailed in Table 4-2. Total direct costs for the corrective measures program remedial activities are estimated to be $150,750.

Table 4-2. Cost Breakdown for Operations and Management Activities Associated with the Proposed Land Treatment Corrective Measures Alternative

Activity	Unit	Quantity	Cost/Unit	Total Cost
Earth Moving	cubic yd	60,500	$0.90/cubic yard	$ 54,450
Fertilizer	ton	53	$220/ton	$ 11,660
General Operations and Maintenance Labor	hour	2,880	$18/hr	$ 51,840
Post-Remediation Land Contouring	cubic yd	31,400	$0.80	$ 25,120
Soil Analyses	individual samples	500	$50/sample	$25,000
			TOTAL PROJECT COST	**$168,070**

4.4 Project Schedule

As stated in Section 2.2 of this document, Navajo is currently engaged in interim corrective measures activities consistent with the initial phase of the proposed corrective measures alternative program described in this work plan. Because of the logistic arrangements already in place, and the relatively low-technology requirements of the proposed program, Navajo anticipates that, subsequent to EPA's approval of this workplan, remediation activities (delineation of an initial treatment cell area, application of appropriate soil amendments, routine tillage, etc.) can proceed within 2 weeks of notification.

As also discussed in Section 2.2, Navajo has been engaged in various interim corrective measures activities involving Pond 1 soils for the past 5 years. Based on the results and knowledge gained from that experience, it is estimated that completion of the corrective measures program described in this workplan will be accomplished within 18 to 24 months of the formal initiation of site activities.

4.5 Interim Groundwater Monitoring

The following sections describe additional investigation plans for groundwater adjacent to inactive evaporation Pond 1. The format shown below essentially follows that presented in Section 4.1.3 of the July 1994 RFI Phase III Workplan for TMD and the Active Evaporation Ponds submitted to EPA Region VI. Activities described in Fieldwork 1 below commenced in November 1994. Fieldwork 2 activities are scheduled for January 1995. Requirements for routine post-closure groundwater monitoring will be proposed in the unit closure plan to be submitted subsequent to the completion of corrective measures activities.

The groundwater investigation in the vicinity of Pond 1 will include the following activities:

- Measurement of water levels in shallow and deep paired monitor well MW-6A and MW-6B;
- Sampling of shallow and deep monitor wells adjacent to Pond 1 to update and verify constituent concentrations found in the Phase II study;
- Sampling of the pond windmill;
- Installation of a deep monitor well (in addition to the two proposed in the Phase III Workplan) in the vicinity of MW-4 to delineate vertical extent of contamination at depths greater than 50 ft., if any, and to provide hydrogeologic baseline information on deeper water zones;
- Performing borehole aquifer tests on the new monitor well to determine *in situ* hydraulic conductivity; and
- Collection of water quality samples from the new monitor well.

4.5.1 Pond 1 Field Work 1

Static water level measurements will be obtained from MW-6, the shallow and deep paired monitor wells adjacent to Pond 1. The measurements will be taken with an electric tape to update and verify the vertical hydraulic gradient. This information will be collected concurrently with the RFI Phase III Field Work 1 activity described in that workplan. Procedures for obtaining static water levels are included in Section 4.2.2.1 of the RFI Phase III Workplan.

Wells selected for sampling (Table 4-3) will be purged and water samples collected pursuant to EPA RCRA guidance. A description of these procedures is presented in RFI Phase III Workplan Section 4.2.3. This work will be performed concurrently with the Phase III Workplan activities to provide for efficient use of staff.

Chemical analyses will focus on verifying constituents detected in earlier sampling and determining changes in concentrations in metals and BTEX volatile organics. Metal constituents of concern include arsenic, chromium, lead and nickel. For comparison purposes, filtered and unfiltered samples will be collected for metals determination in wells having or suspected of having turbidity problems. Filtered samples will be filtered in the field using a 0.45 micron filter before sample preservation. Quality assurance procedures to be used in collection and preservation of samples are discussed in RFI Phase III Workplan Section 4.2.3.

4.5.2 Pond 1 Field Work 2

In addition to the two additional monitor wells proposed to be installed at locations MW-5 and OCD-7, a third well is proposed that would be located in the vicinity of MW-4. However, the exact location of this well must await completion of negotiations with the landowner(s). EPA is currently assisting in this effort by making direct contact with the landowner or his representative. If negotiations are unsuccessful, the location of the well will be moved north to Navajo property and the well will be located on a line between MW-3 and MW-4. If at all possible, monitor well installation at Pond 1 will occur at the time of installation of the other two monitor wells.

The new Pond 1 deep well is expected to be screened for a length of 10 ft. at a depth approximately 15 ft. beneath the base of MW-4 or about 33 from the land surface. Therefore the total depth of this well is expected to be about 43 ft. However, exact depth and screened interval will be determined in the field based on boring lithology. If discrete lithologic intervals are found and are separated by a confining layer, the deep well will be screened opposite the first transmissive zone beneath the confining layer. If no confining layer is found, the well will be screened in a transmissive zone 15 ft. beneath the base of MW-4.

Construction details for the proposed monitor wells are provided in RFI Phase III Workplan Section 4.2.1. Construction of deep wells will include installation of a surface casing through the upper zones to prevent cross-contamination of sediments and groundwater, and to prevent short-circuiting of flow that can influence vertical hydraulic gradient measurements. Borehole *in situ* permeability tests (slug tests) will be performed on the two newly installed monitor wells as described in RFI Phase III Workplan Section 4.2.2.2.

Table 4-3. Basic Elements of the Proposed Groundwater Sampling for Evaporation Pond 1

Field Work 1 (to be performed concurrently with RFI Phase III Field Work 1 activities)

- Water level elevations of paired monitor wells 6A and 6B.
- Groundwater sampling of deep and shallow monitor wells MW 3, 4, 6, and the pond windmill. Constituents to be sampled are:
  - Field Parameters: pH, temperature, specific electrical conductance
  - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
  - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
  - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
  - Water chemistry: As needed to characterize aquifer water quality

Field Work 2 (to be performed concurrently with RFI Phase III Field Work 2 activities)

- Water level elevations of paired monitor wells 6A and 6B.
- Groundwater sampling of the new deep well installed at locations MW-4 or alternate location between MW-3 and MW-4. Constituents to be sampled are:
  - Field Parameters: pH, temperature, specific electrical conductance
  - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
  - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
  - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
  - Water chemistry: Sampling of new wells to characterize aquifer water quality.

The newly installed monitoring wells, plus the existing paired monitor wells sampled during Field Work 1, will be measured using an electric or steel tape to obtain static water level measurements for verification of vertical hydraulic gradient. Prior to mapping water level measurements, elevations of the new paired monitor wells will be verified by a land survey using a registered professional surveyor. Procedures for obtaining static water levels and groundwater samples are included in Sections 4.2.2.1 and 4.2.3 of the RFI Phase III Workplan, respectively. Constituents to be sampled in new wells are shown above in Table 4-3.

4.6 Community Relations Activities

Navajo currently operates under the auspices of a community relations plan which was created as part of the original RFI Phase II Work Plan for Three-Mile Ditch and the Evaporation Ponds, and approved by EPA as part of the final work plan. The community relations plan includes requirements for public notices, scheduled meetings, identification of a Community Relations Coordinator, creation of a public information repository and reading room, and a mailing list to actively interested parties.

Since ongoing activities associated with the CMS Work Plan are a continuation of the overall Corrective Measures Program initiated with RFI activities, the existing community relations plan will be expanded to transmit information to the community and other interested parties regarding the ongoing status of proposed and active corrective measures activities at Pond 1.

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APPENDIX A

POND 1 RFI PHASE II
SOILS DATA

Table A-1. RFI Phase II soil sampling, Evaporation Pond 1 — oil and grease and volatile organic compounds (mg/kg).

Sample	Sample depth (ft)	Oil and grease (%)	Acetone	Benzene	Ethyl-benzene	Methylene chloride	Toluene	Xylenes (total)
EP-TR-001-01	1	8.27	0.387	0.03	0.443	< 0.028	0.622	2.05
EP-TR-001-02	3	1.11	0.437	< 0.034	0.128	< 0.034	0.082	0.484
EP-TR-001-03	6	0.4	0.295	< 0.025	0.052	< 0.025	0.032	0.159
EP-TR-001-04	9	0.06	0.176	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-001-05	13	< 0.05	< 0.012	< 0.006	< 0.006	0.014	< 0.006	< 0.006
EP-TR-002-01	1	18.49	< 0.391	< 0.196	0.59	< 0.196	0.376	1.57
EP-TR-002-02 [b]	3	0.96	0.442	< 0.007	0.488	< 0.007	0.083	1270
EP-TR-002-03 [c]	6	0.08	0.556	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-002-04	9	0.08	0.043	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
EP-TR-002-05	13	< 0.05	< 0.014	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-01	1	7.05	< 0.061	< 0.031	< 0.031	< 0.031	< 0.031	0.264
EP-TR-003-02	3	< 0.05	0.228	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-03	3 (duplicate)	0.26	0.189	< 0.007	< 0.007	0.015	< 0.007	< 0.007
EP-TR-003-04	6	0.05	< 0.014	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-05	11	<0.05	0.033	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-004-01	1	16.07	< 0.314	< 0.157	0.332	< 0.157	< 0.157	< 0.157
EP-TR-004-02	3	0.10	0.079	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-004-03	6	< 0.05	0.184	< 0.034	< 0.034	< 0.034	< 0.034	< 0.034
EP-TR-004-04	9	< 0.05	< 0.012	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-005-01	1	0.19	< 0.012	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-005-02	3	0.11	0.264	< 0.007	< 0.007	<7	< 0.007	< 0.007
EP-TR-005-03	6	0.13	0.235	< 0.007	< 0.007	91	< 0.007	< 0.007
EP-TR-005-04	9	0.10	0.172	< 0.006	< 0.006	0.122	< 0.006	< 0.006
EP-TR-006-01	1	12.56	< 0.263	< 0.132	< 0.132	< 0.132	0.147	< 0.132
EP-TR-006-02	3	0.12	0.7	< 0.032	< 0.032	0.147	< 0.032	< 0.032
EP-TR-006-03	6	0.05	0.054	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-006-04	9	< 0.05	0.028	< 0.006	< 0.006	0.008	< 0.006	< 0.006
EP-TR-006-05	0-1	18.61	< 4.320	< 2.160	2.34	< 2.160	3.06	6.51

a = Trackhoe bucket grab sample of pond surface sludges adjacent to trench EP-TR-006.
b = 2-butanone (0.127 mg/kg) and carbon disulfide (0.033 mg/kg) also detected.
c = 2-butanone (146 mg/kg) also detected.

Table A-2. RFI Phase II soil sampling, Evaporation Pond — pH, electrical conductivity, and total metals concentrations (mg/kg).

Sample	Sample depth (ft)	pH	Electrical conductivity (mmhos/cm)	Arsenic	Chromium	Lead	Nickel	Zinc
EP-TR-001-01	1	8.5	2.9	26.1	74	389	21	54
EP-TR-001-02	3	8.5	4.9	3.9	29	17	26	64
EP-TR-001-03	6	7.5	6.4	7.6	17	7	24	44
EP-TR-001-04	9	7.6	5.0	2.2	16	4	23	25
EP-TR-001-05	13	8.1	2.6	2.4	16	1	20	36
EP-TR-002-01	1	8.3	3.6	38.6	1011	93	37	303
EP-TR-002-02	3	8.8	2.8	1.8	19	10	21	49
EP-TR-002-03	6	7.5	6.1	8.6	17	6	24	41
EP-TR-002-04	9	7.9	5.3	4	16	5	28	37
EP-TR-002-05	13	7.9	5.3	9.9	16	6	31	42
EP-TR-003-01	1	8.1	3.1	22.6	633	73	14	434
EP-TR-003-02	3	7.8	5.8	9.1	30	14	23	57
EP-TR-003-03	3 (duplicate)	7.7	6.5	10.3	26	12	22	55
EP-TR-003-04	6	7.7	5.0	7.1	24	7	14	53
EP-TR-003-05	11	7.7	4.0	3.3	20	6	10	32
EP-TR-004-01	1	8.2	8.0	19.7	398	28	12	194
EP-TR-004-02	3	9.1	3.3	1.4	14	4	7	21
EP-TR-004-03	6	9.5	2.7	8.7	34	14	22	73
EP-TR-004-04	9	8.2	1.9	3.1	9	3	5	37
EP-TR-005-01	1	7.6	6.6	1.6	32	9	14	40
EP-TR-005-02	3	8.5	6.4	1.5	19	7	13	33
EP-TR-005-03	6	9.4	4.2	3.9	25	11	18	48
EP-TR-005-04	9	8.7	5.1	11.6	26	8	14	38
EP-TR-006-01	1	7.7	7.0	39.9	235	153	37	161
EP-TR-006-02	3	9.1	3.9	2.4	29	9	13	63
EP-TR-006-03	6	7.6	6.3	6.5	18	4	10	31
EP-TR-006-04	9	8.7	2.6	2.2	12	7	10	31
EP-TR-006-05 [a]	1	8.6	6.0	16.1	320	36	14	320

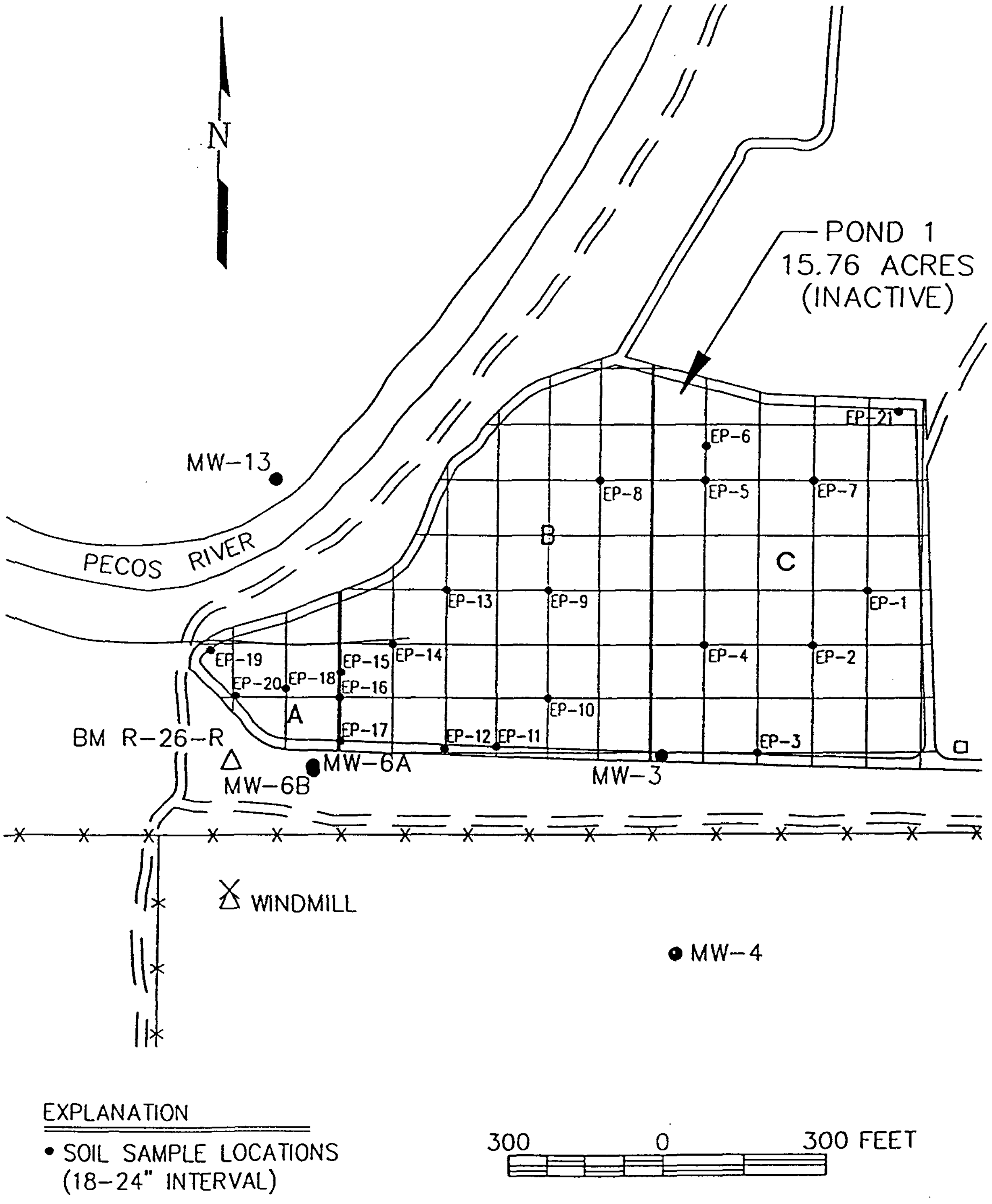
a = Trackhoe bucket grab sample of pond surface sludges adjacent to trench EP-TR-006.

APPENDIX B

POND 1 SOILS TPH DATA
(NOVEMBER, 1993)

Table B-1. Pond 1 Soil TPH Concentrations: 1.5 - 2.0 ft. (November 1993 sample event)

Location	TPH (mg/kg)	pH
EP-1	<10	
EP-2	32	
EP-3	1970	8.4
EP-4	59	
EP-5	25600	
EP-6	48300	8.6
EP-7	32400	
EP-8	2890	
EP-9	21000	8.2
EP-10	2940	
EP-11	33500	
EP-12	105000	9.0
EP-13	81700	
EP-14	2940	
EP-15	51100	8.7
EP-16	58200	
EP-17	41100	
EP-18	33600	7.4
EP-19	27900	
EP-20	110000	
EP-21	99400	
AVG.	**38982**	**8.4**



RE/SPEC INC.
RESEARCH & SPECIALISTS

Pond 1 soil sample locations,
TPH sampling, November 1993.

Navajo

PROJECT: 622093004-110 (POND1)
LOCATION: ARTESIA, NEW MEXICO
APPR:
DATE: 11/23/93
DRAWN BY: RMO
SCALE AS SHOWN
DATE: 11/23/93
FIGURE: B-1

APPENDIX C

POND 1 RFI PHASE II
GROUNDWATER DATA

Table C-1. Volatile organic compounds detected during field sampling, Evaporation Pond area, Navajo Refinery, RFI Phase II.

Well ID	Laboratory	Date sampled	Acetone		Benzene		2-Butanone (MEK)		Carbon disulfide		Ethylbenzene		Methylene chloride		Toluene		Xylenes (total)	
			Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)
Evaporation Pond	C922424	11/20/92	0.092	0.010	0.043	0.005			0.032	0.005	0.016	0.005			0.061	0.005	0.045	0.005
MW-03	C922322	11/12/92			0.017	0.005					0.016	0.005			0.021	0.005	0.025	0.005
MW-04	C922333	11/12/92			0.021	0.005					0.019	0.005			0.009	0.005	0.032	0.005
MW-05A(Field Duplicate)	C922335	11/11/92			0.013	0.005					0.006	0.005			0.028	0.005	0.008	0.005
MW-06A	C922323	11/12/92									0.007	0.005			0.006	0.005	0.014	0.005
MW-06B	C930278	1/30/93			0.009	0.005	0.048	0.010	0.117	0.005					0.006	0.005		
MW-12	C922658	12/18/92											0.007	0.005				
MW-14	C922655	12/17/92											0.020	0.005				
OCD-7B	C930279	1/30/93			0.009	0.005												
Windmill	C922656	12/17/92											0.010	0.005				

PQL = Practical quantitation limit.

Table C-2. Semivolatile organic compounds detected during field sampling, Evaporation pond area, Navajo Refinery, RFI Phase II.

Well ID	Laboratory number	Date sampled	B2EP Result (µg/L)	B2EP PQL (µg/L)	DNBP Result (µg/L)	DNBP PQL (µg/L)	DM24 Result (µg/L)	DM24 PQL (µg/L)
MW-2B	C922653	12/16/92	28	25				
MW-14	C922655	12/17/92			66	25		
MW-14 (Field Dup)	C922654	12/17/92			78	25		
MW-20	C930223	1/26/93			27	25		
OCD-8B	C930203	1/23/93	35	25				
OCD-8B (Field Dup)	C930204	1/23/93	21	20				
Evaporation Pond	C922424	11/20/92					180	50

PQL = Practical Quantitative Limit
B2EP = bis(2-Ethylhexyl)phthalate
DNBP = Di-n-butyl phthalate
DM24 = 2,4-Dimethylphenol
MN1 = 1-Methylnaphthalene
MN2 = 2-Methylnaphthalene
NAPH = Naphthalene

Table C-3 . Results of metals analyses, Evaporation Ponds, Navajo Refinery, RFI Phase II.

Well sample identification	Laboratory number	Date samples	TAS ^{a}	TAS ^{b}	TAS ^{c}	DAS ^{d}	TCR ^{e}	DCR ^{f}	TPB ^{g}	DPB ^{h}	TNI ^{i}	TNI ^{j}	DNI ^{k}	pH	EC ^{l}
NEP-GW-EPA-1	C922391/15722	18-Nov-92	ND	ND		ND	ND	ND	ND	ND	0.08	ND	0.06	7.2	5340
NEP-GW-MW-01-01	C922278/15632	10-Nov-92	0.02	0.023	0.01	ND	3.65	ND	ND	ND	0.35	0.22	0.2	7.5	14900
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92	0.022			ND	3.62	ND	ND	ND	0.34		0.18	7.5	14900
NEP-GW-MW-02A	C922280/15633	10-Nov-92	0.087	0.117	0.09	0.073	0.1	ND	ND	ND	0.12	ND	0.1	7.4	11300
NEP-GW-MW-02B	C922653/16029	16-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.04		ND	7.4	3430
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92	ND			ND	ND	ND	ND	ND	0.03		ND	7.4	3430
NEP-GW-MW-03	C922322/15647	12-Nov-92	0.078	0.096		0.054	0.03	ND	ND	ND	0.12	0.04	0.08	7.3	7220
NEP-GW-MW-04	C922333/15644	12-Nov-92	0.08	0.112	0.136	0.069	ND	ND	ND	ND	0.11	ND	0.07	7.3	7610
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92	0.085			0.071	ND	ND	ND	ND	0.09		0.07	7.3	7620
NEP-GW-MW-05A	C922334/15645	11-Nov-92	0.074	0.089		0.063	0.03	ND	ND	ND	0.27	0.12	0.25	7.2	28000
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92	0.077			0.062	0.02	ND	ND	ND	0.26		0.26	7.2	28100
NEP-GW-MW-05B	C930136/W00059	22-Jan-93	0.131	0.15	0.162	0.106	ND	ND	ND	ND	ND		ND	7.1	9310
NEP-GW-MW-06A	C922323/15648	12-Nov-92	0.065			0.03	0.05	ND	ND	ND	0.11	0.04	0.04	7.4	4950
NEP-GW-MW-06B	C930278/W00344	30-Jan-93	0.021	0.02		0.016	ND	ND	ND	ND	ND		ND	11.9	6410
NEP-GW-MW-07A	C922281/15634	11-Nov-92	0.038	0.037	0.05	0.03	0.07	ND	ND	ND	0.13	ND	0.09	7.2	13900
NEP-GW-MW-07B	C930106/W00056	21-Jan-93	0.014	0.013	0.016	0.011	ND	ND	ND	ND	ND		ND	7.5	10700
NEP-GW-MW-10	C922390/15721	18-Nov-92	0.011	0.011		0.007	0.02	ND	ND	ND	0.09		0.07	7.2	6190
NEP-GW-MW-11A	C922567/15975	12-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.19		0.18	7.1	23700
NEP-GW-MW-11B	C930205/W00184	23-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		ND	7.3	20500
NEP-GW-MW-12	C922658/16033	18-Dec-92	ND	ND		ND	0.02	ND	ND	ND	0.05		ND	7.2	18700
NEP-GW-MW-13	C922659/16034	18-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.03		ND	7.5	5180
NEP-GW-MW-14	C922655/16031	17-Dec-92	0.012	0.012		0.01	ND	ND	ND	ND	0.04		ND	7.4	11200
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-92	0.01			0.007	0.02	ND	ND	ND	0.03		ND	7.3	10900
TMD-GW-MW-15	C930105/W00055	20-Jan-93	0.01	0.006		0.006	0.03	ND	ND	ND	ND		ND	7.5	3590
NEP-GW-MW-17	C930209/W00189	26-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		0.01	7.7	2600
NEP-GW-MW-18A	C930207/W00187	25-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.03		0.01	7.3	16400
NEP-GW-MW-18B	C930602/W01466	11-Mar-93	ND	ND			0.02		ND		ND			7.7	4650
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-93	ND				0.02		ND		ND			7.7	4640
NEP-GW-MW-19	C930208/W00188	26-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		ND	7.6	7280
NEP-GW-MW-22A	C930282/W00347	29-Jan-93	0.013	0.013		0.011	ND	ND	ND	ND	ND		ND	7.4	5750
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93	0.014			0.011	ND	ND	ND	ND	0.02		ND	7.4	5790
NEP-GW-MW-22B	C930283/W00348	29-Jan-93	0.007	0.008		0.005	ND	ND	ND	ND	0.01		0.01	7.1	6180
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93	0.008			0.005	ND	ND	ND	ND	ND		ND	7.1	6180
NEP-GW-MW-23	C930229/W00271	28-Jan-93	0.007	0.008		0.006	ND	ND	ND	ND	ND		ND	7.2	15900
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93	0.007			0.006	ND	ND	ND	ND	ND		ND	7.2	15900
NEP-GW-MW-24	C930281/W00346	28-Jan-93	ND	ND		ND	ND	ND	ND	ND	ND		ND	7.3	16300
NEP-GW-OCD-1	C922324/15649	13-Nov-92	0.097	0.115	0.154	0.071	0.06	ND	0.03	ND	0.16	0.05	0.11	7.2	14200
NEP-GW-OCD-2A	C922357/15669	15-Nov-92	0.067	0.084		0.043	0.04	ND	ND	ND	0.15	ND	0.12	7	15400
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93	0.007	0.005	0.018	0.006	ND	ND	ND	ND	0.01		ND	7.3	14700
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92	0.069			0.043	0.04	ND	ND	ND	0.14		0.13	7	15400
NEP-GW-OCD-3	C922358/15670	16-Nov-92	0.021	0.022		ND	0.19	ND	0.06	ND	0.28	0.09	0.12	7.1	17300
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92	0.015	0.017		0.005	ND	ND	ND	ND	0.15		0.11	7.2	19000

Table C-3 . Continued.

Well sample identification	Laboratory number	Date samples	TAS[a]	TAS[b]	TAS[c]	DAS[d]	TCR[e]	DCR[f]	TPB[g]	DPB[h]	TNI[i]	TNI[j]	DNI[k]	pH	EC[l]
NEP-GW-OCD-5	C922399/15728	16-Nov-92	0.008	0.008		0.007	ND	ND	ND	ND	0.13	ND	0.12	7.2	17800
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92	0.009			0.008	ND	ND	ND	ND	0.12		0.12	7.2	17900
NEP-GW-OCD-5 (Dup of Fld D)	C922394/15731	17-Nov-92	0.008			0.007	ND	ND	ND	ND	0.13		0.12	7.2	17900
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92	0.036	0.048		0.028	ND	ND	ND	ND	0.14	ND	0.13	7.1	14500
NEP-GW-OCD-7 (Fld Blank)	C922395/15725	18-Nov-92	ND				ND		ND		0.04				
NEP-GW-OCD-7A	C922389/15720	18-Nov-92	0.021	0.023		0.012	0.02	ND	ND	ND	0.15		0.13	7.3	13300
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93	0.175			0.154	0.02	ND	ND	ND	0.02		0.02	7.3	10500
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93	0.005	0.005		ND	ND	ND	ND	ND	0.01		ND	7.6	6110
NEP-GW-OCD-8A	C922393/15723	17-Nov-92	0.032	0.037		0.019	ND	ND	ND	ND	0.12	ND	0.11	7	12400
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.02		ND	7.3	7490
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93	ND			ND	ND	ND	ND	ND	0.03		0.01	7.7	7270
Pecos River at OCD 7	C922425/W01464	20-Nov-92												7.3	7080
NEP-Windmill	C922656/16032	17-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.02		ND	7.4	6610
Evaporation Pond at OCD-7	C922424/15745/W01463	20-Nov-92	0.167				ND		ND		0.06			7.6	10900

Key	**Test description/method**	**Detection limits**
a	Total arsenic — Method 7061	0.005
b	Total arsenic — Method 7061 — Verification	0.005
c	Total arsenic — Method 7060 — Verification	0.005
d	Dissolved arsenic — Method 701	0.01
e	Total chromium — Method 7191	0.02
f	Dissolved chromium — Method 7191	0.02
g	Total lead — Method 7421	0.02
h	Dissolved lead — Method 7421	0.02
i	Total nickel — Method 7520	0.01
j	Total nickel — Method 7520 — verification	0.05
k	Dissolved nickel — Method 7520	0.01
l	Electrical conductivity, μmhos/cm at 25 ° C	

ND = Not detected.

Standards	**EPA Drinking Water (mg/L)**	**NMWQCC Groundwater**
As	0.05	0.1
Cr	0.1	0.5
Pb	0.015 (Action level)	0.05
Ni	0.1	0.2 (irrigation)

Table C-4. Results of inorganic water quality analyses, Evaporation Pond, Navajo Refinery, RFI Phase II.

Well sample ID	Laboratory no.	Date sampled		pH (Laboratory)	Electrical Conductivity at 25°C (Laboratory)	Total dissolved solids at 180°C	Total calcium	Total alkalinity	Total hardness	Flouride	Calcium	Calcium	Magnesium	Magnesium	Potassium	Potassium
			Detection level Units	0.1 (s.u.)	1 (µmhos/cm)	1 (mg/L)	1 (mg/L)	1 (mg/L)	1 (mg/L)	0.1 (mg/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)
NEP-GW-EPA-1	C922391/15722	18-Nov-92		7.2	5340	3750	3670	167	1960	0.8	495	24.70	176	14.47	7.1	0.18
NEP-GW-MW-01-01	C922278/15632	10-Nov-92		7.5	14900	11200	10500	406	3880	1.1	764	38.12	480	39.47	14.0	0.36
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92		7.5	14900	11300	NA	408	NA	1.1	769	NA	480	NA	16.0	NA
NEP-GW-MW-02A	C922280/15633	10-Nov-92		7.4	11300	8430	8430	523	1980	9.9	573	28.59	134	11.02	14.0	0.36
NEP-GW-MW-02B	C922653/16029	16-Dec-93		7.4	3430	2500	2320	160	1220	1.2	304	15.17	112	9.21	20.0	0.51
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92		7.4	3430	2540	NA	160	NA	1.2	300	NA	112	NA	18.0	NA
NEP-GW-MW-03	C922322/15647	11-Nov-92		7.3	7220	5310	4570	285	1630	3.0	457	22.80	119	9.79	12.0	0.31
NEP-GW-MW-04	C922333/15644	12-Nov-92		7.3	7610	5360	5080	234	1410	1.8	370	18.46	119	9.79	5.5	0.15
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92		7.3	7620	5360	NA	233	NA	1.8	376	NA	121	NA	5.0	NA
NEP-GW-MW-05A	C922334/15645	11-Nov-92		7.2	28000	24300	22300	423	5650	3.3	585	29.19	1020	83.88	9.0	0.23
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92		7.2	28100	24400	22200	427	5640	3.3	579	28.89	1020	83.88	9.3	0.23
NEP-GW-MW-05B	C930136/W00059	22-Jan-93		7.1	9310	7350	7160	328	2460	1.5	650	32.44	204	16.78	13.0	0.33
NEP-GW-MW-06A	C922323/15648	12-Nov-92		7.4	4950	3540	3300	136	1090	2.7	282	14.07	93	7.65	3.5	0.10
NEP-GW-MW-06B	C930278/W00344	30-Jan-93		11.9	6410	3800	3660	428	1620	0.4	648	32.34	1	0.08	27.0	0.69
NEP-GW-MW-07A	C922281/15634	11-Nov-92		7.2	13900	11500	11000	302	2780	1.4	471	23.50	389	31.99	12.0	0.31
NEP-GW-MW-07B	C930106/W00056	21-Jan-93		7.5	10700	9220	7980	293	1670	1.4	547	27.30	74	6.09	14.0	0.36
NEP-GW-MW-10	C922390/15721	18-Nov-92		7.2	6190	4400	4380	223	1340	1.1	417	20.81	72	5.92	7.4	0.18
NEP-GW-MW-11A	C922567/15975	12-Dec-92		7.1	23700	16100	15200	331	3980	1.0	964	48.10	384	31.58	31.0	0.79
NEP-GW-MW-11B	C930205/W00184	23-Jan-93		7.3	20500	14000	13600	217	5950	0.9	961	47.95	317	26.07	41.0	1.05
NEP-GW-MW-12	C922658/16033	18-Dec-92		7.2	18700	13500	12400	358	4470	1.1	788	39.32	608	50.00	19.0	0.49
NEP-GW-MW-13	C922659/16034	18-Dec-92		7.5	5180	3630	3370	254	1340	0.7	352	17.56	112	9.21	17.0	0.43
NEP-GW-MW-14	C922655/16031	17-Dec-93		7.4	11200	8230	7780	405	2320	1.0	456	22.75	288	23.68	18.0	0.46
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-93		7.3	10900	7890	7550	396	2260	1.0	444	22.16	280	23.03	21.0	0.54
TMD-GW-MW-15	C930105/W00055	20-Jan-93		7.5	3590	2790	2670	150	1190	1.1	308	15.37	102	8.39	11.0	0.28
NEP-GW-MW-17	C930209/W00189	26-Jan-93		7.7	2600	2230	2020	121	1370	1.1	387	19.31	99	8.14	13.0	0.33
NEP-GW-MW-18A	C930207/W00187	25-Jan-93		7.3	16400	12600	11900	286	4530	1.6	721	35.98	664	54.61	30.0	0.77
NEP-GW-MW-18B	C930602/W01466	11-Mar-93		7.7	4650	3710	3550	164	2110	1.1	588	29.34	157	12.91	17.0	0.43
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-94		7.7	4640	3710	NA	164	NA	1.1	577	NA	154	NA	16.0	NA
NEP-GW-MW-19	C930208/W00188	26-Jan-93		7.6	7280	5720	5150	210	2790	0.9	745	37.18	226	18.59	10.0	0.26
NEP-GW-MW-22A	C930282/W00347	29-Jan-93		7.4	5750	4410	4220	159	1520	1.5	421	21.01	114	9.38	6.0	0.15
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93		7.4	5790	4400	4290	159	1560	1.5	434	21.66	117	9.62	7.0	0.18
NEP-GW-MW-22B	C930283/W00348	29-Jan-93		7.1	6180	4700	4510	213	1720	1.0	461	23.00	139	11.43	4.0	0.10
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93		7.1	6180	4720	NA	212	NA	1.0	464	NA	139	NA	5.0	NA
NEP-GW-MW-23	C930229/W00271	28-Jan-93		7.2	15900	11700	10500	349	3890	0.8	988	49.30	347	28.54	14.0	0.36
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93		7.2	15900	11700	NA	349	NA	0.8	986	NA	342	NA	14.0	NA
NEP-GW-MW-24	C930281/W00346	28-Jan-93		7.3	16300	11600	10786	242	2951	1.0	787	39.27	240	19.74	38.0	0.97
NEP-GW-OCD-1	C922324/15649	13-Nov-92		7.2	14200	10300	8570	526	1860	5.7	487	24.30	156	12.83	7.2	0.18
NEP-GW-OCD-2A	C922357/15669	15-Nov-92		7.0	15400	11800	10900	404	2780	1.2	565	28.19	333	27.38	8.1	0.20
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92		7.0	15400	11700	NA	394	NA	1.2	567	NA	313	NA	9.0	NA
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93		7.3	14700	11600	11100	408	4140	0.9	844	42.12	494	40.63	13.0	0.33
NEP-GW-OCD-3	C922358/15670	16-Nov-92		7.1	17300	11600	10300	281	3340	0.9	922	46.01	268	22.04	29.0	0.74
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92		7.2	19000	13100	11800	197	2790	0.9	724	36.13	240	19.74	50.0	1.28
NEP-GW-OCD-5	C922399/15728	16-Nov-92		7.2	17800	12400	12000	199	3070	1.0	847	42.27	232	19.08	37.0	0.95
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92		7.2	17900	12400	11900	202	3050	1.0	846	42.22	228	18.75	36.0	0.92
NEP-GW-OCD-5 (LabDup of Fld D)	C922394/15731	17-Nov-92		7.2	17900	12400	NA	205	NA	1.0	849	NA	225	NA	36.0	NA
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92		7.1	14500	10900	10400	495	2550	2.9	675	33.68	210	17.27	15.0	0.38
NEP-GW-OCD-7A	C922389/15720	18-Nov-92		7.3	13300	10300	9570	564	2670	4.1	620	30.94	274	22.53	8.5	0.23
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93		7.3	10500	8350	7940	511	2390	6.6	652	32.53	186	15.30	14.0	0.36
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93		7.6	6110	5060	4840	141	1850	1.2	547	27.30	117	9.62	10.0	0.26
NEP-GW-OCD-8A	C922393/15723	17-Nov-92		7.0	12400	9670	9050	434	2850	2.5	633	31.59	308	25.33	11.0	0.28
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93		7.3	7490	5400	5240	164	2930	0.9	834	41.62	207	17.02	12.0	0.31
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93		7.7	7270	5270	5130	163	2840	0.9	807	40.27	202	16.61	14.0	0.36
NEP-Navajo Effluent	C930367/W00731	11-Feb-93		8.9	9300	7348	4840	829	279	151.0	21	1.05	55	4.52	22.0	0.56
Evaporation Pond at OCD 7	C922424/15745	16-Nov-92		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Evaporation Pond at OCD 7	C922424/15745/W01463	16-Nov-92		7.6	10900	7080	6620	534	354	36.3	46	2.30	58	4.77	67.0	1.31
NEP-Windmill	C922656/16032	17-Dec-92		7.4	6610	4740	4450	163	1530	1.1	316	15.77	180	14.80	14.0	0.36
Pecos River at OCD 7	C922425/W01464	16-Nov-92		7.3	7080	5110	4735	165	2190	0.9	571	28.49	186	15.30	13.0	0.33

Table C-4. Continued.

Well sample ID	Laboratory no.	Date sampled	Detection level Units	Sodium	Sodium	HCO_3	HCO_3	CO_3	CO_3	OH	OH	Chloride	Chloride	SO_4	SO_4	Cation sum	Anion sum	Percent difference
				1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	(meq)	(meq)	(%)
NEP-GW-EPA-1	C922391/15722	18-Nov-92		480	20.88	204	3.34	0	0.00	0	0.00	989	27.90	1420	29.56	60.23	60.80	-0.47
NEP-GW-MW-01-01	C922278/15632	10-Nov-92		2130	92.65	495	8.11	0	0.00	0	0.00	3750	105.78	3020	62.88	170.60	176.77	-1.78
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92		2130	NA	NA	NA	NA	NA	NA	NA	3740	NA	3010	NA	NA	NA	NA
NEP-GW-MW-02A	C922280/15633	10-Nov-92		2170	94.39	638	10.46	0	0.00	0	0.00	2120	59.8	3180	66.21	134.36	134.47	-0.78
NEP-GW-MW-02B	C922653/16029	16-Dec-93		268	11.66	195	3.20	0	0.00	0	0.00	497	14.02	1020	21.24	36.55	38.46	-2.55
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92		268	NA	NA	NA	NA	NA	NA	NA	498	NA	1020	NA	NA	NA	NA
NEP-GW-MW-03	C922322/15647	11-Nov-92		975	42.41	348	5.70	0	0.00	0	0.00	1820	51.34	1020	21.24	75.31	78.28	-1.93
NEP-GW-MW-04	C922333/15644	12-Nov-92		1180	51.33	285	4.67	0	0.00	0	0.00	1380	38.93	1880	39.14	79.73	82.74	-1.85
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92		1170	NA	NA	NA	NA	NA	NA	NA	1410	NA	1870	NA	NA	NA	NA
NEP-GW-MW-05A	C922334/15645	11-Nov-92		5250	228.36	516	8.46	0	0.00	0	0.00	5410	152.61	9770	203.41	341.66	364.48	-3.23
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92		5150	224.01	520	8.52	0	0.00	0	0.00	5470	154.30	9740	202.79	337.01	365.61	-4.07
NEP-GW-MW-05B	C930136/W00059	22-Jan-93		1600	69.60	400	6.56	0	0.00	0	0.00	1760	49.65	2730	56.84	119.15	113.05	2.63
NEP-GW-MW-06A	C922323/15648	12-Nov-92		700	30.45	166	2.72	0	0.00	0	0.00	654	18.45	1490	31.02	52.27	52.19	0.08
NEP-GW-MW-06B	C930278/W00344	30-Jan-93		574	24.97	0	0.00	37	1.22	125	7.33	968	27.31	1180	24.57	58.08	60.43	-1.98
NEP-GW-MW-07A	C922281/15634	11-Nov-92		2930	127.45	368	6.03	0	0.00	0	0.00	2750	77.57	4260	88.69	183.25	172.29	3.08
NEP-GW-MW-07B	C930106/W00056	21-Jan-93		1990	86.56	357	5.85	0	0.00	0	0.00	1880	53.03	3300	68.71	120.31	127.59	-2.94
NEP-GW-MW-10	C922390/15721	18-Nov-92		970	42.19	272	4.46	0	0.00	0	0.00	982	27.70	1800	37.48	69.10	69.64	-0.39
NEP-GW-MW-11A	C922567/15975	12-Dec-92		3860	167.90	404	6.62	0	0.00	0	0.00	7108	200.51	2610	54.34	248.37	261.47	-2.57
NEP-GW-MW-11B	C930205/W00184	23-Jan-93		3410	148.33	265	4.34	0	0.00	0	0.00	5950	167.84	2790	58.09	223.40	230.27	-1.51
NEP-GW-MW-12	C922658/16033	18-Dec-92		2560	111.35	437	7.16	0	0.00	0	0.00	4980	140.48	3250	67.67	201.16	215.31	-3.40
NEP-GW-MW-13	C922659/16034	18-Dec-92		596	25.92	310	5.08	0	0.00	0	0.00	914	25.78	1230	25.61	53.12	56.47	-3.06
NEP-GW-MW-14	C922655/16031	17-Dec-93		1720	74.82	493	8.08	0	0.00	0	0.00	2150	60.65	2900	60.38	121.71	129.11	-2.95
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-93		1650	71.77	483	7.92	0	0.00	0	0.00	2080	58.67	2830	58.92	117.50	125.51	-3.30
TMD-GW-MW-15	C930105/W00055	20-Jan-93		447	19.44	182	2.98	0	0.00	0	0.00	564	15.91	1150	23.94	43.48	42.83	0.75
NEP-GW-MW-17	C930209/W00189	26-Jan-93		109	4.74	147	2.41	0	0.00	0	0.00	122	3.44	1220	25.40	32.52	31.25	1.99
NEP-GW-MW-18A	C930207/W00187	25-Jan-93		2420	105.26	348	5.70	0	0.00	0	0.00	3930	110.86	3950	82.24	196.62	198.80	-0.55
NEP-GW-MW-18B	C930602/W01466	11-Mar-93		356	15.48	200	3.28	0	0.00	0	0.00	661	18.65	1670	34.77	58.16	56.70	1.27
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-94		353	NA	NA	NA	NA	NA	NA	NA	668	NA	1690	NA	NA	NA	NA
NEP-GW-MW-19	C930208/W00188	26-Jan-93		718	31.23	256	4.20	0	0.00	0	0.00	1370	38.65	1950	40.60	87.26	83.45	2.23
NEP-GW-MW-22A	C930282/W00347	29-Jan-93		799	34.75	193	3.16	0	0.00	0	0.00	835	23.55	1950	40.60	65.29	67.31	-1.52
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93		809	35.19	193	3.16	0	0.00	0	0.00	844	23.81	1990	41.43	66.65	68.40	-1.30
NEP-GW-MW-22B	C930283/W00348	29-Jan-93		830	36.10	259	4.25	0	0.00	0	0.00	983	27.73	1970	41.02	70.63	73.00	-1.65
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93		827	NA	NA	NA	NA	NA	NA	NA	983	NA	1950	NA	NA	NA	NA
NEP-GW-MW-23	C930229/W00271	28-Jan-93		2180	94.82	425	6.97	0	0.00	0	0.00	4240	119.61	2570	53.51	173.02	180.09	-2.00
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93		2160	NA	NA	NA	NA	NA	NA	NA	4260	NA	2660	NA	NA	NA	NA
NEP-GW-MW-24	C930281/W00346	28-Jan-93		2500	108.74	295	4.84	0	0.00	0	0.00	4170	117.63	2910	60.59	168.72	183.06	-4.08
NEP-GW-OCD-1	C922324/15649	13-Nov-92		2230	97.00	642	10.52	0	0.00	0	0.00	1930	54.44	3450	71.83	134.31	136.79	-0.91
NEP-GW-OCD-2A	C922357/15669	15-Nov-92		2510	109.18	493	8.08	0	0.00	0	0.00	3220	90.83	3990	83.07	164.95	181.98	-4.91
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92		2600	NA	NA	NA	NA	NA	NA	NA	3200	NA	3980	NA	NA	NA	NA
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93		2320	100.91	498	8.16	0	0.00	0	0.00	3710	104.65	3450	71.83	183.99	184.64	-0.18
NEP-GW-OCD-3	C922358/15670	16-Nov-92		2330	101.35	281	4.61	0	0.00	0	0.00	4130	116.50	2520	52.47	170.14	173.58	-1.00
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92		3120	135.71	240	3.93	0	0.00	0	0.00	4500	126.94	3010	62.67	192.86	193.54	-0.18
NEP-GW-OCD-5	C922399/15728	16-Nov-92		3030	131.80	243	3.98	0	0.00	0	0.00	4720	133.15	2980	62.04	194.10	199.17	-1.29
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92		2930	127.45	246	4.03	0	0.00	0	0.00	4760	134.27	3000	62.46	189.34	200.76	-2.93
NEP-GW-OCD-5 (LabDup of Fld D)	C922394/15731	17-Nov-92		2970	NA	NA	NA	NA	NA	NA	NA	4780	NA	2990	NA	NA	NA	NA
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92		2550	110.92	603	9.89	0	0.00	0	0.00	3000	84.63	3670	76.41	162.25	170.93	-2.61
NEP-GW-OCD-7A	C922389/15720	18-Nov-92		2120	92.21	687	11.26	0	0.00	0	0.00	2480	69.96	3730	77.66	145.91	158.88	-4.26
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93		1950	84.82	623	10.21	0	0.00	0	0.00	2040	57.55	2800	58.30	133.01	126.06	2.68
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93		813	35.36	172	2.82	0	0.00	0	0.00	690	19.46	2570	53.51	72.54	75.79	-2.19
NEP-GW-OCD-8A	C922393/15723	17-Nov-92		1930	83.95	529	8.67	0	0.00	0	0.00	2290	64.60	3620	75.37	141.15	148.64	-2.58
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93		651	28.32	200	3.28	0	0.00	0	0.00	1630	45.98	1810	37.68	87.27	86.94	0.19
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93		628	27.32	199	3.26	0	0.00	0	0.00	1580	44.57	1800	37.48	84.56	85.31	-0.44
NEP-Navajo Effluent	C930367/W00731	11-Feb-93		1290	56.11	1011	16.57	0	0.00	0	0.00	1920	54.16	1034	21.53	62.24	92.26	-19.43
Evaporation Pond at OCD 7	C922424/15745	16-Nov-92		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Evaporation Pond at OCD 7	C922424/15745/W01463	16-Nov-92		2000	86.99	651	10.67	0	0.00	0	0.00	2180	61.50	1950	40.60	95.77	112.77	-8.15
NEP-Windmill	C922656/16032	17-Dec-92		872	37.93	199	3.26	0	0.00	0	0.00	1190	33.57	1780	37.06	68.86	73.89	-3.52
Pecos River at OCD 7	C922425/W01464	16-Nov-92		733	31.88	201	3.30	0	0.00	0	0.00	1470	41.47	1660	34.56	76.00	79.32	-2.14

APPENDIX D

DERIVATION OF SOIL CONCENTRATION-BASED LIMITS FOR METAL CONSTITUENTS FROM THE PART 503 MUNICIPAL SLUDGE REGULATIONS

Under the authority of Sections 405(d) and (e) of the Clean Water Act, EPA regulations exist to protect public health and the environment from any reasonably anticipated adverse effects of certain pollutants that may be present in surface-applied sewage sludge (40 CFR Part 503, Subpart B-Land Application). Subpart B of the regulations specifies pollutant limits for certain metal constituents which are typically contained in sewage sludge. The sludge land application pollutant limits are listed in Tables 1-4 of 40 CFR 503.13. Depending upon the environmental setting (home garden, agricultural or forest land) in which sludge application occurs, pollutant limits are established on the basis of one or more of the following criteria: ceiling concentrations (mg/kg) for pollutants contained in the sludge; maximum cumulative applied pollutant load (kg/ha); or the maximum annual loading rates for pollutant constituents of concern (kg/ha).

The Part 503 sludge pollutant limits were established on the basis of a comprehensive risk assessment conducted by the EPA Office of Science and Technology, the results of which were published in the Technical Support Document for Land Application for Sewage Sludge (November, 1992). In order to conduct that risk assessment, various sources of technical data were combined with conservative default assumptions to evaluate the potential for adverse effects to human health and the environment. In the following discussion, relevant information cited from the technical support document are referenced by page number.

As described above, the pollutant limits specified in 40 CFR 503.13 refer to constituent concentrations associated with the sludge itself, rather than resulting concentrations of constituents persisting in the soil once application activities have ceased. Therefore, for many of the environmental pathways targeted for risk evaluation (pp. 5-2), it was necessary for EPA to assign various default characteristics for a generic soil in order to derive soil-based pollutant concentration values that could be employed in a more direct manner for the evaluation of potential adverse health effects and the execution of fate and migration modeling.

It is apparent that, as a matter of necessity, EPA started with soil-based pollutant concentration limits for several environmental pathways of concern, and subsequently established sludge-based pollutant limits that would not exceed the soil-based limits. Because the default soil characteristics employed in the risk assessment are specified in the Part 503 technical support document, it is possible to derive soil-based maximum pollutant concentration values that correspond to the sludge-based pollutant limits presented in 40 CFR 503.13. In particular, two of the default soil assumptions provide the information necessary to derive the soil-based pollutant limits: that sludge is incorporated into the soil to a depth of 15 cm, and that the total mass of that soil interval possesses a weight of 2×10^9 g dry weight/ha (pp. 5-19).

The comparison of the Pond 1 soils with the Part 503 pollutant limit criteria was conducted on the basis of an agricultural land scenario. Thus, the relevant Part 503 pollutant limit for this scenario are specified at 40 CFR 503.13(a)(2)(i) and 40 CFR 503.13 (Table 2). In turn, the cumulative pollutant loading rates presented in Table 2 were extracted from the analysis of the most limiting environmental exposure pathway for each constituent, which is presented as Table 6-2 of the support document (p.6-5). Table 6-2 presents the limiting results for each pathway for inorganic pollutants, reported as reference cumulative application rate of pollutant. For three of the Pond 1 constituents of concern, the most limiting environmental pathway passes from sludge through the soil medium to the receptor (Table D-1). For the remaining two Pond 1 constituents of concern (arsenic and lead) the most limiting exposure pathway does not pass through the soil medium, but instead proceeds directly from sludge to receptor The following table summarizes the most limiting environmental pathway and associated maximum pollutant limit for the Pond 1 inorganic constituents of concern.

Table D-1. Most Limiting Environmental Pathway and Pollutant Limit for Inorganic Pollutants Contained in Sewage Sludge

Constituent	Limiting Pathway	Pollutant Limit (1)
Chromium	Sludge to Soil to Plant	3000 kg/ha
Nickel	Sludge to Soil to Plant	420 kg/ha
Zinc	Sludge to Soil to Plant	2800 kg/ha
Arsenic	Sludge to Human	41 ug/g
Lead	Sludge to Human	300 ug/g

(1) Pollutant limits for chromium, nickel and zinc are based on a reference cumulative application rate (RPc) expressed as kg pollutant/ha. Pollutant limits for arsenic and lead are based on a reference sludge concentration (RSc) expressed as ug pollutant/g sludge.

Based on the assumed mass of sludge-incorporated soil and the reference cumulative application rates (RPc) of chromium, nickel, and lead for their most limiting pathway, the soil-based cumulative loading limit for each constituent may be simply calculated. For example, for the case of chromium, the reference cumulative application rate (RPc) = 3,000 kg/ha, which is incorporated into a 15 cm-deep soil zone having a mass of 2 x 10^9 g (2 x 10^6 kg). Therefore:

$$\textbf{3000 kg chromium per ha-15 cm / 2 x } \mathbf{10^6} \textbf{ kg soil per ha-15 cm}$$
$$\textbf{= 1500 kg chromium / 1 x } \mathbf{10^6} \textbf{ kg soil = 1500 ppm}$$

In the case of the remaining Pond 1 constituents of concern (arsenic and lead), calculation of soil-based pollutant limits is more straightforward, since worst-case exposure to these constituents was determined to occur when sludge is directly ingested by a human receptor. Therefore, the specified pollutant limits for these are not strictly medium-dependent, and can thus be validly compared to other forms of potentially ingestible solid media, such as soil. Since the RSc values for arsenic and lead are expressed in ug/g, the conversion to parts per million requires no additional calculations. For instance, in the case of arsenic, using the RSc value presented in Table 6-2 of the support document (p.6-5):

41 ug arsenic / g containing media = 41 ppm arsenic.

As a final note, the pollutant limit for lead established on the basis of the sludge-to-human pathway was originally determined according to the EPA integrated uptake biokinetic (IUBK) model, which resulted in an allowable sludge concentration of 500 ppm lead. However, EPA subsequently made a policy decision to reduce the allowable limit to 300 ppm, based on the observation that animals fed up to 10 percent of their diet as sewage sludge did not exhibit alterations in their lead body burden until the lead concentration in the sludge exceeded 300 ppm. Therefore, the Part 503 pollutant limit for lead represents a relatively conservative health-based standard.

EVAPORATION POND 1
CORRECTIVE MEASURES STUDY
WORKPLAN

prepared for

Navajo Refining Company
Artesia, New Mexico

August 1994

by

R/S RE/SPEC INC.
RESEARCH / SPECIALISTS

TELEPHONE
(505) 748-3311

EASYLINK
62905278

REFINING COMPANY

501 EAST MAIN STREET • P. O. BOX 159
ARTESIA, NEW MEXICO 88211-0159

FAX
(505) 746-6410 ACCTG
(505) 746-6155 EXEC
(505) 748-9077 ENGR
(505) 746-4438 P / L

August 30, 1994

Mr. Allyn M. Davis, Director
Hazardous Waste Management Division (6H)
U. S. Environmental Protection Agency, Region VI
1445 Ross Avenue, Suite 1200
Dallas, TX 75202-2733

RE: Transmittal of Corrective Measures Workplan, Closed Evaporation Pond 1, Navajo Refinery, Artesia, New Mexico, August 1994

Dear Mr. Davis:

Enclosed please find the Corrective Measures Workplan for the above-referenced Solid Waste Management Unit. The workplan is provided as required in your letter dated May 19, 1994 to Navajo Refining Company. The workplan document presents Navajo's proposed approach to address remediation of hydrocarbon-impacted solids contained in Evaporation Pond 1. As discussed in the workplan, the recommended corrective measures alternative consists of onsite excavation of hydrocarbon-contaminated soils, followed by remedial treatment within the confines of the unit employing standard landfarm technology.

Navajo strongly believes that the corrective measures alternative identified and proposed in this workplan represents the most appropriate approach for addressing the environmental remediation of Pond 1 soils. It is hoped that EPA will concur with Navajo's reasoning and justification for the approach taken in this workplan, and will also recognize that the intent is to expedite the environmental remediation of the unit in a manner that is both cost-effective and soundly grounded in environmental principles.

As an interim corrective measures action, Navajo has previously executed rudimentary land treatment activities to initiate the biodegradation of surface soils at the unit. Although no empirical evidence is available regarding the efficacy of the basic landfarm approach at this location, the overwhelming qualitative observational evidence available to personnel familiar with the recent history of the unit, plus documented success of this approach at other sites containing similarly contaminated soils, makes it very clear that land treatment of Pond 1 soils is a highly feasible remediation option. In numerous discussions with EPA Region 6 personnel, the possibility of onsite bioremediation of Pond 1 soils has been repeatedly mentioned, and Navajo has received no indication from EPA to cause us to believe that they would prefer an alternative approach to remediation of unit soils.

If EPA agrees that the approach advanced in this workplan is acceptable in principle, Navajo is prepared to work closely with EPA to finalize the details of the corrective measures program for Pond 1, and to initiate the planned activities in a prompt and timely manner.

If you have any questions, please do not hesitate to contact me or David Griffin, Superintendent of Environmental Affairs, at (505) 748-3311.

Sincerely,

Matthew P. Clifton
Senior Vice President

MPC/pb

enclosures

EVAPORATION POND 1
CORRECTIVE MEASURES STUDY
WORKPLAN

prepared for

Navajo Refining Company
Artesia, New Mexico

by

RE/SPEC, Inc.
4775 Indian School Road, NE #300
Albuquerque, New Mexico 87110

August 1994

David G Boyer
David G. Boyer
Project Manager

Brian P. Sullivan
Brian P. Sullivan
Assistant Project Manager

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1.0 INTRODUCTION

Navajo Refining Company (Navajo) operates a petroleum refinery located in Artesia, New Mexico (EPA I.D. No. NMD 048918817). The facility is regulated under the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984. At the time that the U.S. Environmental Protection Agency (EPA) conducted a preliminary review (PR) of the facility, certain facility areas were identified as solid waste management units. Among these were:

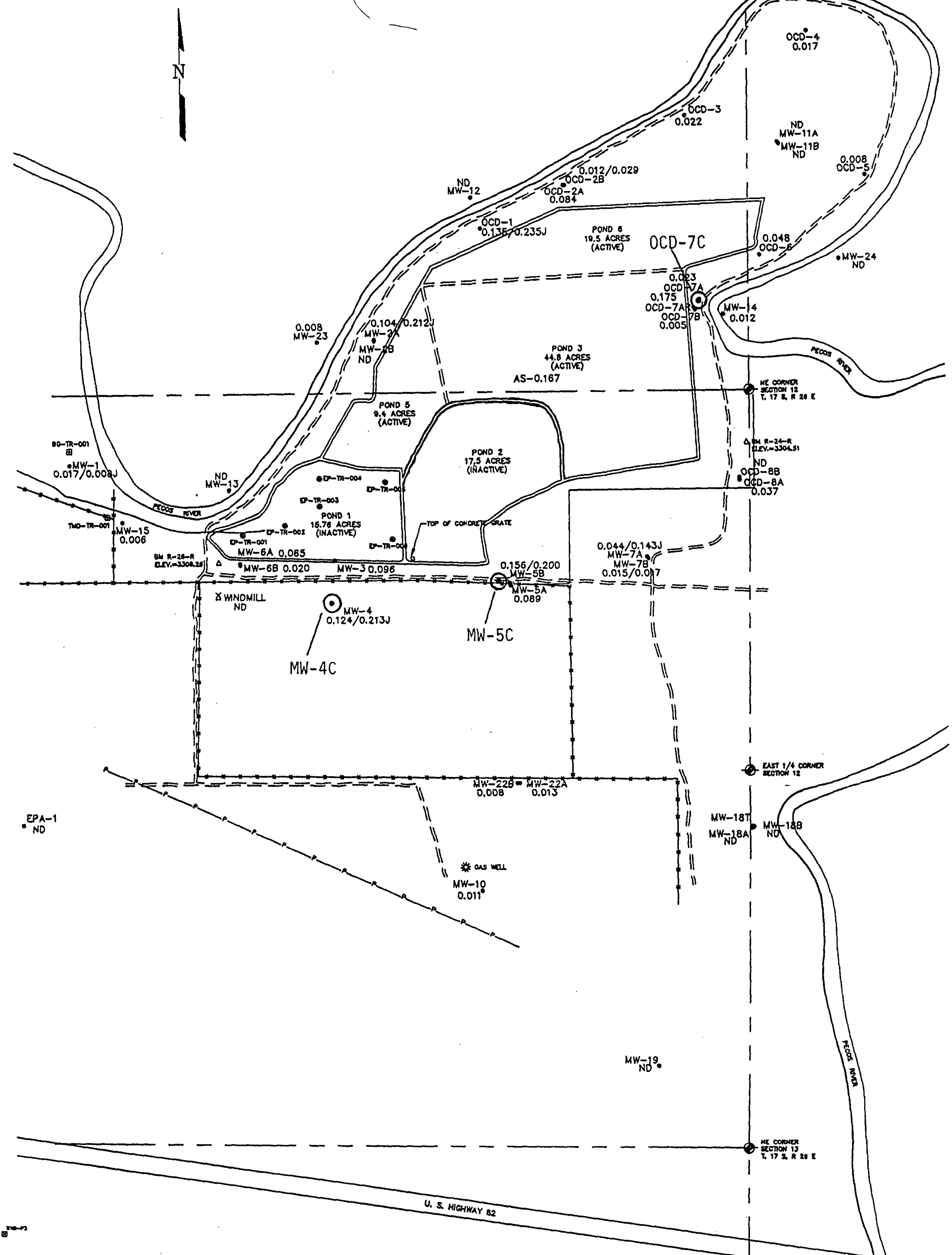
- An unlined wastewater conveyance unit known as Three-Mile Ditch (TMD) operated from the 1930s to 1987, and
- The facility evaporation pond system.

The evaporation pond system consists of now-inactive surface impoundments known as Evaporation Pond 1 and Evaporation Pond 2, which formerly received wastewater conveyed by the ditch, and a series of interconnected active evaporation ponds, which currently receive facility wastewater conveyed via an underground pipeline. A site plan for the facility evaporation ponds system is presented as Figure 1-1.

Under the technical framework of the RCRA corrective action program, EPA determined that a RCRA Facility Investigation (RFI) was required for these two facility units to characterize the nature and extent of releases of hazardous constituents. As a result, TMD and the evaporation ponds were the subject of RFI Phase I and Phase II investigations completed in 1990 and 1993, respectively. As stated in May 19, 1994 correspondence from EPA to Navajo, EPA is now requiring that a RFI Phase III investigation be executed for TMD and the active evaporation ponds, together with the preparation of a Corrective Measures Workplan for Evaporation Pond 1. The draft RFI Phase III workplan for TMD and the active ponds, dated July 31, 1994, was previously submitted to EPA.

The Corrective Measures Study (CMS) approach envisions evaluation of several or numerous alternatives for corrective measures depending on the site specific conditions and characteristics of the released hazardous constituents. As discussed later in this document, conditions at Evaporation Pond 1 are conducive to on-site remediation efforts and Navajo began such efforts, such as dewatering and soil aeration, shortly after ceasing discharges in 1987. Therefore, based on previous RFI results showing minimal environmental risk and in consideration of existing ongoing remediation activities, the CMS procedures have been modified to reflect the existing conditions and on-going activities at this unit.

Figure 1-1. Navajo Evaporation Ponds Site Plan



EXPLANATION:

⊞ BG-TR-001	BACKGROUND TRENCH
TMD-TR-001	EXPLORATORY TRENCH, THREE-MILE DITCH
● EP-TR-001	EXPLORATORY TRENCH, EVAPORATION POND 1
• MW-4 0.124/0.213J	MONITOR WELL WITH TOTAL ARSENIC CONCENTRATION (mg/l), KWBES/PRC SPLIT SAMPLE (WHERE PERFORMED)
⊠	PIEZOMETER
J	ESTIMATED VALUE
ND	NOT DETECTED AT 0.005 (mg/l)
⊙	Proposed Deep Monitor Well Location

NOTE: MAP COMPILED FROM NAVAJO REFINERY AND USGS SPRING LAKE 7.5 MINUTE QUADRANGLE. WELL LOCATIONS AND ELEVATIONS FROM NAVAJO REFINERY CONTROL. WELL LOCATIONS SURVEYED 2/9: JAQUESS & ASSOCIATES.

LOCATION T 17 S, R 26 E, NMPM, EDDY COUNTY, NM

NOTE: KWBES ARSENIC CONCENTRATION SHOWN IS THE VERIFICATION ANALYSIS OR AVERAGE OF TWO VERIFICATION ANALYSES; IF NO VERIFICATION ANALYSIS WAS PERFORMED, VALUE SHOWN IS ORIGINAL CONCENTRATION.

800 0 800 2400 FEET

R/S RE/SPEC INC. RESEARCH SPECIALISTS	Navajo Evaporation Ponds Site Plan	
prepared for: Navajo	PROJECT: 318/2.1	
	LOCATION: NAVAJO REFINERY, ARTESIA, NM	
	APPR:	DATE: 11/23/93
	DRAWN BY:	SCALE AS SHOWN
	DATE: 4/27/93	FIGURE: 1-1

This CMS document presents the findings of a corrective measures alternatives evaluation for hydrocarbon-contaminated soils in Pond 1, and provides preliminary details of additional recommended corrective measures to be taken at the unit, including both routine monitoring of unit soils during their remediation, and actions to be taken to comply with EPA-specified monitoring requirements for groundwater underlying the unit.

The workplan is organized into four sections. Section 2.0 is concerned with the identification and development of the selected corrective measures alternative, including a description of the current situation, establishment of corrective action objectives, and a description of ongoing interim measures being conducted at the unit. Section 3.0 provides an evaluation of the effectiveness of the corrective measures alternative from the viewpoint of technological feasibility and potential short- and long-term effects on human health and the environment. Section 4.0 details preliminary design, operations and management criteria for the selected corrective alternatives measure, including remediation goals, monitoring requirements for unit soils and groundwater, and proposed content and scheduling of routine inspections and progress reports.

2.0 SELECTION OF CORRECTIVE MEASURES ALTERNATIVE

2.1 Current Conditions

Detailed discussions of climate, soils, geology and groundwater in the vicinity of the refining process areas, Three-Mile Ditch, and the facility evaporation ponds were presented in the November 1993 RFI Phase II report and summarized in the July 1994 RFI Phase III workplan. Therefore, only a summary discussion of soil and groundwater conditions as they exist at evaporation Pond 1 is presented below with more complete and wide-ranging information available in cited reports.

2.1.1 Soil

Pond 1 soils were evaluated for hydrocarbon content and hazardous constituents during the course of the units' Phase II RFI (submitted to EPA in November, 1993). As part of the Phase II investigation, soil samples were obtained at various depths from six trackhoe-excavated trenches located within the unit.

The Phase II analytical data for the Pond 1 soils is summarized in Appendix A of this document. The data indicated that organic and inorganic contaminants were most heavily concentrated in the upper soils of the unit above a depth of 3 ft. The average percent oil and grease concentration reported in soil samples obtained at a one-foot sample depth was 10.4 % (Appendix A, Table 1). Oil and grease concentrations decreased markedly at sample intervals below the one-foot depth. At the three-foot sample interval, the average oil and grease concentration declined to 0.41%, with the average being skewed upwards by two samples collected at the trench locations completed proximal to the ditch influent point, which exhibited relatively elevated oil and grease concentrations (approximately 1%). At successive soil sample depth intervals below 3 ft., oil and grease concentrations became attenuated with depth (Appendix A, Table 1).

Further characterization of the hydrocarbon profile for the surface soils of Pond 1 soils was provided by additional voluntary soil sampling conducted by Navajo at the unit in November 1993. At that time, soil samples were collected from a 1.5 to 2-foot depth interval at 21 locations across the unit and analyzed for total petroleum hydrocarbons (TPH). Sampling locations and analytical data for the November 1993 soil sampling event is presented in Appendix B. The laboratory analytical data from that sample event yielded average TPH values of 4,100 mg/kg, roughly equivalent to an oil and grease concentration of 4.1%.

The RFI Phase II analytical results for inorganic metal constituents in Pond 1 soils indicated that elevated metal concentrations were limited to the upper portion of the soil profile within a few feet of the surface, with arsenic, chromium and lead being identified as potential metals of concern (Appendix A, Table 2). The apparent immobilization and fixation of these three constituents in the upper soil profile was further confirmed by the results of TCLP testing, which failed to yield any TC exceedances.

Pond 1 is currently undergoing interim corrective measures actions (see Section 2.2) to remediate surface soils. As a result of the interim actions, the unit does not currently provide vegetative cover for wildlife, and neither supports or attracts vegetation-dependent populations of above-ground or subterranean vertebrate or invertebrate fauna. Consequently, there is little risk that contaminants contained in unit soils are entering the foodchain or otherwise exerting a deleterious impact on the surrounding ecosystem.

The potential risk for further contamination to groundwater underlying the unit is considered to be minimal. Hazardous VOA and SVOA constituents are predominantly concentrated in the upper soil profile of Pond 1 soils, which are generally fine-textured, and the regional climate is semiarid. RFI Phase II data demonstrates that metal constituents are immobilized in the upper few feet of the soil surface in Pond 1, and the very low leaching potential of these soils is further demonstrated by the failure of unit soil samples to yield TC exceedances for any metal constituents. Thus, with the inactivation and dewatering of Pond 1 in 1987, the potential for leaching of hazardous organic constituents to groundwater has been drastically reduced.

2.1.2 Groundwater

Groundwater monitoring in the vicinity of the evaporation ponds using monitoring wells constructed to RCRA specifications has been performed since 1986. Prior to that time several shallow wells were used to monitor for state required constituents. Constituent concentrations for organics, metals, and water chemistry inorganics were presented in the RFI Phase II report. Copies of these data are reproduced as Appendix C Table C-1 through C-4 and a summary of the more important findings are provided below.

Four monitor wells have been installed in the vicinity of Pond 1 at locations either downgradient or slightly off-gradient from the direction of groundwater flow. Three are shallow wells tapping the upper 10 ft. of saturated sediments while the remaining boring is a deeper well screened 32 to 41 ft. into the saturated zone at a depth of 39 to 48 ft. beneath the surface.

In the vicinity of the evaporation ponds, elevated levels of volatile organic constituents are found mainly south and downgradient of Pond 1. Monitor wells MW-3, 4, 6A and 6B had detectable levels of benzene, ethylbenzene, toluene, and xylene (BETX) volatiles, but benzene was the only constituent where samples exceeded the EPA MCL health based standard of 0.005 mg/l (ppm). The maximum benzene concentration was approximately 0.021 mg/l. Other than BETX, the only other volatile organics detected in the analyses were carbon disulfide and 2-butanone in one well (MW-6B). No identifiable semi-volatiles were detected in monitor wells surrounding Pond 1 at practical quantitation levels in the range of 0.025 to 0.030 mg/l.

Based on results obtained during the Phase I RFI, water samples were taken during the Phase II study for analysis of arsenic, chromium, lead and nickel. Samples for chromium, lead and nickel in the four monitor wells near Pond 1 were either not detected or found at levels less than EPA drinking water quality standards. Arsenic levels, as averaged from EPA method 7061 initial and verification analyses, ranged from 0.021 to 0.096 mg/l. These values exceeded the EPA drinking water standard of 0.05 mg/l in all but one well (MW-6B) in the vicinity of Pond 1, but were lower than the New Mexico ground water quality standard of 0.1 mg/l.

The analytical results of water quality sampling of the monitor wells must be evaluated in the overall context of groundwater quality in the vicinity of the ponds. As documented by U.S. Geological Survey (USGS) studies and reported in the RFI Phase II report, the area immediately adjacent to the Pecos River serves as a regional zone of groundwater discharge. Groundwater in an area from the river west to the Sacramento Mountains discharges upwards into the river and shallow alluvium adjacent to the channel. This effect was observed and documented during the Phase II work. Upward vertical gradients were recorded in paired monitor wells away from the immediate area of the ponds.

As water nears the surface, water quality markedly deteriorates due to the combined effect of evaporation of water and transpiration by water-loving phreatophytes entrenched along the river channel. Total dissolved solids (TDS)of the river as measured during the Phase II study exceed 5100 mg/l and the USGS has documented values greater than 10,000 mg/l at their Artesia gauging station. During the Phase II RFI, water quality measurements from four monitor wells adjacent to the river and upgradient from the ponds, including three wells on the opposite side of the river from the ponds, resulted in an average TDS exceeding 10,000 mg/l. Groundwater in the alluvium a short distance to the west is of slightly better quality. The average of the TDS of the evaporation pond windmill and the EPA-1 monitor well on the western edge of the shallow alluvium is greater than 4200 mg/l. However, even this water greatly exceeds the EPA recommended drinking water standard of 500 mg/l.

The exceedingly poor natural water quality in the alluvium immediately adjacent to the river and ponds prevents it from being used as a drinking water source for humans or even livestock. The Phase II study documented that groundwater movement downgradient from the ponds is southeastward and the final discharge zone is a marshy area overgrown with salt cedar near the U.S. Highway 82 crossing of the Pecos River.

2.2 Interim Corrective Measures

Since approximately Fall 1989, Navajo has been engaged in interim corrective actions to facilitate complete access to all portions of the unit and to initiate biodegradation of the hydrocarbon-contaminated surface soils. In order to desiccate and solidify heavy waste solid deposits located around the periphery of the unit, initial activities employed a trackhoe to undertake bulk turning and mixing of waste solids and soils across the entire unit. From Summer 1990 through Summer 1994, Pond 1 surface soils have been tractor-disced at a frequency of approximately once a month, with the precise timing of tillage events dependent on the availability of sufficient soil moisture to minimize wind-induced soil erosion.

3.0 ESTABLISHMENT OF THE CORRECTIVE MEASURES ALTERNATIVE

The following sections identify appropriate corrective measures objectives, and, on the basis of those objectives, identify the most appropriate corrective measures alternative.

3.1 Establishment of Corrective Measures Objectives

Pursuant to EPA guidance, facility specific objectives are to be proposed to the administrative authority for corrective action. These objectives shall be based on public health and environmental criteria, information gathered during the RFI, EPA guidance, and the requirements of any applicable Federal statutes and regulations.

As reported in the Phase II RFI and summarized previously in Section 2.1.2, impacts of any hazardous constituent releases from Pond 1 on groundwater having a current or potential use by humans, livestock, or for agricultural purposes are either non-existent or only minimal. This is due to the naturally occurring poor water quality documented in the area and the hydrogeologic conditions at the location of the ponds. Additionally, EPA has directed that additional investigation of groundwater quality be performed as part of this workplan and in the workplan recently submitted to Region VI.

Consequently, the corrective measures objectives to be established as part of this workplan are limited to addressing issues related to solid waste materials deposited in Pond 1 during active use and impacts on underlying soil materials.

3.1.1 Risk Evaluation of Pond Soil Sampling Data

The available soil analytical data for Pond 1 indicates that unit soils contain hydrocarbon contaminants including trace concentrations of VOA and SVOA organic constituents, as well as levels of several metal constituents significantly greater than background concentration values. The reported soil concentration values for organic and inorganic constituents indicate that the potential short and long-term risk to human health subsequent to direct exposure to unit soils is negligible.

Furthermore, potential environmental risk is further diminished by the remote location of the unit, approximately three miles east of the city of Artesia in an area dedicated to farming and open rangeland. Access to the facility is controlled by a network of fences and gates, and by the adjacent presence of the Pecos River.

Since organic hydrocarbon constituents present in Pond 1 soils will ultimately be degraded to simple nonhazardous carbon molecules, long-term environmental concerns associated with the unit are related to the persistence of elevated concentrations of arsenic, chromium, and lead in unit soils. Because Pond 1 is situated in a relatively remote agricultural setting, an appropriate assessment of overall environmental risk posed by elevated metal constituents would entail a comparison of unit soils to risk-based standards developed for an agricultural/forest setting.

3.1.2 Determination of Limiting Exposure Pathways

A reliable comparative source to assist in defining risk-based limits for soils occurring in an agricultural setting is found in the EPA document entitled Technical Support Document for Land Application of Sewage Sludge. The technical support document was developed to provide justification for the promulgation of the final rule regulating the beneficial land application of municipal sewage sludge (40 CFR Part 503).

The EPA technical support effort entailed a comprehensive review of existing scientific data concerning the environmental effects of ten metal constituents. The data was assessed, summarized, and then used to model the concentration-related risk levels posed by the constituents in the context of 14 agricultural and non-agricultural environmental exposure pathways. Risk-based pollutant limits were established for each constituent of concern at the level of the lowest risk-based number for any of the evaluated pathways.

In order to model the effects of the metal constituents in sewage sludge applications to land, EPA defined assumed values for soil mass and depth of sludge incorporation in order to obtain concentration-based exposure values (see Section 5.1.2.5.3 of the Technical Support Document). For the three Pond 1 metal constituents of concern, Table 3-1 presents the Part 503 risk-based pollutant limits and most limiting pathway that were used to establish each limit value. Employing the assumptions for depth of sludge incorporation and total soil mass specified by EPA in the Part 503 technical support document, Table 3-1 also presents calculated concentration-based soil values used by EPA in the establishment of the risk-based sludge application limits for these constituents.

As shown in Table 3-1, the average soil concentration values obtained for arsenic, chromium, and lead during the Pond 1 RFI Phase II are well below the derived soil concentration limits for those constituents. A single Pond 1 soil sample obtained during the Phase II RFI from the one-foot sample depth yielded a concentration value in excess of the Part 503 limit for lead. However, the overall average concentration value for lead in Pond 1 soils was well below the Part 503 limit (Table 3-1).

It is acknowledged that the soil contaminant profile for Pond 1 soils exhibits significant differences from the sludge application scenario employed by EPA for its development of the Part 503 soil standards. For instance, Part 503 rules assume an approximate soil mixing depth for incorporated sludges of approximately 6 in. In contrast, elevated metal concentrations in Pond 1 soils occur from the soil surface to a depth extending somewhere between 1 to 3 ft. below soil surface. However, as discussed below, the comparison of Pond 1 soils with the Part 503 sludge standards is appropriate and meaningful.

Table 3-1. Comparison Of Part 503 Risk-Based Pollutant Limits, Limiting Pathways, And Derived Concentration-Based Limits With Pond 1 Soil Metal Concentrations

Table 3-1. Comparision of Part 503 risk-based pollutant limits, limiting pathways, and derived concentration-based limits with Pond 1 soil metal concentrations

Constituent	Range/Average for Pond 1 soils (mg/kg)(1)	Primary Limiting Exposure Pathway and Risk-Based Limit	Derived Concentration Limit - Primary Exposure Pathway	Secondary Limiting Exposure Pathway and Risk-Based Limit	Derived Concentration Limit - Secondary Exposure Pathway
Arsenic	1.6-39.9 / 23.5	Sludge to child via oral ingestion 41 kg/ha (2)	41 mg/kg	Sludge to groundwater to human via drinking, 1200 kg/ha (3)	600 mg/kg
Chromium	32-1011 / 386	Phytotoxicity 3000kg/ha (3)	1500 mg/kg	Sludge to groundwater to human via drinking, 12000 kg/ha (3)	6000 mg/kg
Lead	9-389 / 112	Sludge to child via oral ingestion 300 kg/ha (2)	300 mg/kg	Sludge to livestock via oral ingestion, 1200 kg/ha (2)	1200 mg/kg

(1) RFI Phase II soils data for 1 ft sample depth
(2) kg constituent per 1 X 06 kg dry wt sludge, as specified in Part 503 Tech. Supp. Doc., p. 6-2.
(3) kg constituent per 2 X 06 kg soil, as specified in Part 503 Tech. Supp. Doc., p. 5-19

For arsenic and lead, the Part 503 limiting risk-based exposure pathway is based on direct oral ingestion of contaminated soils. Therefore, the Part 503 risk assessment conducted for this exposure pathway is independent of the depth to which soils have been impacted.

The second most-limiting pathway for arsenic under the Part 503 rules is based on human ingestion of contaminated groundwater obtained from a well located immediately at the unit boundary. Based on a 6-in. sludge incorporation interval in surface soils, EPA has determined that an arsenic loading limit no greater than 1200 kg/ha is necessary to protect a generic shallow groundwater source underlying agricultural soils subjected to sludge applications. The risk-based limit for this pathway established by EPA employed extremely conservative assumptions regarding the environmental setting: soil texture, in both the vadose zone and underlying saturated zone was assumed to consist of pure sand; and the water table under a site to which sewage sludge was applied was not greater than 1 meter from the treated surface.

In contrast to the 6-in. incorporation depth specified for arsenic in the Part 503 regulations, Pond 1 soil arsenic levels in excess of background concentrations may exist between 1 to 3 ft. below the soil surface. However, when the Part 503 soil-groundwater-human pathway limit is converted to a soil concentration-based value, the average arsenic concentration in Pond 1 soils (39 mg/kg) is approximately fifteen times less than the specified Part 503 limit for that pathway (600 mg/kg). Furthermore, the Pond 1 soil environment is far less conducive to subsurface contaminant leaching than the soil scenario modeled by EPA for the Part 503 regulations for that pathway. Pond 1 soils possess considerable clay content, as well as a depth to water table that is approximately four to five times greater than that used for the Part 503 assessment.

For lead, the second most-limiting exposure pathway under the Part 503 rules is based on livestock consumption of sludge adhering to forage crops and/or sludge on the soil surface. For the conservative assumptions used by EPA in developing a risk-based limit for this pathway, EPA has determined that a soil concentration-based limit of 1200 mg/kg is appropriate for lead. As was the case for the child sludge ingestion exposure pathway for lead, criteria for the livestock consumption pathway are independent of the depth to which the lead contaminant extends into the soil profile. Therefore, the comparison of Pond 1 soils with the Part 503 standards for these two most limiting lead exposure pathways would appear to remain valid.

For chromium, the limiting Part 503 exposure pathway is based on toxic effects to plant life. The Part 503 risk assessment conducted for this pathway may be sensitive to variations in total contaminant depth in soils, since it was largely based on field-test data of surface-applied sludge, and a major metal toxicity avoidance mechanism for plants involves establishment of adequate root mass beneath metal-contaminated surface soils. However, when the Part 503 phytotoxicity pathway limit for chromium is converted to a soil concentration-based value, the average chromium concentration in Pond 1 soils (386 mg/kg) is approximately four times less than the phytotoxicity limit established under the

Part 503 regulations (1500 mg/kg). The second most limiting exposure pathway for chromium under the Part 503 regulations is based on human ingestion of contaminated groundwater obtained from a well located immediately at the unit boundary. The risk-based limit for that pathway is equivalent to a total soil concentration of 6000 mg/kg, which again was based on the assumption of sandy vadose zone and saturated soils, and a one-meter depth to groundwater.

3.1.3 Selection of Corrective Measures Objectives

In consideration of the environmental setting of the unit and the nature and magnitude of contaminants currently present at the site, it is concluded that appropriate corrective measures objectives should include the remediation of surface soils at the unit to the extent necessary to further reduce the concentration of bulk hydrocarbon contamination and trace levels of hazardous organic constituents. Specifically, soil hydrocarbon content should be reduced to the extent necessary to establish a permanent vegetative cover in keeping with the original native environment.

In general, vegetation can be established and maintained in soils possessing oil and grease concentrations of 1% or less. However, in order to ensure both the successful establishment of a permanent vegetative cover and further reduction in the concentration levels of hazardous organic constituents, a target remediation goal of 1000 mg/kg total petroleum hydrocarbons (TPH), equivalent to a 0.1% oil and grease concentration, is hereby proposed for the Pond 1 soils. The proposed remediation standard would be applicable from the unit surface to the water table.

Navajo notes that, in the course of numerous discussions and correspondence with EPA Region 6 personnel, the agency has indicated that they consider Pond 1 to be a potentially suitable repository for hydrocarbon-impacted subsurface soils presently contained within the confines of the former Three-Mile Ditch unit. Based on preliminary observations, the RFI Phase II report estimated that Pond 1 placement of hydrocarbon-contaminated soils excavated from the ditch would add at least 1.5 ft. to the elevation of Pond 1. Three-Mile Ditch is the subject of continuing investigation, so that issues related to that unit have yet to be resolved. At this time, the possibility remains that Pond 1 soils may eventually be overlain by soil materials derived from the ditch. The proposed target remediation goal of 1000 mg/kg is considered to be a protective clean-up standard under either of the two site management scenarios discussed above (unit closure and re-vegetation versus receipt of additional soil materials prior to closure).

3.2 Identification of Corrective Measures Alternative

As discussed in Section 3.1, the proposed corrective measures objectives for Pond 1 are intended to reduce soil hydrocarbon concentrations to levels that will permit the establishment of a permanent vegetative cover over the unit in keeping with the original native environment. The proposed target remediation goal of 1000 mg/kg TPH for Pond 1 soils will also ensure that residual hazardous organic constituents are further reduced to the point of non-detection or otherwise sufficiently low to ensure the protection of human health and the environment.

Since no immediate threat to human health and the environment has been identified in association with the contaminants present in Pond 1 soils, excavation and offsite removal of the hydrocarbon contaminated soils is not warranted. Therefore, off-site remediation and/or disposal options for Pond 1 soils are not considered further in this document.

Various on-site remediation technologies appropriate for the treatment of the hydrocarbon-contaminated soils, such as thermal desorption or incineration, would achieve an adequate remediation of hydrocarbon-contaminated soils in Pond 1 in the minimum possible amount of time. However, such alternative options would be highly intensive in terms of planning, design, testing, and energy and cost expenditures. Therefore, use of such technology-intensive remediation methods is not considered consistent with the overall level of environmental risk presently posed by unit soils.

In view of the low overall level of environmental risk posed by the unit, it is concluded that traditional land treatment bioremediation technology will afford the most appropriate and cost-effective means to remediate Pond 1 soils. Land treatment is a proven bioremediation method that produces consistent and reliable results requiring low-technology equipment and a relatively simple level of expertise.

Based on knowledge of the soil contaminant profile in Pond 1 and experience with the interim corrective actions previously undertaken at the unit, it is anticipated that bioremediation of the unit to the target clean-up standard of 1000 mg/kg TPH can be completed in approximately two years. Although more technology-intensive remediation approaches may potentially accomplish the same remediation objectives in a shorter time frame, Navajo believes that should such an alternative corrective measures approach be pursued, corrective action implementation would require significant amounts of additional time for evaluation, logistics, planning, and testing.

In contrast, should approval be granted for the proposed bioremediation program described in Section 4.0 of this document, Navajo has the capability to promptly initiate corrective measures activities. Consequently, disparities between land treatment versus other technologies in terms of the rate at which unit remediation would proceed will be greatly diminished, due to the fact that Navajo possesses a high level of preparedness to proceed with the proposed corrective measures land treatment alternative.

4.0 PRELIMINARY DETAILS OF CORRECTIVE MEASURE DESIGN, OPERATION AND MANAGEMENT

The following sections present preliminary descriptions of the bioremediation program for Pond 1 soils. Section 4.1 describes the general remediation strategy. Section 4.2 describes the basic features of the land treatment operation and environmental monitoring. Installation and testing of a new deep groundwater monitoring well and environmental monitoring of new and existing wells adjacent to the unit are detailed in Section 4.3. Documentation and reporting requirements for the corrective measures program are discussed in Section 4.4.

4.1 General Remediation Strategy

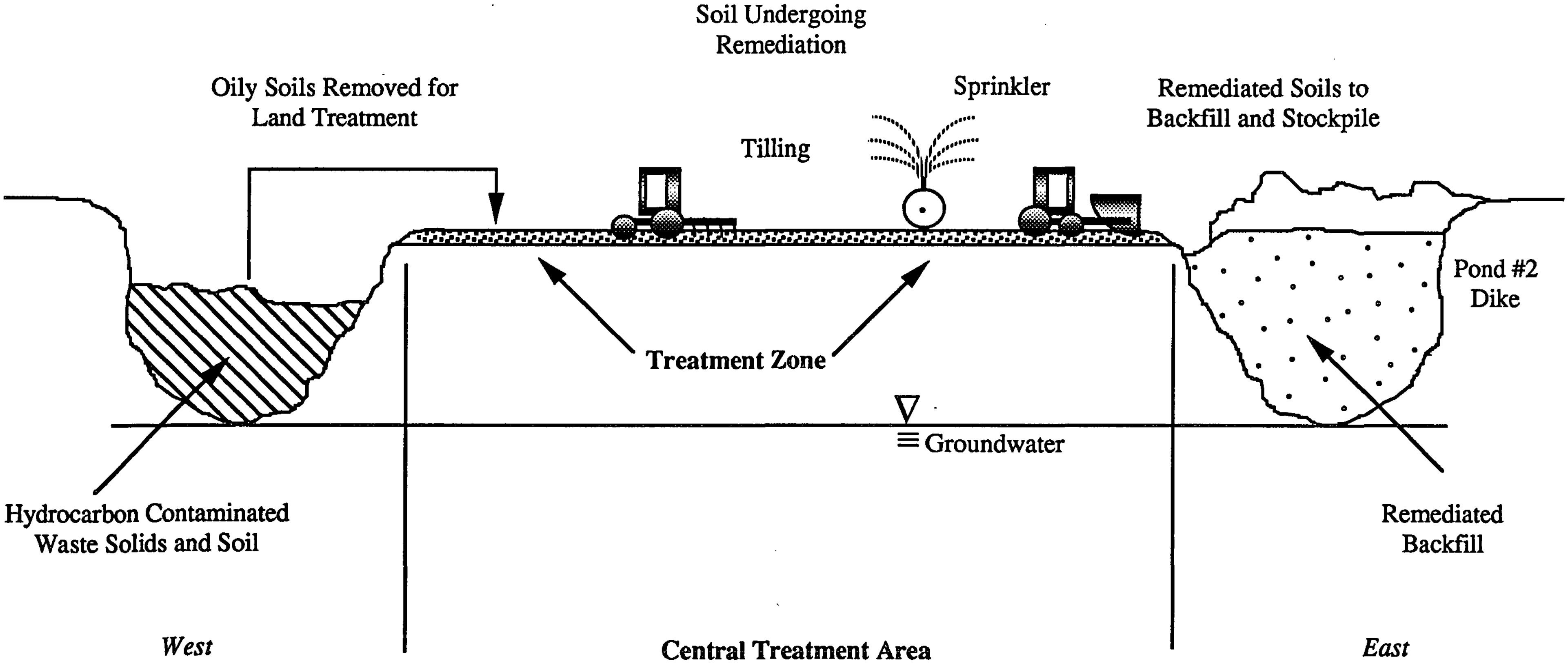
The general strategy of the proposed bioremediation program is presented in Figure 4-1. Based on knowledge of existing site conditions, the middle of the unit is largely underlain by a relatively shallow layer of hydrocarbon contamination, generally not exceeding a maximum depth of 3 ft. This central area is estimated to encompass at least 10 to 12 acres of the 15 total acres of the unit. At the eastern end of the unit, immediately adjacent to the dike dividing Pond 1 from Pond 2, an initial excavation of all hydrocarbon-contaminated soils will be conducted with the depth of excavation not too exceed the depth of groundwater. The excavated area will subsequently be used as an interim stockpile area for remediated soils, as described below. The excavated soils will be surface applied across the remainder of the unit, and standard land treatment methods, including tillage, soil amendment applications and irrigation will be initiated..

When surface soils have been remediated to target clean-up levels, the treated soils will be scraped from the treatment area for backfill of the excavation, and remediation begun on the next lower segment of soils, if contaminated. When the initial excavation area has been backfilled, treated soils will be scraped from the treatment area and deposited in the designated eastern stockpile area. As this treat-and-peel process proceeds, the treated soils will be deposited above the backfill area to an elevation slightly below the level of the existing dike separating Pond 1 from Pond 2. Contaminated soils in the treatment area will be remediated, removed and stockpiled in a process that gradually extends westwards across the Pond 1 area until sufficient volumes of soils have been removed to reveal a clean base for a delineated central treatment area.

As stated above, it is expected that a large central area of the unit will exhibit relatively uniform, shallow hydrocarbon contamination. When the treat-and-peel process has achieved a "clean" soil base in the central area of the unit, this area will be delineated as the final treatment area. Excavation work will then proceed around the unit periphery, as well as those areas extending out from the narrow western end of the unit, where hydrocarbon-contaminated soils are known to extend to greatest depth. Contaminated soils from periphery areas will gradually be excavated and applied to the central treatment

Figure 4-1. Schematic Diagram of Proposed Pond 1 Biotreatment Program

Figure 4-1. Schematic Diagram of Proposed Pond 1 Biotreatment Program.



area. At no time will the volume of excavated soils placed on the active treatment area exceed a total applied depth of 8 in. Excavation, treatment, and subsequent backfilling of these deep peripheral soils will continue until all unit soils extending from the surface to groundwater have been remediated to the target clean-up standard.

Prior to the completion of remediation activities at the unit, Navajo will submit a unit closure plan to EPA Region 6, which will include a description of final soil verification sampling and establishment of a final vegetative cover, unless, as discussed previously, the unit is designated for additional duty as a bioremediation cell for receipt and treatment of hydrocarbon-impacted soils from the Three-Mile Ditch.

4.2 Unit Management, Operations and Monitoring

At the initiation of remediation operations, surface soils will be evaluated for physical and chemical parameters relevant to their capacity to sustain microbial biodegradation. Soil tests will be conducted to ascertain the nutrient and salt status of the soils, and on the basis of the test results, soil amendments will be applied to the soil as needed to establish optimal chemical conditions for biodegradation of hydrocarbon materials.

An irrigation system will be installed at the unit to maintain adequate soil moisture necessary to sustain optimum microbial populations in treatment zone soils to a depth of approximately 8 to 12 in. The applied irrigation water will be withdrawn from active Evaporation Pond 5, with irrigation treatments being applied as needed to keep treatment zone soils moist.

Unit soils will be tilled twice a month to a depth of approximately 8 to 12 in., except for periods when wetter soil conditions deny access to tractors and equipment.

All personnel engaged in corrective measures activities will report to the Navajo project manager prior to, and at the completion of all site activities associated with the corrective measures program. A standard reporting form will be used to record and track all site activities. At a minimum, the following activities will be recorded:

- Date of initiation of all excavation activities;
- Total soil volume removed from each excavation sector;
- Date and extent of tillage events;
- Date of application, type, and quantities of soil amendments; and,
- Date and volume of irrigation applications.

Prior to backfilling of excavated areas, soil samples collected from areas where treated surface soils are to be scraped from the treatment area will be tested for TPH concentrations to ensure that target remediation goals have been achieved.

4.3 Groundwater Monitoring

The following sections describe additional investigation plans for groundwater adjacent to inactive evaporation Pond 1. The format shown below essentially follows that presented in Section 4.1.3 of the July 1994 RFI Phase III Workplan for Three-Mile Ditch and the Active Evaporation Ponds submitted to EPA Region VI.

The groundwater investigation in the vicinity of Pond 1 will include the following activities:

- Measurement of water levels in shallow and deep paired monitor well MW-6A and MW-6B;
- Sampling of shallow and deep monitor wells adjacent to Pond 1 to update and verify constituent concentrations found in the Phase II study;
- Sampling of the pond windmill;
- Installation of a deep monitor well (in addition to the two proposed in the Phase III Workplan) in the vicinity of MW-4 to delineate vertical extent of contamination at depths greater than 50 ft., if any, and to provide hydrogeologic baseline information on deeper water zones;
- Performing borehole aquifer tests on the new monitor well to determine *in situ* hydraulic conductivity, and;
- Collection of water quality samples from the new monitor well.

4.3.1 Pond 1 Field Work 1

Static water level measurements will be obtained from MW-6, the shallow and deep paired monitor wells adjacent to Pond 1. The measurements will be taken with an electric tape to update and verify the vertical hydraulic gradient. This information will be collected concurrently with the RFI Phase III Field Work 1 activity described in that workplan. Procedures for obtaining static water levels are included in Section 4.2.2.1 of the RFI Phase III Workplan.

Wells selected for sampling (Table 4-1) will be purged and water samples collected pursuant to EPA RCRA guidance. A description of these procedures is presented in RFI Phase III Workplan Section 4.2.3. This work will be performed concurrently with the Phase III Workplan activities to provide for efficient use of staff.

Table 4-1. Basic Elements of the Proposed Groundwater Sampling for Evaporation Pond 1

Field Work 1
(to be performed concurrently with RFI Phase III Field Work 1 activities)

- Water level elevations of paired monitor wells 6A and 6B.
- Groundwater sampling of deep and shallow monitor wells MW 3, 4, 6, and the pond windmill. Constituents to be sampled are:
  - Field Parameters: pH, temperature, specific electrical conductance
  - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
  - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
  - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
  - Water chemistry: As needed to characterize aquifer water quality

Field Work 2
(to be performed concurrently with RFI Phase III Field Work 2 activities)

- Water level elevations of paired monitor wells 6A and 6B.
- Groundwater sampling of the new deep well installed at locations MW-4 or alternate location between MW-3 and MW-4. Constituents to be sampled are:
  - Field Parameters: pH, temperature, specific electrical conductance
  - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
  - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
  - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
  - Water chemistry: Sampling of new wells to characterize aquifer water quality.

Chemical analyses will focus on verifying constituents detected in earlier sampling and determining changes in concentrations in metals and BTEX volatile organics. Metal constituents of concern include arsenic, chromium, lead and nickel. For comparison purposes, filtered and unfiltered samples will be collected for metals determination in wells having or suspected of having turbidity problems. Filtered samples will be filtered in the field using a 0.45 micron filter before sample preservation. Quality assurance procedures to be used in collection and preservation of samples are discussed in RFI Phase III Workplan Section 4.2.3. Table 4-1 also shows the constituents that are to be analyzed for the verification sampling.

4.3.2 Pond 1 Field Work 2

In addition to the two additional monitor wells proposed to be installed at locations MW-5 and OCD-7, a third well is proposed that would be located in the vicinity of MW-4. However, the exact location of this well must await completion of negotiations with the landowner(s). EPA is currently assisting in this effort by making direct contact with the landowner or his representative. If negotiations are unsuccessful, the location of the well will be moved north to Navajo property and the well will be located on a line between MW-3 and MW-4. If at all possible, monitor well installation at Pond 1 will occur at the time of installation of the other two monitor wells.

The new Pond 1 deep well is expected to be screened for a length of 10 ft. at a depth approximately 15 ft. beneath the base of MW-4 or about 33 from the land surface. Therefore the total depth of this well is expected to be about 43 ft. However, exact depth and screened interval will be determined in the field based on boring lithology. If discrete lithologic intervals are found and are separated by a confining layer, the deep well will be screened opposite the first transmissive zone beneath the confining layer. If no confining layer is found, the well will be screened in a transmissive zone 15 ft. beneath the base of MW-4.

Construction details for the proposed monitor wells are provided in RFI Phase III Workplan Section 4.2.1. Construction of deep wells will include installation of a surface casing through the upper zones to prevent cross-contamination of sediments and groundwater, and to prevent short-circuiting of flow that can influence vertical hydraulic gradient measurements. Borehole *in situ* permeability tests (slug tests) will be performed on the two newly installed monitor wells as described in RFI Phase III Workplan Section 4.2.2.2.

The newly installed monitoring wells, plus the existing paired monitor wells sampled during Field Work 1, will be measured using an electric or steel tape to obtain static water level measurements for verification of vertical hydraulic gradient. Prior to mapping water level measurements, elevations of the new paired monitor wells will be verified by a land survey using a registered professional surveyor. Procedures for obtaining static water levels and groundwater samples are included in Sections 4.2.2.1 and 4.2.3 of the RFI

Phase III Workplan, respectively. Constituents to be sampled in new wells are shown above in Table 4-1.

4.3.3 Additional Groundwater Monitoring

Groundwater monitoring is currently being performed in the area of the evaporation ponds pursuant to a schedule authorized by the NMOCD as a condition of ground water discharge plan approval. This monitoring will be continued at least through the time that Pond 1 is undergoing soils remediation with the possible addition of several constituents to monitor impacts, if any, of remediation activities on groundwater. Final decisions involving water quality constituent monitoring and frequency will be detailed in the final Corrective Measures Implementation Workplan document required to be submitted to EPA prior to initiating the remediation actions proposed in this document. Decisions involving long term monitoring of groundwater in the area of the evaporation ponds must await resolution of the larger issues of wastewater disposal location and active evaporation pond decommissioning which are under discussion between Navajo and the EPA.

4.4 Corrective Measures Documentation and Reporting

Within 15 months of the initiation of the Pond 1 Corrective Measures Program an initial report will be submitted to EPA Region 6 which will include documentation and presentation of all corrective measures activities and environmental monitoring data. Thereafter, subsequent annual reports will be submitted until unit soils are fully remediated. As stated previously, Navajo anticipates that, subsequent to the initiation of the Corrective Measures Program for Pond 1, remediation of unit soils can be completed in approximately two years.

5.0 REFERENCES

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APPENDIX A

POND 1 RFI PHASE II
SOILS DATA

Table A-1. RFI Phase II soil sampling, Evaporation Pond 1 — oil and grease and volatile organic compounds (mg/kg).

Sample	Sample depth (ft)	Oil and grease (%)	Acetone	Benzene	Ethyl-benzene	Methylene chloride	Toluene	Xylenes (total)
EP-TR-001-01	1	8.27	0.387	0.03	0.443	< 0.028	0.622	2.05
EP-TR-001-02	3	1.11	0.437	< 0.034	0.128	< 0.034	0.082	0.484
EP-TR-001-03	6	0.4	0.295	< 0.025	0.052	< 0.025	0.032	0.159
EP-TR-001-04	9	0.06	0.176	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-001-05	13	< 0.05	< 0.012	< 0.006	< 0.006	0.014	< 0.006	< 0.006
EP-TR-002-01	1	18.49	< 0.391	< 0.196	0.59	< 0.196	0.376	1.57
EP-TR-002-02 [b]	3	0.96	0.442	< 0.007	0.488	< 0.007	0.083	1270
EP-TR-002-03 [c]	6	0.08	0.556	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-002-04	9	0.08	0.043	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
EP-TR-002-05	13	< 0.05	< 0.014	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-01	1	7.05	< 0.061	< 0.031	< 0.031	< 0.031	< 0.031	0.264
EP-TR-003-02	3	< 0.05	0.228	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-03	3 (duplicate)	0.26	0.189	< 0.007	< 0.007	0.015	< 0.007	< 0.007
EP-TR-003-04	6	0.05	< 0.014	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-003-05	11	<0.05	0.033	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-004-01	1	16.07	< 0.314	< 0.157	0.332	< 0.157	< 0.157	< 0.157
EP-TR-004-02	3	0.10	0.079	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-004-03	6	< 0.05	0.184	< 0.034	< 0.034	< 0.034	< 0.034	< 0.034
EP-TR-004-04	9	< 0.05	< 0.012	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-005-01	1	0.19	< 0.012	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
EP-TR-005-02	3	0.11	0.264	< 0.007	< 0.007	<7	< 0.007	< 0.007
EP-TR-005-03	6	0.13	0.235	< 0.007	< 0.007	91	< 0.007	< 0.007
EP-TR-005-04	9	0.10	0.172	< 0.006	< 0.006	0.122	< 0.006	< 0.006
EP-TR-006-01	1	12.56	< 0.263	< 0.132	< 0.132	< 0.132	0.147	< 0.132
EP-TR-006-02	3	0.12	0.7	< 0.032	< 0.032	0.147	< 0.032	< 0.032
EP-TR-006-03	6	0.05	0.054	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
EP-TR-006-04	9	< 0.05	0.028	< 0.006	< 0.006	0.008	< 0.006	< 0.006
EP-TR-006-05	0-1	18.61	< 4.320	< 2.160	2.34	< 2.160	3.06	6.51

a = Trackhoe bucket grab sample of pond surface sludges adjacent to trench EP-TR-006.
b = 2-butanone (0.127 mg/kg) and carbon disulfide (0.033 mg/kg) also detected.
c = 2-butanone (146 mg/kg) also detected.

Table A-2. RFI Phase II soil sampling, Evaporation Pond — pH, electrical conductivity, and total metals concentrations (mg/kg).

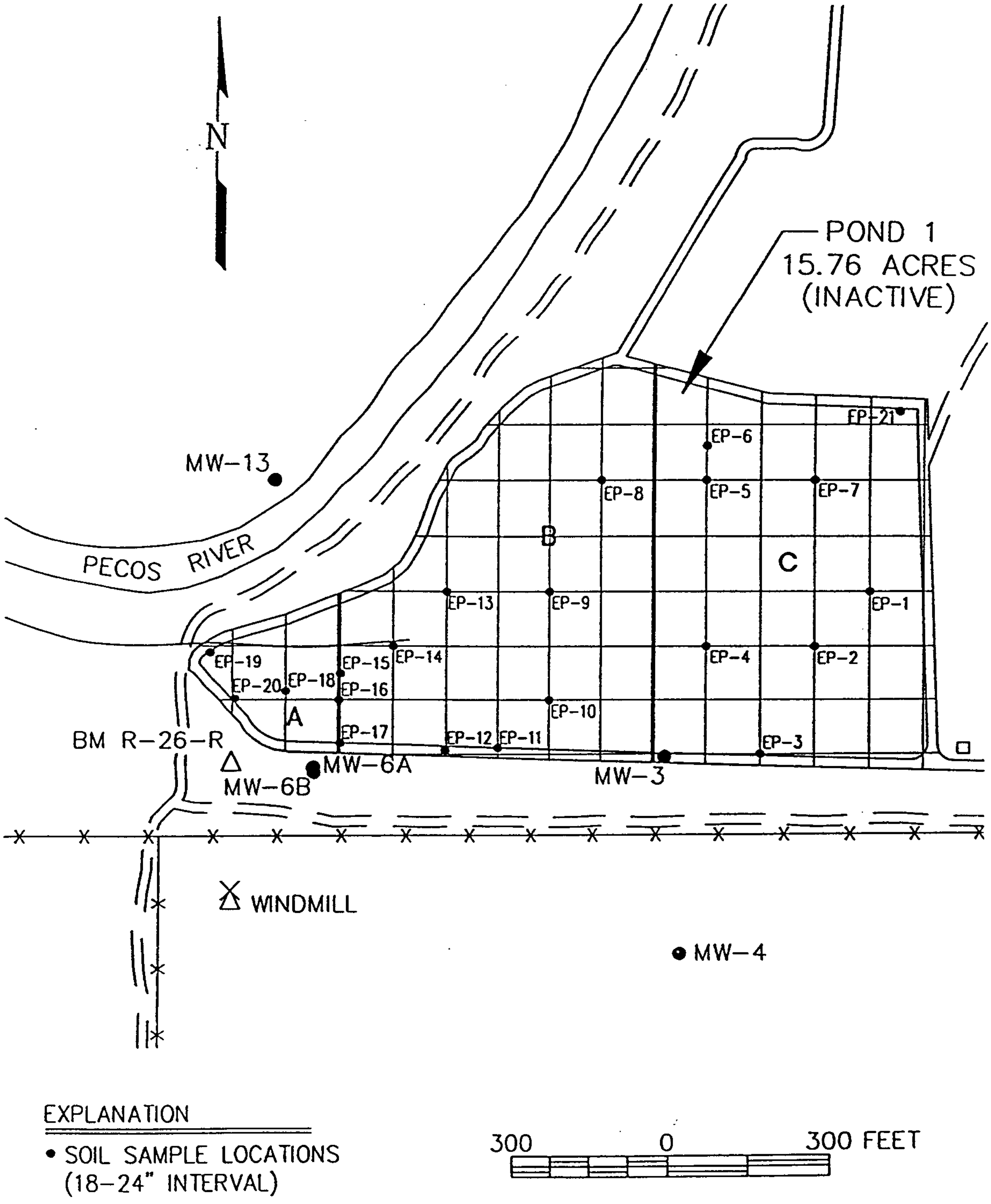
Sample	Sample depth (ft)	pH	Electrical conductivity (mmhos/cm)	Arsenic	Chromium	Lead	Nickel	Zinc
EP-TR-001-01	1	8.5	2.9	26.1	74	389	21	54
EP-TR-001-02	3	8.5	4.9	3.9	29	17	26	64
EP-TR-001-03	6	7.5	6.4	7.6	17	7	24	44
EP-TR-001-04	9	7.6	5.0	2.2	16	4	23	25
EP-TR-001-05	13	8.1	2.6	2.4	16	1	20	36
EP-TR-002-01	1	8.3	3.6	38.6	1011	93	37	303
EP-TR-002-02	3	8.8	2.8	1.8	19	10	21	49
EP-TR-002-03	6	7.5	6.1	8.6	17	6	24	41
EP-TR-002-04	9	7.9	5.3	4	16	5	28	37
EP-TR-002-05	13	7.9	5.3	9.9	16	6	31	42
EP-TR-003-01	1	8.1	3.1	22.6	633	73	14	434
EP-TR-003-02	3	7.8	5.8	9.1	30	14	23	57
EP-TR-003-03	3 (duplicate)	7.7	6.5	10.3	26	12	22	55
EP-TR-003-04	6	7.7	5.0	7.1	24	7	14	53
EP-TR-003-05	11	7.7	4.0	3.3	20	6	10	32
EP-TR-004-01	1	8.2	8.0	19.7	398	28	12	194
EP-TR-004-02	3	9.1	3.3	1.4	14	4	7	21
EP-TR-004-03	6	9.5	2.7	8.7	34	14	22	73
EP-TR-004-04	9	8.2	1.9	3.1	9	3	5	37
EP-TR-005-01	1	7.6	6.6	1.6	32	9	14	40
EP-TR-005-02	3	8.5	6.4	1.5	19	7	13	33
EP-TR-005-03	6	9.4	4.2	3.9	25	11	18	48
EP-TR-005-04	9	8.7	5.1	11.6	26	8	14	38
EP-TR-006-01	1	7.7	7.0	39.9	235	153	37	161
EP-TR-006-02	3	9.1	3.9	2.4	29	9	13	63
EP-TR-006-03	6	7.6	6.3	6.5	18	4	10	31
EP-TR-006-04	9	8.7	2.6	2.2	12	7	10	31
EP-TR-006-05 [a]	1	8.6	6.0	16.1	320	36	14	320

a = Trackhoe bucket grab sample of pond surface sludges adjacent to trench EP-TR-006.

APPENDIX B

POND 1 SOILS TPH DATA

(November 1993)



RE/SPEC INC.
RESEARCH SPECIALISTS

Pond 1 soil sample locations,
TPH sampling, November 1993.

Navajo

PROJECT: 622093004-110 (POND1)	
LOCATION: ARTESIA, NEW MEXICO	
APPR:	DATE: 11/23/93
DRAWN BY: RMO	SCALE AS SHOWN
DATE: 11/23/93	FIGURE: B-1

Table B-1. Pond 1 soil TPH concnetrations: 1.5 - 2.0 ft
(November 1993 sample event).

Location	TPH (mg/kg)	pH
EP-1	<10	
EP-2	32	
EP-3	1970	8.4
EP-4	59	
EP-5	25600	
EP-6	48300	8.6
EP-7	32400	
EP-8	2890	
EP-9	21000	8.2
EP-10	2940	
EP-11	33500	
EP-12	105000	9.0
EP-13	81700	
EP-14	2940	
EP-15	51100	8.7
EP-16	58200	
EP-17	41100	
EP-18	33600	7.4
EP-19	27900	
EP-20	110000	
EP-21	99400	
AVG.	**38982**	**8.4**

APPENDIX C

POND 1 RFI PHASE II GROUNDWATER DATA

Table C-1. Volatile organic compounds detected during field sampling, Evaporation Pond area, Navajo Refinery, RFI Phase II.

Well ID	Laboratory	Date sampled	Acetone		Benzene		2-Butanone (MEK)		Carbon disulfide		Ethylbenzene		Methylene chloride		Toluene		Xylenes (total)	
			Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)	Result (mg/L)	PQL (mg/L)
Evaporation Pond	C922424	11/20/92	0.092	0.010	0.043	0.005			0.032	0.005	0.016	0.005			0.061	0.005	0.045	0.005
MW-03	C922322	11/12/92			0.017	0.005					0.016	0.005			0.021	0.005	0.025	0.005
MW-04	C922333	11/12/92			0.021	0.005					0.019	0.005			0.009	0.005	0.032	0.005
MW-05A(Field Duplicate)	C922335	11/11/92			0.013	0.005					0.006	0.005			0.028	0.005	0.008	0.005
MW-06A	C922323	11/12/92									0.007	0.005			0.006	0.005	0.014	0.005
MW-06B	C930278	1/30/93			0.009	0.005	0.048	0.010	0.117	0.005					0.006	0.005		
MW-12	C922658	12/18/92											0.007	0.005				
MW-14	C922655	12/17/92											0.020	0.005				
OCD-7B	C930279	1/30/93			0.009	0.005												
Windmill	C922656	12/17/92											0.010	0.005				

PQL = Practical quantitation limit.

Table C-2. Semivolatile organic compounds detected during field sampling, Evaporation pond area, Navajo Refinery, RFI Phase II.

Well ID	Laboratory number	Date sampled	B2EP		DNBP		DM24	
			Result (µg/L)	PQL (µg/L)	Result (µg/L)	PQL (µg/L)	Result (µg/L)	PQL (µg/L)
MW-2B	C922653	12/16/92	28	25				
MW-14	C922655	12/17/92			66	25		
MW-14 (Field Dup)	C922654	12/17/92			78	25		
MW-20	C930223	1/26/93			27	25		
OCD-8B	C930203	1/23/93	35	25				
OCD-8B (Field Dup)	C930204	1/23/93	21	20				
Evaporation Pond	C922424	11/20/92					180	50

PQL = Practical Quantitative Limit
B2EP = bis(2-Ethylhexyl)phthalate
DNBP = Di-n-butyl phthalate
DM24 = 2,4-Dimethylphenol
MN1 = 1-Methylnaphthalene
MN2 = 2-Methylnaphthalene
NAPH = Naphthalene

Table C-3 . Results of metals analyses, Evaporation Ponds, Navajo Refinery, RFI Phase II.

Well sample identification	Laboratory number	Date samples	TAS[a]	TAS[b]	TAS[c]	DAS[d]	TCR[e]	DCR[f]	TPB[g]	DPB[h]	TNI[i]	TNI[j]	DNI[k]	pH	EC[l]
NEP-GW-EPA-1	C922391/15722	18-Nov-92	ND	ND		ND	ND	ND	ND	ND	0.08	ND	0.06	7.2	5340
NEP-GW-MW-01-01	C922278/15632	10-Nov-92	0.02	0.023	0.01	ND	3.65	ND	ND	ND	0.35	0.22	0.2	7.5	14900
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92	0.022			ND	3.62	ND	ND	ND	0.34		0.18	7.5	14900
NEP-GW-MW-02A	C922280/15633	10-Nov-92	0.087	0.117	0.09	0.073	0.1	ND	ND	ND	0.12	ND	0.1	7.4	11300
NEP-GW-MW-02B	C922653/16029	16-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.04		ND	7.4	3430
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92	ND			ND	ND	ND	ND	ND	0.03		ND	7.4	3430
NEP-GW-MW-03	C922322/15647	12-Nov-92	0.078	0.096		0.054	0.03	ND	ND	ND	0.12	0.04	0.08	7.3	7220
NEP-GW-MW-04	C922333/15644	12-Nov-92	0.08	0.112	0.136	0.069	ND	ND	ND	ND	0.11	ND	0.07	7.3	7610
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92	0.085			0.071	ND	ND	ND	ND	0.09		0.07	7.3	7620
NEP-GW-MW-05A	C922334/15645	11-Nov-92	0.074	0.089		0.063	0.03	ND	ND	ND	0.27	0.12	0.25	7.2	28000
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92	0.077			0.062	0.02	ND	ND	ND	0.26		0.26	7.2	28100
NEP-GW-MW-05B	C930136/W00059	22-Jan-93	0.131	0.15	0.162	0.106	ND	ND	ND	ND	ND		ND	7.1	9310
NEP-GW-MW-06A	C922323/15648	12-Nov-92	0.065			0.03	0.05	ND	ND	ND	0.11	0.04	0.04	7.4	4950
NEP-GW-MW-06B	C930278/W00344	30-Jan-93	0.021	0.02		0.016	ND	ND	ND	ND	ND		ND	11.9	6410
NEP-GW-MW-07A	C922281/15634	11-Nov-92	0.038	0.037	0.05	0.03	0.07	ND	ND	ND	0.13	ND	0.09	7.2	13900
NEP-GW-MW-07B	C930106/W00056	21-Jan-93	0.014	0.013	0.016	0.011	ND	ND	ND	ND	ND		ND	7.5	10700
NEP-GW-MW-10	C922390/15721	18-Nov-92	0.011	0.011		0.007	0.02	ND	ND	ND	0.09		0.07	7.2	6190
NEP-GW-MW-11A	C922567/15975	12-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.19		0.18	7.1	23700
NEP-GW-MW-11B	C930205/W00184	23-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		ND	7.3	20500
NEP-GW-MW-12	C922658/16033	18-Dec-92	ND	ND		ND	0.02	ND	ND	ND	0.05		ND	7.2	18700
NEP-GW-MW-13	C922659/16034	18-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.03		ND	7.5	5180
NEP-GW-MW-14	C922655/16031	17-Dec-92	0.012	0.012		0.01	ND	ND	ND	ND	0.04		ND	7.4	11200
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-92	0.01			0.007	0.02	ND	ND	ND	0.03		ND	7.3	10900
TMD-GW-MW-15	C930105/W00055	20-Jan-93	0.01	0.006		0.006	0.03	ND	ND	ND	ND		ND	7.5	3590
NEP-GW-MW-17	C930209/W00189	26-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		0.01	7.7	2600
NEP-GW-MW-18A	C930207/W00187	25-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.03		0.01	7.3	16400
NEP-GW-MW-18B	C930602/W01466	11-Mar-93	ND	ND			0.02		ND		ND			7.7	4650
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-93	ND				0.02		ND		ND			7.7	4640
NEP-GW-MW-19	C930208/W00188	26-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.01		ND	7.6	7280
NEP-GW-MW-22A	C930282/W00347	29-Jan-93	0.013	0.013		0.011	ND	ND	ND	ND	ND		ND	7.4	5750
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93	0.014			0.011	ND	ND	ND	ND	0.02		ND	7.4	5790
NEP-GW-MW-22B	C930283/W00348	29-Jan-93	0.007	0.008		0.005	ND	ND	ND	ND	0.01		0.01	7.1	6180
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93	0.008			0.005	ND	ND	ND	ND	ND		ND	7.1	6180
NEP-GW-MW-23	C930229/W00271	28-Jan-93	0.007	0.008		0.006	ND	ND	ND	ND	ND		ND	7.2	15900
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93	0.007			0.006	ND	ND	ND	ND	ND		ND	7.2	15900
NEP-GW-MW-24	C930281/W00346	28-Jan-93	ND	ND		ND	ND	ND	ND	ND	ND		ND	7.3	16300
NEP-GW-OCD-1	C922324/15649	13-Nov-92	0.097	0.115	0.154	0.071	0.06	ND	0.03	ND	0.16	0.05	0.11	7.2	14200
NEP-GW-OCD-2A	C922357/15669	15-Nov-92	0.067	0.084		0.043	0.04	ND	ND	ND	0.15	ND	0.12	7	15400
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93	0.007	0.005	0.018	0.006	ND	ND	ND	ND	0.01		ND	7.3	14700
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92	0.069			0.043	0.04	ND	ND	ND	0.14		0.13	7	15400
NEP-GW-OCD-3	C922358/15670	16-Nov-92	0.021	0.022		ND	0.19	ND	0.06	ND	0.28	0.09	0.12	7.1	17300
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92	0.015	0.017		0.005	ND	ND	ND	ND	0.15		0.11	7.2	19000

Table C-3 . Continued.

Well sample identification	Laboratory number	Date samples	TAS ^{a}	TAS ^{b}	TAS ^{c}	DAS ^{d}	TCR ^{e}	DCR ^{f}	TPB ^{g}	DPB ^{h}	TNI ^{i}	TNI ^{j}	DNI ^{k}	pH	EC ^{l}
NEP-GW-OCD-5	C922399/15728	16-Nov-92	0.008	0.008		0.007	ND	ND	ND	ND	0.13	ND	0.12	7.2	17800
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92	0.009			0.008	ND	ND	ND	ND	0.12		0.12	7.2	17900
NEP-GW-OCD-5 (Dup of Fld D)	C922394/15731	17-Nov-92	0.008			0.007	ND	ND	ND	ND	0.13		0.12	7.2	17900
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92	0.036	0.048		0.028	ND	ND	ND	ND	0.14	ND	0.13	7.1	14500
NEP-GW-OCD-7 (Fld Blank)	C922395/15725	18-Nov-92	ND				ND		ND		0.04				
NEP-GW-OCD-7A	C922389/15720	18-Nov-92	0.021	0.023		0.012	0.02	ND	ND	ND	0.15		0.13	7.3	13300
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93	0.175			0.154	0.02	ND	ND	ND	0.02		0.02	7.3	10500
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93	0.005	0.005		ND	ND	ND	ND	ND	0.01		ND	7.6	6110
NEP-GW-OCD-8A	C922393/15723	17-Nov-92	0.032	0.037		0.019	ND	ND	ND	ND	0.12	ND	0.11	7	12400
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93	ND	ND		ND	ND	ND	ND	ND	0.02		ND	7.3	7490
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93	ND			ND	ND	ND	ND	ND	0.03		0.01	7.7	7270
Pecos River at OCD 7	C922425/W01464	20-Nov-92												7.3	7080
NEP-Windmill	C922656/16032	17-Dec-92	ND	ND		ND	ND	ND	ND	ND	0.02		ND	7.4	6610
Evaporation Pond at OCD-7	C922424/15745/W01463	20-Nov-92	0.167				ND		ND		0.06			7.6	10900

Key	Test description/method	Detection limits
a	Total arsenic — Method 7061	0.005
b	Total arsenic — Method 7061 — Verification	0.005
c	Total arsenic — Method 7060 — Verification	0.005
d	Dissolved arsenic — Method 701	0.01
e	Total chromium — Method 7191	0.02
f	Dissolved chromium — Method 7191	0.02
g	Total lead — Method 7421	0.02
h	Dissolved lead — Method 7421	0.02
i	Total nickel — Method 7520	0.01
j	Total nickel — Method 7520 — verification	0.05
k	Dissolved nickel — Method 7520	0.01
l	Electrical conductivity, μmhos/cm at 25 ° C	

ND = Not detected.

Standards	EPA Drinking Water (mg/L)	NMWQCC Groundwater
As	0.05	0.1
Cr	0.1	0.5
Pb	0.015 (Action level)	0.05
Ni	0.1	0.2 (irrigation)

Table C-4. Results of inorganic water quality analyses, Evaporation Pond, Navajo Refinery, RFI Phase II.

Well sample ID	Laboratory no.	Date sampled	Detection level Units	pH (Laboratory) 0.1 (s.u.)	Electrical Conductivity at 25°C (Laboratory) 1 (µmhos/cm)	Total dissolved solids at 180°C 1 (mg/L)	Total calcium 1 (mg/L)	Total alkalinity 1 (mg/L)	Total hardness 1 (mg/L)	Flouride 0.1 (mg/L)	Calcium 1 (mg/L)	Calcium (meq/L)	Magnesium 1 (mg/L)	Magnesium (meq/L)	Potassium 1 (mg/L)	Potassium (meq/L)
NEP-GW-EPA-1	C922391/15722	18-Nov-92		7.2	5340	3750	3670	167	1960	0.8	495	24.70	176	14.47	7.1	0.18
NEP-GW-MW-01-01	C922278/15632	10-Nov-92		7.5	14900	11200	10500	406	3880	1.1	764	38.12	480	39.47	14.0	0.36
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92		7.5	14900	11300	NA	408	NA	1.1	769	NA	480	NA	16.0	NA
NEP-GW-MW-02A	C922280/15633	10-Nov-92		7.4	11300	8430	8430	523	1980	9.9	573	28.59	134	11.02	14.0	0.36
NEP-GW-MW-02B	C922653/16029	16-Dec-93		7.4	3430	2500	2320	160	1220	1.2	304	15.17	112	9.21	20.0	0.51
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92		7.4	3430	2540	NA	160	NA	1.2	300	NA	112	NA	18.0	NA
NEP-GW-MW-03	C922322/15647	11-Nov-92		7.3	7220	5310	4570	285	1630	3.0	457	22.80	119	9.79	12.0	0.31
NEP-GW-MW-04	C922333/15644	12-Nov-92		7.3	7610	5360	5080	234	1410	1.8	370	18.46	119	9.79	5.5	0.15
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92		7.3	7620	5360	NA	233	NA	1.8	376	NA	121	NA	5.0	NA
NEP-GW-MW-05A	C922334/15645	11-Nov-92		7.2	28000	24300	22300	423	5650	3.3	585	29.19	1020	83.88	9.0	0.23
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92		7.2	28100	24400	22200	427	5640	3.3	579	28.89	1020	83.88	9.3	0.23
NEP-GW-MW-05B	C930136/W00059	22-Jan-93		7.1	9310	7350	7160	328	2460	1.5	650	32.44	204	16.78	13.0	0.33
NEP-GW-MW-06A	C922323/15648	12-Nov-92		7.4	4950	3540	3300	136	1090	2.7	282	14.07	93	7.65	3.5	0.10
NEP-GW-MW-06B	C930278/W00344	30-Jan-93		11.9	6410	3800	3660	428	1620	0.4	648	32.34	1	0.08	27.0	0.69
NEP-GW-MW-07A	C922281/15634	11-Nov-92		7.2	13900	11500	11000	302	2780	1.4	471	23.50	389	31.99	12.0	0.31
NEP-GW-MW-07B	C930106/W00056	21-Jan-93		7.5	10700	9220	7980	293	1670	1.4	547	27.30	74	6.09	14.0	0.36
NEP-GW-MW-10	C922390/15721	18-Nov-92		7.2	6190	4400	4380	223	1340	1.1	417	20.81	72	5.92	7.4	0.18
NEP-GW-MW-11A	C922567/15975	12-Dec-92		7.1	23700	16100	15200	331	3980	1.0	964	48.10	384	31.58	31.0	0.79
NEP-GW-MW-11B	C930205/W00184	23-Jan-93		7.3	20500	14000	13600	217	5950	0.9	961	47.95	317	26.07	41.0	1.05
NEP-GW-MW-12	C922658/16033	18-Dec-92		7.2	18700	13500	12400	358	4470	1.1	788	39.32	608	50.00	19.0	0.49
NEP-GW-MW-13	C922659/16034	18-Dec-92		7.5	5180	3630	3370	254	1340	0.7	352	17.56	112	9.21	17.0	0.43
NEP-GW-MW-14	C922655/16031	17-Dec-93		7.4	11200	8230	7780	405	2320	1.0	456	22.75	288	23.68	18.0	0.46
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-93		7.3	10900	7890	7550	396	2260	1.0	444	22.16	280	23.03	21.0	0.54
TMD-GW-MW-15	C930105/W00055	20-Jan-93		7.5	3590	2790	2670	150	1190	1.1	308	15.37	102	8.39	11.0	0.28
NEP-GW-MW-17	C930209/W00189	26-Jan-93		7.7	2600	2230	2020	121	1370	1.1	387	19.31	99	8.14	13.0	0.33
NEP-GW-MW-18A	C930207/W00187	25-Jan-93		7.3	16400	12600	11900	286	4530	1.6	721	35.98	664	54.61	30.0	0.77
NEP-GW-MW-18B	C930602/W01466	11-Mar-93		7.7	4650	3710	3550	164	2110	1.1	588	29.34	157	12.91	17.0	0.43
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-94		7.7	4640	3710	NA	164	NA	1.1	577	NA	154	NA	16.0	NA
NEP-GW-MW-19	C930208/W00188	26-Jan-93		7.6	7280	5720	5150	210	2790	0.9	745	37.18	226	18.59	10.0	0.26
NEP-GW-MW-22A	C930282/W00347	29-Jan-93		7.4	5750	4410	4220	159	1520	1.5	421	21.01	114	9.38	6.0	0.15
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93		7.4	5790	4400	4290	159	1560	1.5	434	21.66	117	9.62	7.0	0.18
NEP-GW-MW-22B	C930283/W00348	29-Jan-93		7.1	6180	4700	4510	213	1720	1.0	461	23.00	139	11.43	4.0	0.10
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93		7.1	6180	4720	NA	212	NA	1.0	464	NA	139	NA	5.0	NA
NEP-GW-MW-23	C930229/W00271	28-Jan-93		7.2	15900	11700	10500	349	3890	0.8	988	49.30	347	28.54	14.0	0.36
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93		7.2	15900	11700	NA	349	NA	0.8	986	NA	342	NA	14.0	NA
NEP-GW-MW-24	C930281/W00346	28-Jan-93		7.3	16300	11600	10786	242	2951	1.0	787	39.27	240	19.74	38.0	0.97
NEP-GW-OCD-1	C922324/15649	13-Nov-92		7.2	14200	10300	8570	526	1860	5.7	487	24.30	156	12.83	7.2	0.18
NEP-GW-OCD-2A	C922357/15669	15-Nov-92		7.0	15400	11800	10900	404	2780	1.2	565	28.19	333	27.38	8.1	0.20
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92		7.0	15400	11700	NA	394	NA	1.2	567	NA	313	NA	9.0	NA
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93		7.3	14700	11600	11100	408	4140	0.9	844	42.12	494	40.63	13.0	0.33
NEP-GW-OCD-3	C922358/15670	16-Nov-92		7.1	17300	11600	10300	281	3340	0.9	922	46.01	268	22.04	29.0	0.74
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92		7.2	19000	13100	11800	197	2790	0.9	724	36.13	240	19.74	50.0	1.28
NEP-GW-OCD-5	C922399/15728	16-Nov-92		7.2	17800	12400	12000	199	3070	1.0	847	42.27	232	19.08	37.0	0.95
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92		7.2	17900	12400	11900	202	3050	1.0	846	42.22	228	18.75	36.0	0.92
NEP-GW-OCD-5 (LabDup of Fld D)	C922394/15731	17-Nov-92		7.2	17900	12400	NA	205	NA	1.0	849	NA	225	NA	36.0	NA
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92		7.1	14500	10900	10400	495	2550	2.9	675	33.68	210	17.27	15.0	0.38
NEP-GW-OCD-7A	C922389/15720	18-Nov-92		7.3	13300	10300	9570	564	2670	4.1	620	30.94	274	22.53	8.5	0.23
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93		7.3	10500	8350	7940	511	2390	6.6	652	32.53	186	15.30	14.0	0.36
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93		7.6	6110	5060	4840	141	1850	1.2	547	27.30	117	9.62	10.0	0.26
NEP-GW-OCD-8A	C922393/15723	17-Nov-92		7.0	12400	9670	9050	434	2850	2.5	633	31.59	308	25.33	11.0	0.28
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93		7.3	7490	5400	5240	164	2930	0.9	834	41.62	207	17.02	12.0	0.31
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93		7.7	7270	5270	5130	163	2840	0.9	807	40.27	202	16.61	14.0	0.36
NEP-Navajo Effluent	C930367/W00731	11-Feb-93		8.9	9300	7348	4840	829	279	151.0	21	1.05	55	4.52	22.0	0.56
Evaporation Pond at OCD 7	C922424/15745	16-Nov-92		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Evaporation Pond at OCD 7	C922424/15745/W01463	16-Nov-92		7.6	10900	7080	6620	534	354	36.3	46	2.30	58	4.77	67.0	1.31
NEP-Windmill	C922656/16032	17-Dec-92		7.4	6610	4740	4450	163	1530	1.1	316	15.77	180	14.80	14.0	0.36
Pecos River at OCD 7	C922425/W01464	16-Nov-92		7.3	7080	5110	4735	165	2190	0.9	571	28.49	186	15.30	13.0	0.33

Table C-4. Continued.

Well sample ID	Laboratory no.	Date sampled	Detection level Units	Sodium	Sodium	HCO_3	HCO_3	CO_3	CO_3	OH	OH	Chloride	Chloride	SO_4	SO_4	Cation sum	Anion sum	Percent difference
				1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	1 (mg/L)	(meq/L)	(meq)	(meq)	(%)
NEP-GW-EPA-1	C922391/15722	18-Nov-92		480	20.88	204	3.34	0	0.00	0	0.00	989	27.90	1420	29.56	60.23	60.80	-0.47
NEP-GW-MW-01-01	C922278/15632	10-Nov-92		2130	92.65	495	8.11	0	0.00	0	0.00	3750	105.78	3020	62.88	170.60	176.77	-1.78
NEP-GW-MW-01-01 (Lab Dup)	C922278/15635	10-Nov-92		2130	NA	NA	NA	NA	NA	NA	NA	3740	NA	3010	NA	NA	NA	NA
NEP-GW-MW-02A	C922280/15633	10-Nov-92		2170	94.39	638	10.46	0	0.00	0	0.00	2120	59.8	3180	66.21	134.36	134.47	-0.78
NEP-GW-MW-02B	C922653/16029	16-Dec-93		268	11.66	195	3.20	0	0.00	0	0.00	497	14.02	1020	21.24	36.55	38.46	-2.55
NEP-GW-MW-02B (Lab Dup)	C922653/16036	16-Dec-92		268	NA	NA	NA	NA	NA	NA	NA	498	NA	1020	NA	NA	NA	NA
NEP-GW-MW-03	C922322/15647	11-Nov-92		975	42.41	348	5.70	0	0.00	0	0.00	1820	51.34	1020	21.24	75.31	78.28	-1.93
NEP-GW-MW-04	C922333/15644	12-Nov-92		1180	51.33	285	4.67	0	0.00	0	0.00	1380	38.93	1880	39.14	79.73	82.74	-1.85
NEP-GW-MW-04 (Lab Dup)	C922333/15651	12-Nov-92		1170	NA	NA	NA	NA	NA	NA	NA	1410	NA	1870	NA	NA	NA	NA
NEP-GW-MW-05A	C922334/15645	11-Nov-92		5250	228.36	516	8.46	0	0.00	0	0.00	5410	152.61	9770	203.41	341.66	364.48	-3.23
NEP-GW-MW-05A (Fld Dup)	C922335/15646	11-Nov-92		5150	224.01	520	8.52	0	0.00	0	0.00	5470	154.30	9740	202.79	337.01	365.61	-4.07
NEP-GW-MW-05B	C930136/W00059	22-Jan-93		1600	69.60	400	6.56	0	0.00	0	0.00	1760	49.65	2730	56.84	119.15	113.05	2.63
NEP-GW-MW-06A	C922323/15648	12-Nov-92		700	30.45	166	2.72	0	0.00	0	0.00	654	18.45	1490	31.02	52.27	52.19	0.08
NEP-GW-MW-06B	C930278/W00344	30-Jan-93		574	24.97	0	0.00	37	1.22	125	7.33	968	27.31	1180	24.57	58.08	60.43	-1.98
NEP-GW-MW-07A	C922281/15634	11-Nov-92		2930	127.45	368	6.03	0	0.00	0	0.00	2750	77.57	4260	88.69	183.25	172.29	3.08
NEP-GW-MW-07B	C930106/W00056	21-Jan-93		1990	86.56	357	5.85	0	0.00	0	0.00	1880	53.03	3300	68.71	120.31	127.59	-2.94
NEP-GW-MW-10	C922390/15721	18-Nov-92		970	42.19	272	4.46	0	0.00	0	0.00	982	27.70	1800	37.48	69.10	69.64	-0.39
NEP-GW-MW-11A	C922567/15975	12-Dec-92		3860	167.90	404	6.62	0	0.00	0	0.00	7108	200.51	2610	54.34	248.37	261.47	-2.57
NEP-GW-MW-11B	C930205/W00184	23-Jan-93		3410	148.33	265	4.34	0	0.00	0	0.00	5950	167.84	2790	58.09	223.40	230.27	-1.51
NEP-GW-MW-12	C922658/16033	18-Dec-92		2560	111.35	437	7.16	0	0.00	0	0.00	4980	140.48	3250	67.67	201.16	215.31	-3.40
NEP-GW-MW-13	C922659/16034	18-Dec-92		596	25.92	310	5.08	0	0.00	0	0.00	914	25.78	1230	25.61	53.12	56.47	-3.06
NEP-GW-MW-14	C922655/16031	17-Dec-93		1720	74.82	493	8.08	0	0.00	0	0.00	2150	60.65	2900	60.38	121.71	129.11	-2.95
NEP-GW-MW-14 (Fld Dup)	C922654/16030	17-Dec-93		1650	71.77	483	7.92	0	0.00	0	0.00	2080	58.67	2830	58.92	117.50	125.51	-3.30
TMD-GW-MW-15	C930105/W00055	20-Jan-93		447	19.44	182	2.98	0	0.00	0	0.00	564	15.91	1150	23.94	43.48	42.83	0.75
NEP-GW-MW-17	C930209/W00189	26-Jan-93		109	4.74	147	2.41	0	0.00	0	0.00	122	3.44	1220	25.40	32.52	31.25	1.99
NEP-GW-MW-18A	C930207/W00187	25-Jan-93		2420	105.26	348	5.70	0	0.00	0	0.00	3930	110.86	3950	82.24	196.62	198.80	-0.55
NEP-GW-MW-18B	C930602/W01466	11-Mar-93		356	15.48	200	3.28	0	0.00	0	0.00	661	18.65	1670	34.77	58.16	56.70	1.27
NEP-GW-MW-18B (Lab Dup)	C930602/W1467	11-Mar-94		353	NA	NA	NA	NA	NA	NA	NA	668	NA	1690	NA	NA	NA	NA
NEP-GW-MW-19	C930208/W00188	26-Jan-93		718	31.23	256	4.20	0	0.00	0	0.00	1370	38.65	1950	40.60	87.26	83.45	2.23
NEP-GW-MW-22A	C930282/W00347	29-Jan-93		799	34.75	193	3.16	0	0.00	0	0.00	835	23.55	1950	40.60	65.29	67.31	-1.52
NEP-GW-MW-22A (Fld Dup)	C930284/W00349	29-Jan-93		809	35.19	193	3.16	0	0.00	0	0.00	844	23.81	1990	41.43	66.65	68.40	-1.30
NEP-GW-MW-22B	C930283/W00348	29-Jan-93		830	36.10	259	4.25	0	0.00	0	0.00	983	27.73	1970	41.02	70.63	73.00	-1.65
NEP-GW-MW-22B (Lab Dup)	C930283/W00351	29-Jan-93		827	NA	NA	NA	NA	NA	NA	NA	983	NA	1950	NA	NA	NA	NA
NEP-GW-MW-23	C930229/W00271	28-Jan-93		2180	94.82	425	6.97	0	0.00	0	0.00	4240	119.61	2570	53.51	173.02	180.09	-2.00
NEP-GW-MW-23 (Lab Dup)	C930229/W00274	28-Jan-93		2160	NA	NA	NA	NA	NA	NA	NA	4260	NA	2660	NA	NA	NA	NA
NEP-GW-MW-24	C930281/W00346	28-Jan-93		2500	108.74	295	4.84	0	0.00	0	0.00	4170	117.63	2910	60.59	168.72	183.06	-4.08
NEP-GW-OCD-1	C922324/15649	13-Nov-92		2230	97.00	642	10.52	0	0.00	0	0.00	1930	54.44	3450	71.83	134.31	136.79	-0.91
NEP-GW-OCD-2A	C922357/15669	15-Nov-92		2510	109.18	493	8.08	0	0.00	0	0.00	3220	90.83	3990	83.07	164.95	181.98	-4.91
NEP-GW-OCD-2A (Lab Dup)	C922357/15673	15-Nov-92		2600	NA	NA	NA	NA	NA	NA	NA	3200	NA	3980	NA	NA	NA	NA
NEP-GW-OCD-2B	C930134/W00057	21-Jan-93		2320	100.91	498	8.16	0	0.00	0	0.00	3710	104.65	3450	71.83	183.99	184.64	-0.18
NEP-GW-OCD-3	C922358/15670	16-Nov-92		2330	101.35	281	4.61	0	0.00	0	0.00	4130	116.50	2520	52.47	170.14	173.58	-1.00
NEP-GW-OCD-4-1	C922398/15727	16-Nov-92		3120	135.71	240	3.93	0	0.00	0	0.00	4500	126.94	3010	62.67	192.86	193.54	-0.18
NEP-GW-OCD-5	C922399/15728	16-Nov-92		3030	131.80	243	3.98	0	0.00	0	0.00	4720	133.15	2980	62.04	194.10	199.17	-1.29
NEP-GW-OCD-5 (Fld Dup)	C922394/15724	17-Nov-92		2930	127.45	246	4.03	0	0.00	0	0.00	4760	134.27	3000	62.46	189.34	200.76	-2.93
NEP-GW-OCD-5 (LabDup of Fld D)	C922394/15731	17-Nov-92		2970	NA	NA	NA	NA	NA	NA	NA	4780	NA	2990	NA	NA	NA	NA
NEP-GW-OCD-6-1	C922400/15729	16-Nov-92		2550	110.92	603	9.89	0	0.00	0	0.00	3000	84.63	3670	76.41	162.25	170.93	-2.61
NEP-GW-OCD-7A	C922389/15720	18-Nov-92		2120	92.21	687	11.26	0	0.00	0	0.00	2480	69.96	3730	77.66	145.91	158.88	-4.26
NEP-GW-OCD-7A R	C930104/W00054	19-Jan-93		1950	84.82	623	10.21	0	0.00	0	0.00	2040	57.55	2800	58.30	133.01	126.06	2.68
NEP-GW-OCD-7B	C930279/W00345	30-Jan-93		813	35.36	172	2.82	0	0.00	0	0.00	690	19.46	2570	53.51	72.54	75.79	-2.19
NEP-GW-OCD-8A	C922393/15723	17-Nov-92		1930	83.95	529	8.67	0	0.00	0	0.00	2290	64.60	3620	75.37	141.15	148.64	-2.58
NEP-GW-OCD-8B	C930203/W00182	23-Jan-93		651	28.32	200	3.28	0	0.00	0	0.00	1630	45.98	1810	37.68	87.27	86.94	0.19
NEP-GW-OCD-8B (Fld Dup)	C930204/W00183	23-Jan-93		628	27.32	199	3.26	0	0.00	0	0.00	1580	44.57	1800	37.48	84.56	85.31	-0.44
NEP-Navajo Effluent	C930367/W00731	11-Feb-93		1290	56.11	1011	16.57	0	0.00	0	0.00	1920	54.16	1034	21.53	62.24	92.26	-19.43
Evaporation Pond at OCD 7	C922424/15745	16-Nov-92		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Evaporation Pond at OCD 7	C922424/15745/W01463	16-Nov-92		2000	86.99	651	10.67	0	0.00	0	0.00	2180	61.50	1950	40.60	95.77	112.77	-8.15
NEP-Windmill	C922656/16032	17-Dec-92		872	37.93	199	3.26	0	0.00	0	0.00	1190	33.57	1780	37.06	68.86	73.89	-3.52
Pecos River at OCD 7	C922425/W01464	16-Nov-92		733	31.88	201	3.30	0	0.00	0	0.00	1470	41.47	1660	34.56	76.00	79.32	-2.14

RFI PHASE III WORKPLAN
THREE-MILE DITCH AND
EVAPORATION PONDS
(Draft)

prepared for

Navajo Refinery Company
Artesia, New Mexico

July 1994

by

RE/SPEC INC.
RESEARCH SPECIALISTS

TELEPHONE
(505) 748-3311

EASYLINK
62905278

Navajo **REFINING COMPANY**

501 EAST MAIN STREET • P. O. BOX 159
ARTESIA, NEW MEXICO 88211-0159

FAX
(505) 746-6410 ACCTG
(505) 746-6155 EXEC
(505) 748-9077 ENGR
(505) 746-4438 P / L

July 31, 1994

Mr. Allyn M. Davis, Director
Hazardous Waste Management Division (6H)
U.S. Environmental Protection Agency, Region VI
1445 Ross Ave., Suite 1200
Dallas, Texas 75202-2733

Re: Transmittal of RFI Phase III Workplan, Three-Mile Ditch and Evaporation Ponds, Navajo Refinery, Artesia, New Mexico, July 1994.

Dear Mr. Davis:

Enclosed please find the RCRA Facility Investigation (RFI) Phase III workplan for the above-referenced Solid Waste Management Unit. The workplan is provided as required in your letter dated May 19, 1994. The workplan details the additional groundwater monitoring proposed at the active evaporation ponds and along Three-Mile Ditch (TMD), and sediment and water quality sampling of the Pecos River.

In your letter of May 19, EPA offered Navajo the option of using an "excavation approach" in the RFI submittal in which Navajo would remove all ditch sediments for further treatment and disposal. Navajo believes it is premature to commit to this option at this time.

Based on the combined findings of the RFI phase I and II investigations, Navajo had previously concluded that contaminated media contained in the TMD unit posed no significant risk to human health and the environment, including the groundwater, and that no detrimental evidence was found to warrant the excavation of the ditch. This conclusion was based on facts that are summarized in the workplan introduction.

However, Navajo also recognizes that elevated levels of hazardous constituents have been detected in some areas of the ditch although TCLP testing did not show the potential for leaching at levels which would exceed toxicity characteristic thresholds. Although groundwater sampling conducted to date does not show exceedences in groundwater parameters caused by releases from the ditch, we agree that additional groundwater monitoring will assist Navajo technical staff in determining what sections of the ditch, if any, need to be considered for excavation.

Therefore, we have proposed additional groundwater monitoring in close proximity to those areas where previous trenching did not determine the extent of visibly contaminated sediments, or where sediments are in contact or close proximity to groundwater. This monitoring will also better define the localized direction of groundwater flow in the vicinity of the ditch, which was expressed as a concern by EPA staff.

If you have any questions, please do not hesitate to contact me or David Griffin, Superintendent of Environmental Affairs, at (505) 748-3311.

Sincerely,

for Matthew P. Clifton
Senior Vice President

MPC/te

encl.

RFI PHASE III WORKPLAN
THREE-MILE DITCH AND
EVAPORATION PONDS
(Draft)

prepared for

Navajo Refinery Company
Artesia, New Mexico

by

RE/SPEC, Inc.
4775 Indian School Road, NE #300
Albuquerque, New Mexico 87110

July 1994

David G. Boyer
David G. Boyer
Project Manager

Brian P. Sullivan
Brian P. Sullivan
Assistant Project Manager

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1.0 INTRODUCTION

Navajo Refining Company (Navajo) operates a petroleum refinery located in Artesia, New Mexico (EPA I.D. No. NMD 048918817). The facility is regulated under the Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments of 1984. At the time that the U.S. Environmental Protection Agency (EPA) conducted a preliminary review (PR) of the facility, certain facility areas were identified as solid waste management units. Among these were:

- A wastewater conveyance unit known as Three-Mile Ditch (TMD) and,
- The facility evaporation pond system, consisting of now inactive surface impoundments known as Evaporation Pond 1 and Evaporation Pond 2 (CEPs), which formerly received wastewater conveyed by the ditch, and a series of interconnected active evaporation ponds (AEPs), which currently receive facility wastewater conveyed via an underground pipeline.

EPA subsequently determined that a RCRA Facility Investigation (RFI) was required for these SWMUs. As a result, TMD and the AEPs were the subject of RFI Phase I and Phase II investigations. As stated in May 19, 1994 correspondence from EPA to Navajo, EPA is now requiring that a RFI Phase III investigation be executed for these units.

1.1 Goals of the RFI Phase III Investigation

This Phase III workplan is designed to address unresolved issues associated with the TMD, AEPs, and their surrounding environment.

With the exception of a general directive by EPA to further address the issue of groundwater flow along TMD, additional RFI Phase III investigative requirements for TMD were not specified. However, as discussed below, the existing record of the RFI process for TMD indicates that EPA's primary concern is the environmental status of groundwater in the near-surface saturated water zone in the vicinity of the unit. Based on this consideration, this workplan describes an investigative strategy intended to address EPA's concerns regarding the likelihood that hydrocarbon-contaminated soils contained within TMD may provide an ongoing source for the release of hazardous constituents to near-surface groundwater in the vicinity of the unit.

Based on the combined findings of the RFI Phase I and II investigations, Navajo has previously concluded that contaminated media contained in the unit posed no significant risk to human health and the environment, and that no evidence was available to warrant the excavation of the ditch. This conclusion was based on the following facts and observations:

- The contaminated soils residing in the unit are overlain by several feet of clean soils. Under current conditions, the materials do not pose a threat to human health or the environment on the basis of a direct contact scenario;

- Short of deliberate excavation activities that directly follow the course of the ditch, no realistic scenario can be envisioned whereby extensive segments of the residual contaminants might become exposed to the surface environment;

- Even in the unlikely event that all or a large portion of the contaminated media were to become exposed to the surface environment, the remote location and the extremely narrow and elongated configuration of the unit do not lend themselves to any reasonable scenario in which continuous, long-term exposure could be anticipated;

- TCLP evaluation of contaminated soil samples obtained from the ditch failed to yield any exceedances for TC-regulated metals or organic constituents;

- Although it is extremely likely that releases of hazardous constituents to the near-surface saturated zone underlying the unit occurred during the approximately 60-year operational life of the unit, current evidence of widespread groundwater contamination in the vicinity of the unit resulting from the release of hazardous constituents has not been documented. Thus, no evidence has been obtained to suggest an ongoing release to groundwater from the unit is occurring;

- The near-surface saturated zone in the vicinity of Three-Mile Ditch is too discontinuous to provide a potentially usable water source, and the quality of this limited groundwater is poor due to excessive levels of total dissolved solids (TDS); and,

- A comprehensive comparison of groundwater water quality parameters undertaken during the Phase II RFI provided no indication that the near-surface saturated zone was hydrologically connected with deeper groundwater zones in the vicinity of the ditch. However, even if the near surface water zone were interconnected with the most proximal deep groundwater zone, no evidence has been obtained to indicate that the near-surface zone contains hazardous constituents at concentrations that could reasonably be expected to impact groundwater quality in the next deeper groundwater zone.

On the basis of these findings, Navajo believes that excavation of hydrocarbon-contaminated soils from the unit is not warranted. Furthermore, Navajo also believes that excavation of the unit would, in fact, be more likely to result in a greater risk to human health and the environment than would leaving the contaminants in place.

Navajo's primary conclusions, that the ditch essentially posed no threat to human health and the environment, and that hydrocarbon-contaminated soils within the ditch were best left in place, were disputed by EPA. In their technical review of the RFI Phase II report, the EPA reviewer(s) repeatedly expressed their opinion that the waste materials present in the unit posed the potential for an ongoing release of hazardous constituents to groundwater in the near-surface water zone.

The hydrocarbon-impacted soils in the unit have now been characterized by two RFI investigations. Further sample collection and analyses and observations of soils within the unit are unlikely to provide additional information regarding the potential for contaminated soils to leach waste constituents into groundwater. As a result, the proposed Phase III investigative activities for TMD described in this workplan are designed to address EPA concerns in the most direct manner possible, by providing further characterization of groundwater located in the near-surface saturated zone in the vicinity of the unit.

As stated previously, Three-Mile Ditch was, until recent years, in continuous operation for nearly 60 years. Based on a historic consideration of refinery waste management methods and technology, and increasingly stringent environmental regulations, it can be assumed that the unit formerly managed the most concentrated waste burden in its earlier years of operation, with wastewater quality progressively improving over time. Further, the unit has now been inactive for approximately seven years. Therefore, should additional groundwater investigation fail to yield evidence to indicate that the unit is already releasing hydrocarbon contaminants to groundwater, it could reasonably be assumed that this unit will not function as a contaminant source to the near-surface water zone at some future time. The proposed RFI Phase III investigative activities for TMD described in the following sections will provide information that will directly address EPA's concerns regarding the potential threat to groundwater posed by hydrocarbon-contaminated soil within the ditch.

Regarding the active evaporation ponds, information needs require follow-up sampling and evaluation of groundwater from the existing monitor well network, the further vertical delineation of contaminants in groundwater below the unit, and investigation of current surface water and sediment conditions in the Pecos River adjacent to the unit.

1.2 Scope of the Rfi Workplan

The previous RFI Phase I and II investigations for the evaporation pond complex and TMD provided characterization of the facility's environmental setting, potential receptors and sources of contamination, and delineation of the degree and extent of contamination. Since EPA has previously found these evaluations to be technically acceptable, only a general descriptive characterization of the environmental setting for these facilities has been repeated for this document. The Phase I and Phase II reports will be referenced as necessary for information pertaining to the local environmental setting. The workplan also specifies the investigative activities to be completed during the Phase III investigation, including investigative methods and procedures, types of data to be collected, quality assurance/quality control objectives and procedures, and personal health and safety requirements.

1.3 Organization of the RFI Workplan

This workplan is organized into seven sections. Section 2 provides summary descriptions of the TMD and evaporation pond SWMUs at which RFI activities are to be conducted, and the environmental setting. Section 3 provides the project management plan while Section 4 outlines the strategy for conducting the Phase III investigation activities. Sections 5 and 6 provide the Quality Assurance Project Plan and the Data Management Plan, respectively. Personnel protection and environmental safety are addressed in Section 7.0. In Section 8, the outline of a community relations plan is presented.

2.0 FACILITY BACKGROUND AND ENVIRONMENTAL SETTING

2.1 Facility Background

Navajo Refinery is located at 501 East Main Street in Artesia, Eddy County, New Mexico. The general location and main components of the facility are shown in Figure 2-1.

Oil wells were first put down in southeastern New Mexico in the early 1920s. In April, 1924, the Artesia field opened with the production of 90 barrels of oil. Red Lake Field and Maljamar Field followed within two years. Three years later (1929), another large field, Grayburg-Jackson, began production. Subsequently, other large fields have opened in the region.

With the 1924 development of commercial quantities of oil in the Artesia field, the need arose for local refining capacity. A partnership was formed to build a 1000-BPD refinery at Artesia in 1925. Partners were Tomas Flynn, Van Welch, and Martin Yates II. As oil production continued to grow, a second refinery was built in 1931, directly south of the first, by Maljamar Oil and Gas Company. This second plant, known as the Malco Refinery, initially had a capacity of 1800 BPD. About this same time, Continental Oil Company (Conoco) purchased the interests of Flynn, Welch, and Yates in the first refinery.

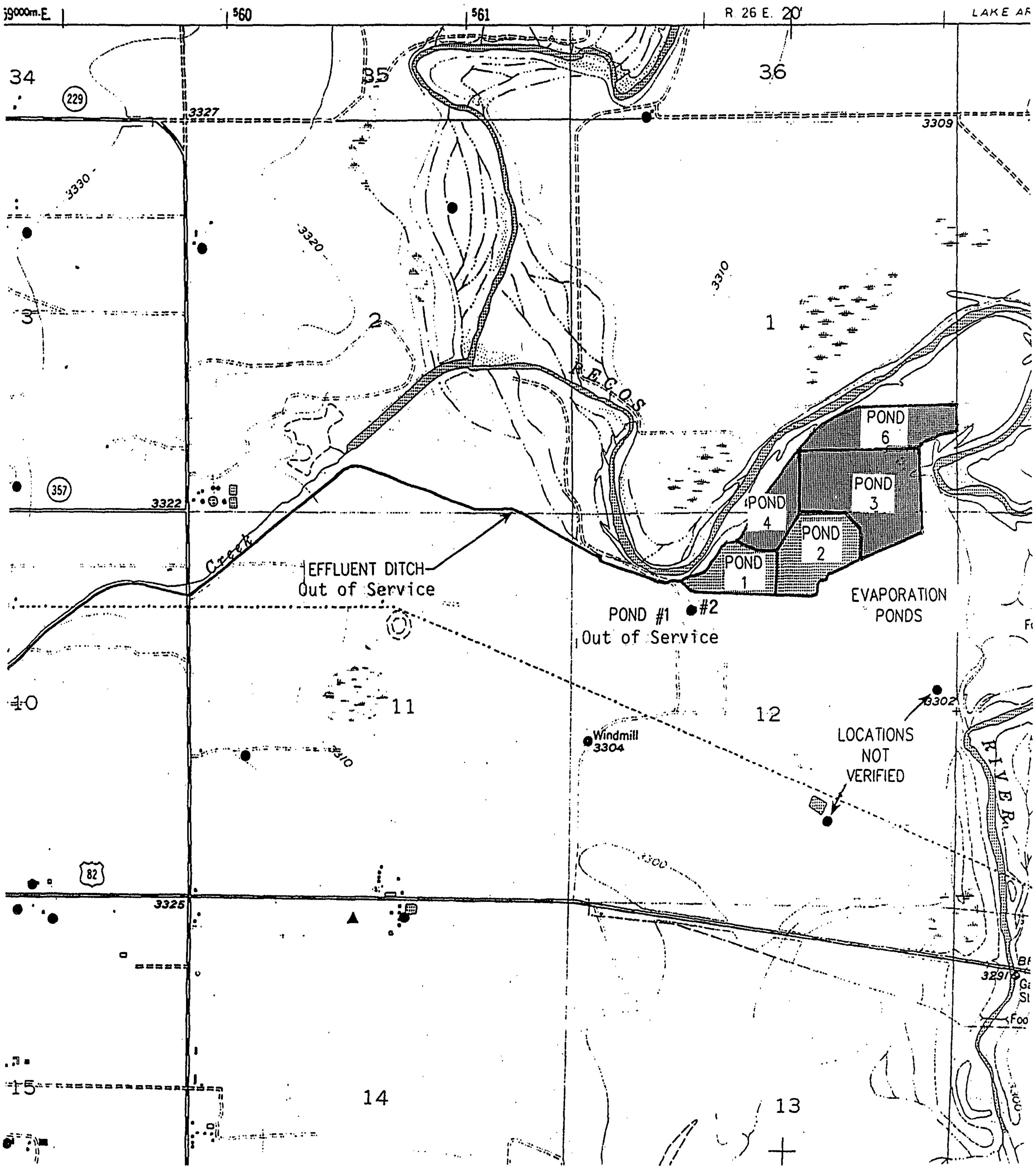
On January 1, 1942, Robert O. Anderson of Roswell, NM, in partnership with Louis Bell, purchased the second (Malco) refinery from Maljamar Oil and Gas Company. Bell shortly sold his interests to Anderson. Under Anderson's direction, the refinery capacity was increased to 5,000 BPD.

Although Conoco continued expansion of the original refinery, the plant facilities became obsolete. To overcome deficiencies, Conoco purchased the Malco Refinery from Anderson in May 1959. The older refinery north of the Malco Refinery was merged through interconnecting pipelines. Petroleum products produced from the North and South refineries covered a wide range and had a combined capacity of 16,000 BPD.

In 1961, the Antitrust Division of the U.S. Justice Department filed suit claiming Conoco to be in violation of antitrust laws. After many court battles, in 1968 the U.S. Supreme Court ordered Conoco to divest within a year. Conoco sold its interests in the refinery, crude oil gathering lines, product pipelines, and El Paso terminals to a newly formed partnership, Navajo Refining Company. Partners were C.L. Norsworthy, Jr., of Dallas, TX and the Holly Corporation, then of Azuza, CA.

The Navajo Refining Company presently is a wholly owned company of the Delaware Registered Holly Corporation. Registration as a corporation occurred July 6, 1982.

Figure 2-1. Navajo Refining Company, Facility Location Map



EXPLANATION

▲ WELLS COMPLETED IN THE DEEP ARTESIAN AQUIFER

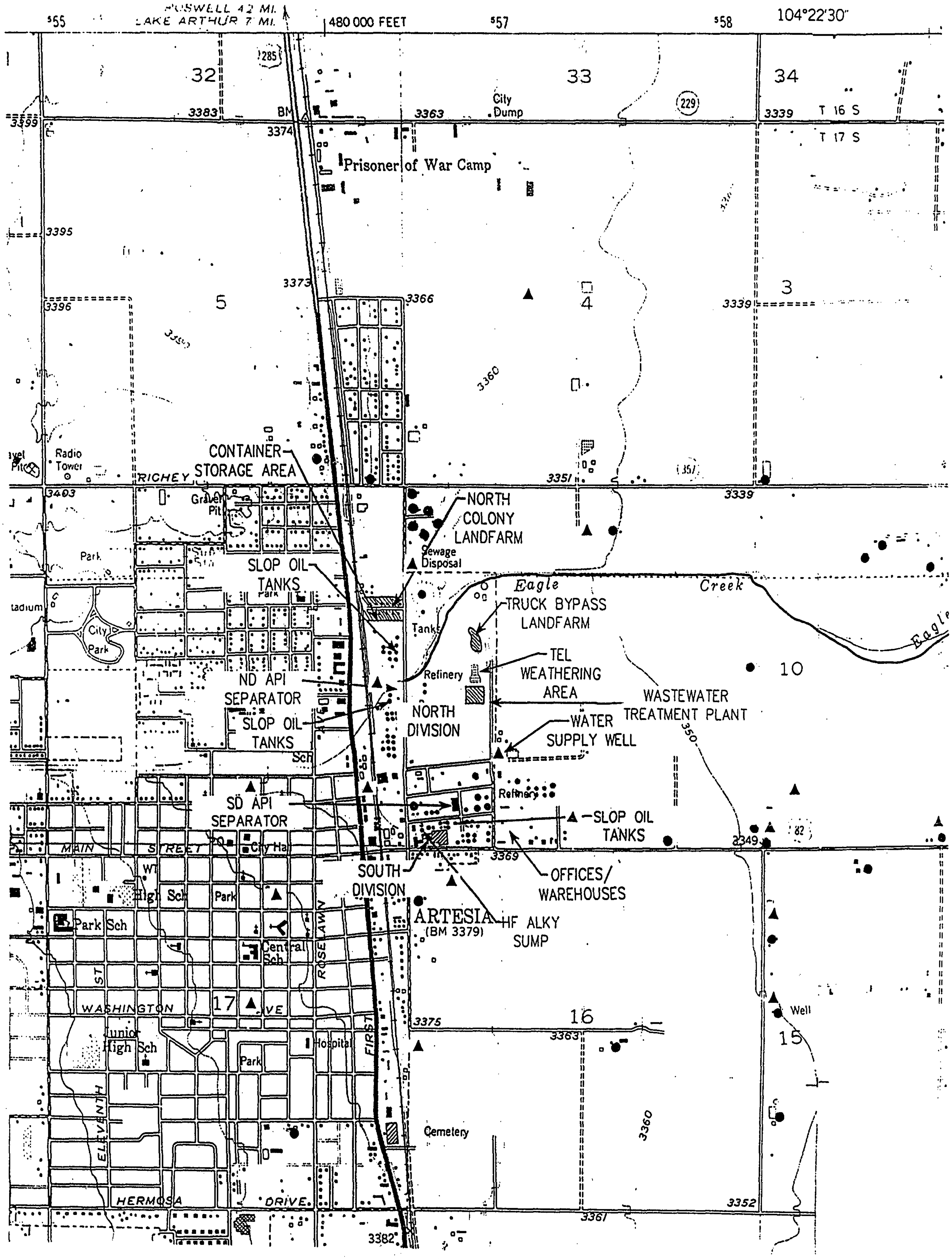
● WELLS COMPLETED IN THE SHALLOW VALLEY FILL AQUIFER

NOTE: MAP COMPILED FROM USGS ARTESIA AND SPRING LAKE 7.5 MINUTE QUADRANGLE (1973).

N

1600 0 1600 FEET

RE/SPEC INC. RESEARCH SPECIALISTS	Navajo Refining Company Facilty Location Map, East Portion	
prepared for: Navajo	PROJECT: 318/2.1	
	LOCATION: NAVAJO REFINERY, ARTESIA, NM	
	APPR:	DATE:
	DRAWN BY:	SCALE: AS SHOWN
	DATE: 9/1/93	FIGURE: 2-1B

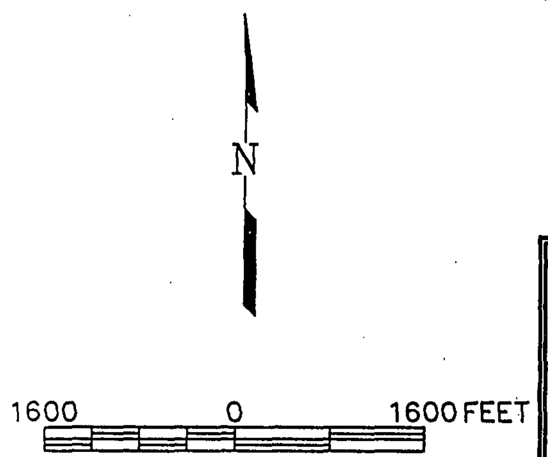


EXPLANATION

▲ WELLS COMPLETED IN THE DEEP ARTESIAN AQUIFER

● WELLS COMPLETED IN THE SHALLOW VALLEY FILL AQUIFER

NOTE: MAP COMPILED FROM USGS ARTESIA AND SPRING LAKE 7.5 MINUTE QUADRANGLE (1973).



RE/SPEC INC.
RESEARCH SPECIALISTS

prepared for:

Navajo

Navajo Refining Company
Facilty Location Map, West Portion

PROJECT: 318/2.1	
LOCATION: NAVAJO REFINERY, ARTESIA, NM	
APPR:	DATE:
DRAWN BY:	SCALE: AS SHOWN
DATE: 9/1/93	FIGURE: 2-1A

The major refining processes at the facility are: crude oil fractionation, fluidized catalytic cracking, alkylation, reforming, and desulfurization. The facility has the capacity to refine about 40,000 barrels of crude per day. Several auxiliary activities are associated with these processes which separate impurities from the feedstocks and products or are required for the operation and maintenance of the refinery. The units associated with these auxiliary activities include: boilers, cooling towers, storage tanks, water purification facilities, desalting units, amine units, and drying and sweetening units.

The production activities at the Navajo Refinery generate a variety of solid wastes and wastewater streams. RCRA solid hazardous wastes (oil-water separator sludges, heat exchanger bundle cleaning sludges, slop oil emulsion solids, dissolved air floatation and, when produced, leaded tank bottoms) were disposed of at the facility's North Colony Landfarm prior to 1990. Waste applications to the NCL ceased that year, and treatment of unit soils by tilling, fertilization and irrigation has routinely occurred in order to maximize the degradation of organic constituents. The wastewater management system presently employed by Navajo consists of a wastewater treatment plant and a system of evaporation ponds. Table 2-1 describes the wastewater streams and the wastewater treatment systems at the facility.

2.2 Description and Current Status of SWMUs

A RCRA Preliminary Assessment Report compiled by A. T. Kearney, Inc. and Harding Lawson Associates was completed at the facility and submitted to EPA in April of 1986. This preliminary review (PR) identified 15 Solid Waste Management Units (SWMUs) at the facility. Table 2-2 identifies the current status of the SWMUs identified in the permits. Below are descriptions of the two SWMUs that are to receive extensive study as part of the Phase II workplan.

2.2.1 Three-Mile Ditch and Eagle Creek

A 3-mile long unlined earthen ditch (approximately 20,000 linear ft) conveyed wastewater from the refinery to Evaporation Pond 1 from the 1930s until 1987 (Figure 2-2). The ditch is 3- to 4-ft wide and 1- to 2-ft deep and was bermed along its course to prevent overflow or influx of surface water. The ditch has a slope of approximately 0.004 ft/ft and lies approximately parallel to the path of Eagle Creek. The ditch parallels the natural drainage of Eagle Creek but is not in the creek. Furthermore, the base of the conveyance ditch is approximately 5 to 10 ft above the creek bed.

In the past, solids were removed from the bottom of the ditch and placed along the berms. None of the ditch wastes have been removed from the site. The berms along approximately 4,500 ft of the eastern end of the unit were bulldozed into the ditch in 1988.

Table 2-1. Wastewater Streams and Wastewater Treatment

Process or auxiliary unit	Wastewater stream contents
Crude oil fractionation	Ammonia, sulfides, chlorides, oil, phenols
Catalytic cracking	Alkaline wastewater containing high BOD and COD concentrations; oil, sulfides, phenols, cyanides, and ammonia
Alkylation	Neutralized solution containing suspended solids, dissolved solids, oil, fluoride, and phenols
Reforming	No waste stream
Desulfurization	Sulfides and phenol compounds
Cooling towers	Chromate, dissolved solids
Water purification	Dissolved solids
Desalting units	Dissolved solids, phenols, ammonia, sulfides
Amine units	No waste stream
General wash water	Site specific

Table 2-2. SWMUs at Navajo Refinery

	RCRA permitted unit	RFI work plan	Operational status
North Colony Landfarm	X	X	Non-operational
TEL Weathering Area			Closed
Truck Bypass Landfarm		X	Non-operational
Evaporation Pond 1		X	Non-operational
Evaporation Pond 2		X	Non-operational
Evaporation Pond 3[a,b]		X	Operational
Evaporation Pond 5[a]		X	Operational
Evaporation Pond 6[a,b]		X	Operational
Three Mile Ditch/Eagle Creek[a]		X	Non-operational
North Colony Container Storage Area			Operational
HF Neutralization Sump			Operational
Slop Oil Tanks			Operational
Oil-Water Separators			Operational
Fire Water Ponds			Operational
Heat Exchanger Bundle Cleaning Areas			Operational

[a] SWMU included in this workplan.
[b] Dikes separating evaporation ponds 3 and 6 have been breached and the ponds operate as a single unit.

2.2.2 Evaporation Ponds

The AEPs (Figure 2-1B) receive approximately 400,000 gallons of wastewater per day from the refinery wastewater treatment plant, via a 20,000 linear ft enclosed conduit. The conduit, constructed of high-density polyethylene with thermally welded joints, replaced an open earthen ditch in 1987. Wastewaters typically contain 2,000 to 3,000 milligrams per liter (mg/L) total dissolved solids. In the immediate proximity of the Pecos River, groundwater near the surface is of very poor quality with TDS levels commonly in excess of 10,000 mg/L.

The ponds are in series and are numbered from upstream to downstream as Ponds 1, 2, 3, 5, and 6. Pond 1 which is out of service, reportedly contains approximately 60,000 tons of sludge. A breached dike between Pond 2 and Ponds 3 and 5 recently has been reconstructed, and the pipeline influent gate relocated to discharge directly into Pond 5. Subsequently, Pond 2 has been taken out of service and dewatered. The dike between Ponds 3 and 6 is breached and mostly submerged, and these combined areas are separated from Pond 5 by a functioning dike that serves as a spillway to control the water level in Pond 5.

2.3 Environmental Setting

The environmental setting for the refinery was provided by both International Technology's (IT), "Hydrogeologic Assessment of Navajo Refinery, Compliance and Review of Investigations Through 1988", project number 30-12-44 completed in January 1989, and by the A. T. Kearney, Inc. and Harding Lawson Associates' April 14, 1986 Preliminary Assessment Report. These reports are summarized and updated by more recent reports where necessary in the subsections that follow.

2.3.1 Climatology

The Artesia, New Mexico area has a semiarid continental climate, characterized by hot summers and mild winters. Measurable rainfall occurs approximately 42 days per year and annual snowfall averages 3-8 in. to yield an average annual precipitation of 10-14 in., with nearly 80% falling from May through October. Lake evaporation in the Eddy County area is 66-72 in. per year, of which two-thirds also takes place from May through October. Thus, the net loss between precipitation and evaporation ranges from 52-62 in. per year. Minimum temperatures are typically 44.0°-49.0°F, but can fall below 0°F in winter; maximum temperatures can exceed 100°F on summer days. The frost-free season is April to October (NOAA, 1982).

2.3.2 Topography and Surface Water

The Navajo Refinery facility is located on the east side of Artesia in the broad Pecos River Valley of eastern New Mexico. The average elevation of the city of Artesia is 3,380 ft above sea level. The plain on which Artesia lies slopes eastward at about 30 ft per mile.

Surface drainage is dominated by small ephemeral creeks and arroyos that flow eastward to the Pecos River, located approximately 3 miles east of the facility.

Natural surface drainage at the facility is to the north and east. The major drainage in the immediate area of the site is Eagle Creek, an ephemeral watercourse flowing in response to rainfall that runs southwest to northeast through the process area of the refinery, and thence runs eastward into the Pecos River. Upstream of the facility as it passes through the city of Artesia, Eagle Creek functions as a major stormwater conveyance for the community. It also drains outlying areas westward towards the Sacramento Mountains, and periodically is scoured by intense stormwater events.

The elevation of Eagle Creek is 3,360 ft. at its entrance to the refinery and decreases to approximately 3,305 ft. at its junction with the Pecos River. A large portion of the facility is within the 100-year floodplain of either Eagle Creek or the Pecos River. However, Eagle Creek has been channelized from west of Artesia to the Pecos, and the area of modification is being extended. In the vicinity of the refinery, the channel of Eagle Creek has been cemented to protect developed areas during flood events. A check dam also was constructed west of Artesia along Eagle Creek. According to the RCRA Preliminary Review (PR) (A.T. Kearney and Harding Lawson, 1986) prepared for this facility, once flood control measures are completed, they should effectively remove Artesia and the refinery from Eagle Creek's 100-year floodplain. As a condition of permit approcal by the NM Oil Conservation Divison, the evaporation ponds adjacent to the Pecos River were required by to be constructed to withstand an 100-year flood event.

2.3.3 Soils

Soils at the refinery are primarily of the Pima and Karro series. The North Colony landfarm is about 60% Pima soils and 40% Karro soils. The frost-free season for Pima and Karro soils is 195 to 210 days. Extended periods of cold weather are rare and frost action potential is slight. In general, soils in the area do not freeze at depths greater than a few inches for more than a few days at a time (USDA - SCS, 1971).

The Pima and Karro soils have similar properties. Pima soils are deep, well-drained, dark colored, calcareous soils, which occur on floodplains of narrow drainageways (e.g., Eagle Creek). These soils have moderate shrink-swell potential, and were subject to periodic flooding. Runoff from Pima soils is slow, permeability is moderately slow, and the water-holding capacity is high. The effective rooting depth is greater than 5 feet, and the water table is deeper than 5 feet.

The Karro soils are highly calcareous. Calcium carbonate typically accumulates at a depth of about 45 inches. These soils are found on level to gently sloping terrains and are susceptible to wind erosion. Runoff is slow and water-holding capacity is high. Permeability is moderate, and the effective rooting depth and the water table are both over 5 feet deep.

2.3.4 Geology

Navajo Refinery is located on the Northwest Shelf of the Permian Basin. In this region, the deposits are comprised of approximately 250 to 300 feet of Quaternary alluvium unconformably overlying approximately 2,000 feet of Permian clastic and carbonate rocks. These Permian deposits unconformably overlie Precambrian syenite, gneiss, and diabase crystalline rocks (Kelley, 1971; Welder, 1983). The relationships between the sedimentary deposits are shown in Figures 2-2 and 2-3 and discussed below.

2.3.4.1 San Andres Formation

The San Andres Formation, oldest of the Permian units discussed in this report, lies immediately above the Precambrian crystalline basement rocks and beneath the Grayburg and Queen Formations. The San Andres Formation is composed mainly of limestone and dolomite containing irregular and erratic solution cavities, which range up to several feet in diameter. Its thickness is greater than 700 ft. The upper portion of the Formation is composed of oolitic dolomite with some anhydrite cement. The deep well lithologic logs from the refinery area indicate that the San Andres Formation is primarily carbonate (logged by drillers as lime or limerock) and probably includes limestone and dolomite.

2.3.4.2 Permian Artesian Group

The Permian Artesian Group is comprised of five formations (in ascending order): the Grayburg, Queen, Seven Rivers, Yates, and Tansill Formations. The Yates and Tansill Formations outcrop at the surface east of the Pecos River and are not present in the vicinity of the refinery. The Permian formations dip 1° to 3° toward the southeast, without any reported major structural features (Lyford, 1973; Welder, 1983).

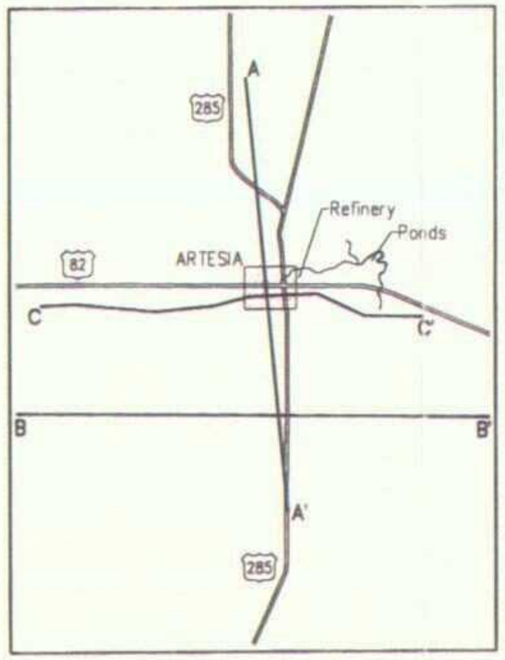
Grayburg and Queen Formations

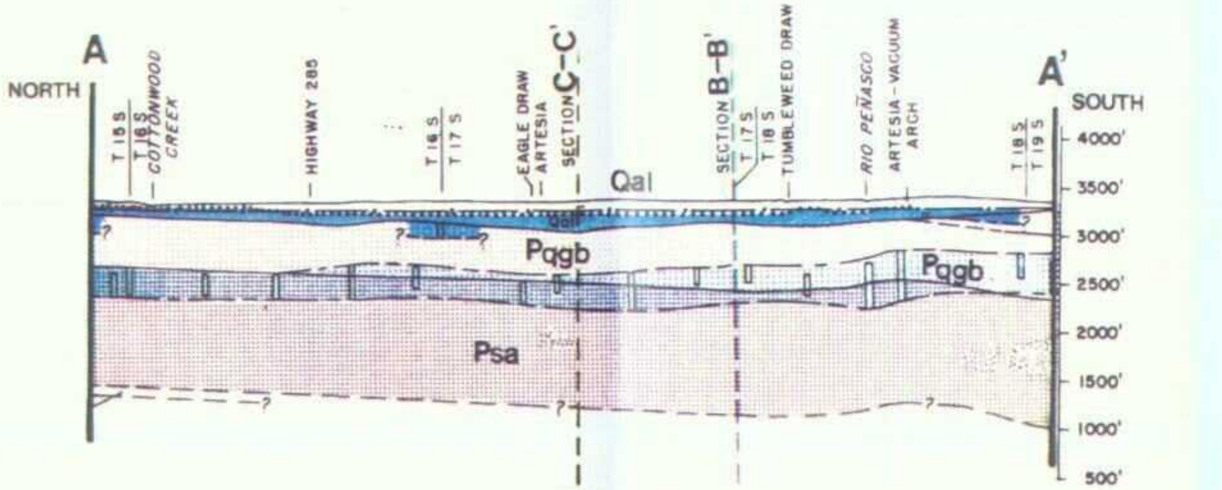
In the area of the refinery the Grayburg and Queen Formations have been mapped as a single unit by geologists as collectively consisting of about 700 ft of interbedded dolomite and calcareous dolomite, gypsum, fine-grained sandstone, carbonates, siltstone, and mudstone. Lithologies of the Queen Formation are similar to those of the Grayburg Formation with the principal difference being a higher proportion of clastics in the Queen, which conformably overlies and grades into the Grayburg Formation. The Grayburg is thought to disconformably overlie the San Andres Formation. In locations where the Seven Rivers Formation is absent, the upper portion of the Queen acts as a confining bed between the deep artesian aquifer and the valley fill aquifer (Section 3.5).

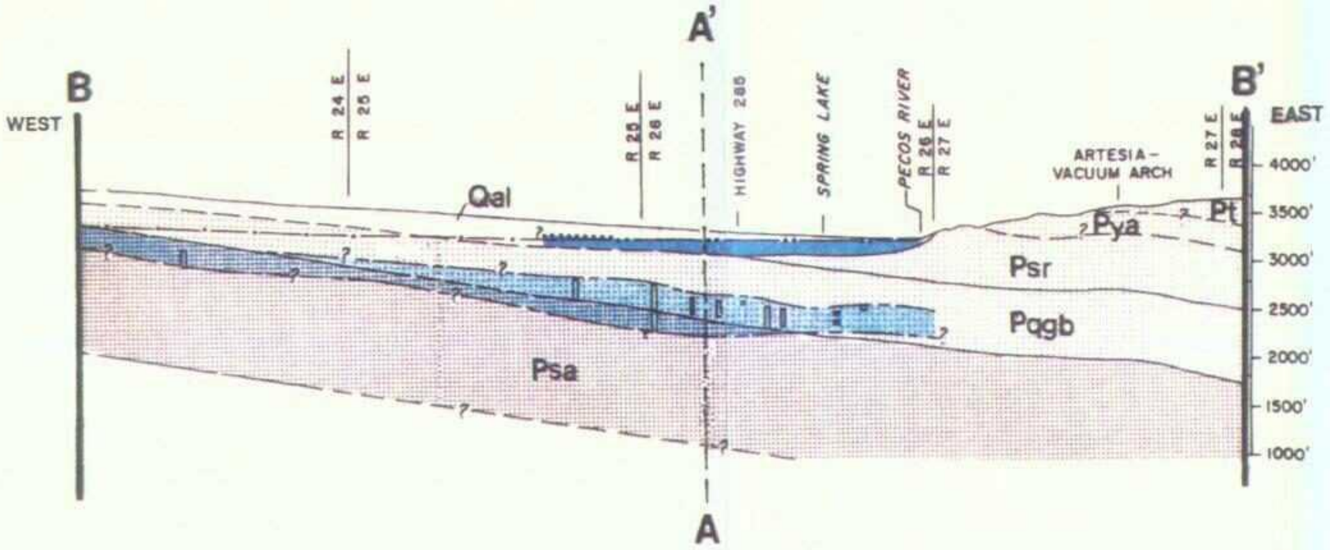
Figure 2-2. Regional Cross-sections A-A' and B-B'

EXPLANATION

Qal	Alluvial deposits— Not mapped in detail might include rocks of Pliocene age and part of the Gatuna Formation of Pleistocene age. Contains the main part of the shallow aquifer of the Roswell basin.
Pt	Tansill Formation
Pya	Yates Formation
Psr	Seven Rivers Formation— (A large part of the shallow aquifer near Lake McMillan)
Pqgb	Queen and Grayburg Formations, undivided. Includes upper part of San Andres Limestone where it is solution altered.
Psa	San Andres Limestone— Contains the main part of the artesian aquifer north of T. 19N. Also includes the "Slaughter zone" (local usage)
——?——	Formation contact--Dashed where approximately located; queried where probable
··············	Water-level surface in the shallow aquifer of the Roswell basin, January 1975
—·—·—	Potentiometric surface--Shows level to which water will rise in wells tapping the artesian aquifer of the Roswell basin, January 1975.
—··—··—	Water-level surface and potentiometric surface--Where the two are separated by less than about 20 feet.
———?-	Aquifer boundary--Marks the generalized boundaries of the shallow and artesian aquifers of the Roswell basin where their boundaries do not coincide with a formation contact: queried where probable.
▯	Water-producing interval--Projected into the sections from wells generally less than 2 miles away.
🟦	Shallow aquifer of the Roswell basin. Shows general distribution only. Contains some nonproductive zones.
🟦	Artesian aquifer of the Roswell basin. Shows general distribution only. Contains some nonproductive zones.







NOTE: MODIFIED FROM WELDER (1983)

0 1 2 3 4 5 6 7 8 9 10 MILES

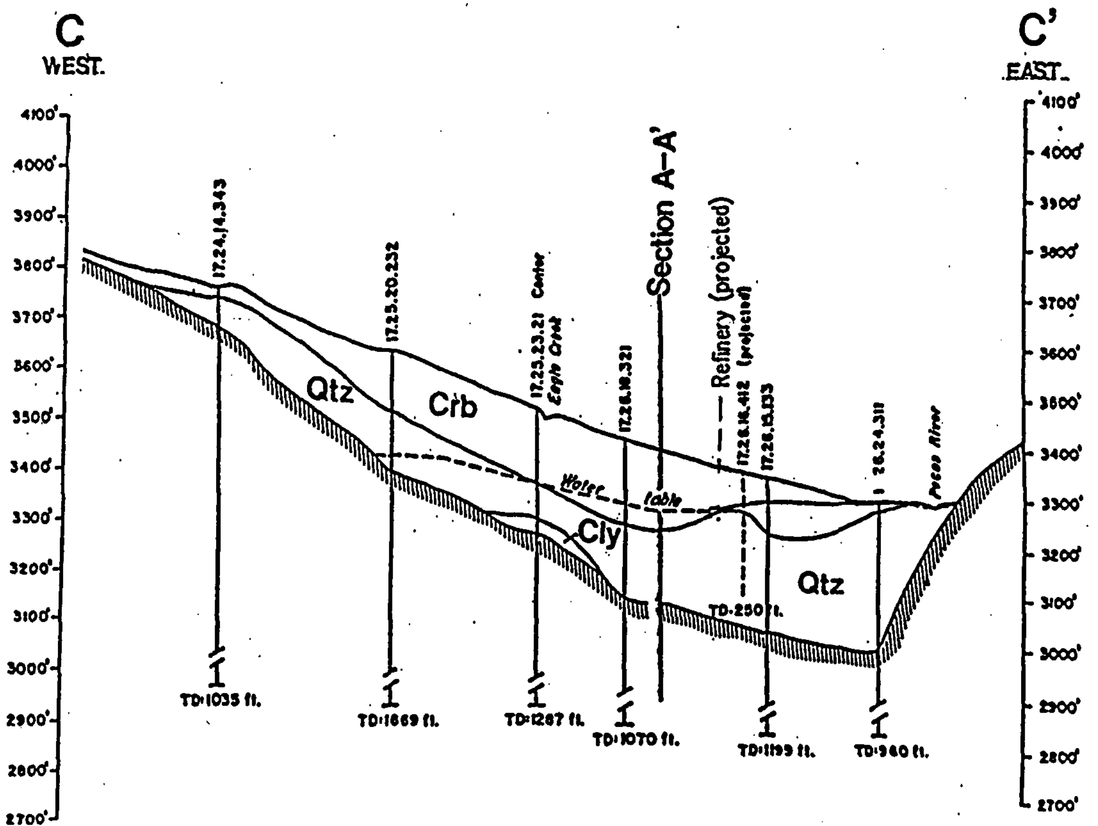
VERTICAL EXAGGERATION X 10
NATIONAL GEODETIC VERTICAL DATUM OF 1929

R/S RE/SPEC INC. RESEARCH SPECIALISTS	Regional Cross-Section A-A' and B-B''	
prepared for: Navajo	PROJECT: 318/2.1	
	LOCATION: NAVAJO REFINERY	
	APPR:	DATE:
	DRAWN BY:	SCALE: AS SHOWN
	DATE: 4/26/93	FIGURE: 2-2

Figure 2-3. Regional Cross-section C-C'

EXPLANATION

Crb	Carbonate-gravel unit
Cly	Clay unit
Qtz	Quartzose unit
▨	Top of Permian rocks
—	Appropriate contact between lithologic units
---	Water table determined from January 1969 water levels. Dashed where approximately located.



NOTE: Modified from Lyford (1973)

0 1 2 MILES

Vertical exaggeration x 53
Datum is mean sea level

RE/SPEC INC.
RESEARCH SPECIALISTS

prepared for:

Navajo

Regional Cross-Section C-C'

PROJECT: 318/2.1	
LOCATION: NAVAJO REFINERY, ARTESIA, NM	
APPR:	DATE:
DRAWN BY:	SCALE: AS SHOWN
DATE: 5/19/92	FIGURE: 2-3

Seven Rivers Formation

The uppermost Permian formation in the Artesia area is the Seven Rivers Formation, which outcrops east of the Pecos River. This eastward-dipping formation is eroded and buried by the valley fill alluvium at a depth of 300 ft in the area between the river and the refinery. In the vicinity of the refinery, the formation thins, and it disappears farther west.

Where the formation is present at depth, it consists of a sequence of evaporites, carbonates, gypsum, and shale, with isolated sand and fractured anhydrite/gypsum lenses. A thorough evaluation of all available borehole logs, supported by an International Technology Corporation Report (1990), provided no evidence that the Seven Rivers Formation is present (at any depth) beneath the refinery. All lithologic logs of wells completed in the refinery area describe unconsolidated alluvial materials to depths from 20 to 250 feet.

2.3.4.3 Quaternary Alluvium

The Quaternary alluvium in the refinery area is dominantly comprised of clays, silts, sands, and gravels deposited in the Pecos River valley. These "valley fill" deposits extend in a north-south belt approximately 20 miles wide, generally west of the Pecos River. The thickness of the valley fill varies from a thin veneer on the western margins of the Pecos River valley to a maximum of 300 feet in several depressions, one located beneath the refinery. These depressions have resulted from dissolution of the underlying Permian carbonates and evaporates. The sedimentology and mineralogy of the valley fill deposits can be divided into three units: the underlying quartzose unit, the interbedded clay unit, and the uppermost carbonate gravel unit.

Quartzose Unit

The quartzose unit consists primarily of fragments of quartz and igneous rocks cemented by calcium carbonate. This unit is laterally continuous throughout the Pecos River valley and is generally less than 250 feet in thickness. The quartzose unit unconformably overlies Permian rocks and is correlative with the quartzose conglomerate described by Fiedler and Nye (1933), and Morgan (1938). The lower quartzose gravels are commonly used for groundwater production.

Clay Unit

The clay unit is not laterally continuous throughout the valley fill deposits, but occurs in isolated lenses generally overlying the quartzose unit. The clay unit is comprised of light- to medium-gray clays and silts deposited in localized ponds and lakes. These ponds and lakes may have formed in conjunction with dissolution and collapse of the underlying Permian rocks.

Carbonate Gravel Unit

The carbonate gravel unit blankets the other valley fill units and forms a fairly uniform slope from the Permian rock outcrop areas on the west side of the valley east to the Pecos River floodplain. The unit consists of coarse-grained carbonate gravel deposits along major drainageways to the Pecos River which grade into brown calcareous silts and thin masses of caliche in the interstream regions. The carbonate gravel unit includes the Lakewood, Orchard Park, and Blackdom terrace deposits of Fiedler and Nye as well as Holocene and Pleistocene Pecos River alluvial deposits. The Lakewood deposits, the lowest of the three terrace units, essentially are the current alluvial sediments in the floodplain along the river. They consist of brown sandy brown silt interbedded with lenses of gravel and sand, and some localized caliche in higher parts. The Lakewood terrace is confined to the area immediately adjacent to the river and is underlain by Pleistocene alluvium deposited by the Pecos and its tributaries.

The agricultural land at Artesia is part of the Orchard Park terrace deposit, which forms a thin veneer overlying older valley fill alluvium. The Orchard Park terrace surface gently rises in elevation to between 5 and 25 feet above the Lakewood terrace. The Orchard Park is generally less than 20 feet in thickness in the refinery area and is comprised of silt interbedded with poorly sorted lenses of mixed-size pebbles in a silt and sand matrix. Chalky caliche commonly occurs in the upper layers. The Blackdom terrace is about 40 to 50 feet in elevation above the Orchard Park terrace west of Artesia. However, the deposits associated with the Blackdom terrace are generally less than 20 feet in thickness. The Blackdom terrace deposits are coarser-grained than the deposits associated with the Orchard Park and Lakewood terraces. In addition, the caliche soils have a higher density than those developed on the Orchard Park terrace.

2.3.5 Groundwater

The principal aquifers in the Artesia area are within the San Andres Formation and the valley fill alluvium (Welder, 1983). Within the valley fill in the vicinity of the refinery process area is a near-surface water-bearing zone, apparently limited in vertical extent, that is shallow with respect to the surface and also exhibits artesian properties at some monitor wells. To avoid confusion and for consistency, the deeper carbonate aquifer is herein called the *deep artesian aquifer*, whereas the water-bearing zones of the shallower, alluvial valley fill aquifer, including those near the refinery evaporation ponds, are referred to collectively as the *valley fill aquifer*. Adjacent to the refinery, the first water-bearing zone in the valley fill aquifer is referred to as the *near-surface saturated zone*.

2.3.5.1 Deep Artesian Aquifer

The deep artesian aquifer is closely related to the Permian San Andres Limestone and generally consists of one or more water-producing zones of variable permeability located in the upper portion of the carbonate rocks. However, in the Artesia area, the producing interval rises stratigraphically and includes lower sections of the overlying Grayburg and

Queen Formations. Beneath the refinery, the depth to the top of the producing interval is about 670 ft and the aquifer thickness is about 440 ft. (Welder, 1983). The Seven Rivers Formation and the other members of the Artesia group are generally considered confining beds, although some pumpage occurs locally from fractures and secondary porosity in the lower Grayburg and Queen members.

The deep artesian aquifer has been extensively developed for industrial, municipal, and agricultural use. The quality of water from this aquifer ranges from 500 to more than 5,000 ppm total dissolved solids (TDS) depending on location. In the area of Artesia, water is generally derived from depths ranging from 850 to 1,250 ft below ground surface. The aquifer is recharged in the Sacramento Mountains to the west of Artesia. Extensive use of this aquifer in recent decades has lowered the potentiometric head in the aquifer in some locations to 50 to 80 ft below ground level, although extensive rainfall in 1991 brought the water levels in some wells close to, or above, the surface.

2.3.5.2 Valley Fill Aquifer

Quaternary alluvial deposits of sand, silt, clay, and gravel are the main components of the valley fill aquifer. These sediments are about 300 ft thick in the area between the refinery and the Pecos River. Lyford (1973) researched these deposits and described the three principal units in the valley fill as quartzose, clay, and carbonate gravel.

The quartzose unit is considered the primary production unit in the valley fill aquifer. Away from the Pecos River, the unit consists of fragments of sandstone, quartzite, quartz, chert, igneous, and carbonate rocks. The fragments range from medium grained (1/4mm) to pebble size (16mm) and commonly are cemented with calcium carbonate (Lyford, 1973). By contrast, in the vicinity of the river, the unit contains principally medium to coarse, uncemented quartz grains.

Silt and clay deposits in the valley fill aquifer are not continuous, but occur as isolated lenses, generally overlying the quartzose unit. Although the clay unit was not identified by Lyford (1973) as occurring in the Artesia area, most logs of wells located immediately to the north and east of the refinery show considerable thicknesses of clays or clay mixtures (e.g., "clay and gyp[sum]," "gumbo"). However, these clays may be more closely related to the fine-grained materials of the carbonate gravel unit found in the interstream areas between the major drainageways.

The thickness of these clay/gypsum mixtures ranges from 20 to 160 ft. The intervals of occurrence differ from well to well, and thin zones of sand or gravels are interspersed in the upper 100 ft. Drillers seeking deep artesian water drill through the valley fill zone and usually log large sections of the intervening zones as "clay and gyp." This lack of detail makes it difficult to correlate specific zones of coarse-grained sediments within the silt and clay deposits. However, drillers wanting to complete wells in the valley fill tend to be more careful in their descriptions and are more likely to record small-scale changes in lithology.

The carbonate gravel unit, described earlier, is the uppermost alluvial unit in the valley fill. Coarse-grained gravels deposited in the major tributaries to the Pecos River grade to calcareous silts and thin zones of caliche in the interstream areas. Near the surface, groundwater is localized in thin discontinuous gravel beds typical of braided channel material deposited during flood events originating in the foothills and Sacramento Mountains to the west.

After examination of drillers' reports, Welder (1983) reported that the valley fill wells tap from one to five water-producing zones. Thicknesses of up to 170 ft have been reported for water-production zones, but most are less than 20 ft. Producing zones are principally sand and gravel separated by less permeable lenses of silt and clay. Wells in the valley fill are completed at depths from 125 ft to deeper than 300 ft, but most in the Artesia area are between 200 and 300 ft deep. Water levels in the valley fill range from 40 to 60 ft below ground level, and the formation yields water containing 500 to 1,500 ppm TDS. The average transmissibility of the alluvium has been estimated at 100,000 to 150,000 gallons per day per square foot, and the average coefficient of storage at about 10% (Hendrickson and Jones, 1952).

Recharge of the shallow valley fill aquifer is generally attributed to irrigation return flow from pumpage of the aquifers and from infiltration from the Pecos River. In areas of the valley where the San Andres and the valley fill aquifers are hydraulically connected in the subsurface, water tends to flow up from the deep to the shallow aquifer except in areas of heavy San Andres pumpage. The general direction of groundwater flow in the valley fill aquifer follows the regional stratigraphic dip eastward toward the Pecos River, then southward subparallel to the river. Above Artesia the river has been a gaining stream for most of the period of record (Welder, 1983). The potentiometric surface of the shallow aquifer slopes gently east and southeast, following regional stratigraphic dips. However, south of Artesia in the vicinity and immediately east of Highway 285, heavy pumping between 1938 and 1975 reversed the hydraulic gradient. In this area, the potentiometric surface forms a shallow trough owing to extensive water use for irrigation.

Adjacent to the Pecos River, the valley fill alluvium contains groundwater beginning at a depth of 6 to 12 ft. The alluvium is predominantly silty sand, which possibly contains lenses of higher permeability material. Groundwater flow is subparallel to the Pecos River Valley, and is generally toward the river, although during periods of high river flow, the hydraulic gradient may be away from the river into the alluvium. However, this reversal has not been adequately documented.

2.3.5.3 Near-Surface Saturated Zone

Lithologic logs from monitor wells installed near the refinery process area document a near-surface saturated zone (NSSZ) overlying the main valley fill alluvium in this vicinity and containing water of variable quality in fractured caliche, and sand and gravel lenses at depths of 15 to 30 ft. This water is under artesian pressure for at least some or most of the year with static water levels 3 to 5 ft above the saturated zones. Locally, this uppermost water zone is likely connected to Eagle Creek west of the refinery and most likely discharges to marshes and shallow alluvium along the west side of the Pecos River. The most probable sources of the water are thought to be recharge from Eagle Creek, and lawn watering runoff from the grass-covered urban park that occupies the Eagle Creek channel immediately upstream of the refinery. The water in the NSSZ is highly variable in quality, volume, areal extent, and saturated thickness. Concentrations of total dissolved solids exceeding 2,000 mg/l and sulfate exceeding 500 mg/l have been recorded in the vicinity of the landfarm (Geraghty & Miller, 1982).

2.4 Identification of Potential Receptors

The community of Artesia is located directly adjacent to the facility. The Preliminary Review (PR) conducted at the facility in 1986 concluded that it does not appear likely that releases from SWMUs at the refinery would affect groundwater quality in the deep artesian aquifers (San Andres and Grayburg/Queen Formations). A review of published literature and recent investigations supports that conclusion.

The U.S. Geological Survey studies cited earlier (Lyford, 1973, and Welder, 1983) document non-pumping artesian water levels close to the surface and as much as 40 ft. higher than valley fill aquifer levels. Wells completed in the deep valley fill near the refinery also appear artesian, with major water producing zones located 200 to 300 feet deep and water levels rising to within 50 ft. of the surface. Artesian pressure, depth from the surface to the major water supply aquifers, and the presence of fine-grained materials acting as confining beds appear to be adequate to prevent downward migration of waste constituents at the refinery process areas. Additionally, public water supply wells are located to the west and upgradient of the refinery process areas.

Recent work (documented in the revised NRC RFI Phase II report for the unused wastewater ditch and evaporation ponds submitted to the USEPA in November, 1993) included a detailed analytical comparison of the groundwater in the near-surface saturated zone with water from several valley fill aquifer wells nearby. The comparison, using Piper trilinear mixing diagrams, did not show any compositional relationship between the two zones.

The PR indicated that the deep aquifers (San Andres and valley fill formations) have been extensively developed for irrigation purposes but the shallow groundwater in the Pecos River Valley alluvium near the refinery evaporation ponds is not currently utilized, except possibly for isolated stock use, owing to poor water quality. The PR concluded that because the river alluvium's westernmost extent is approximately 2.5 miles east of the city of Artesia, a release of waste constituents to groundwater from the SWMUs constructed in the alluvium would not pose a significant health threat to the population of Artesia.

Again, investigation conducted during the recently-completed RFI Phase II study, supported this earlier conclusion. The work documented that upward vertical gradients exist in the vicinity of the evaporation ponds and that groundwater in the valley fill aquifer discharges to the surface alluvium along the river. Much of this shallow groundwater is evaporated or consumed by thick growths of salt cedar vegetation along the river bottom. Both mechanisms concentrate salts in the remaining shallow groundwater with concentrations of total dissolved solids in excess of 10,000 mg/l commonly documented, which render it unfit for human or animal consumption.

2.5 References

The discussion presented in this section is based on information found in the following references:

A. T. Kearney Inc., and Harding Lawson Associates, 1986. *Preliminary Assessment Report, Navajo Refining Company, Artesia, New Mexico*, prepared for U.S. EPA, Region VI, Dallas, TX, Contract No. 68-01-7038, April 14.

Fiedler, A. G., and Nye, S. S., 1933. *Geology and Ground-Water Resources of the Roswell Artesian Basin, New Mexico*, U.S. Geological Survey Water Supply Paper 639, U.S. Govt. Printing Office, Washington, DC.

Geraghty & Miller Inc., 1982. *Installation of Groundwater Monitoring System at the Navajo Refining Company, Artesia, New Mexico*, 25 p., four appendices, Houston, TX.

Hendrickson, G. E., and R. S. Jones, 1952. *Geology and Ground-Water Resources of Eddy County, New Mexico* Groundwater Report, 3, New Mexico Bureau of Mines & Mineral Resources, Socorro, NM.

International Technology Corporation, 1989. *Hydrogeologic Assessment of Navajo Refinery. Compilation and Review of Investigations Through 1988*, report to Navajo Refining Company, Artesia, NM.

Kelley, V. C., 1971. *Geology of Pecos Country, Southeastern New Mexico*, New Mexico Bureau of Mines & Mineral Resources - Memoir 24, University of New Mexico Printing Plant, Socorro, NM.

K. W. Brown Environmental Services, 1993. *RCRA Facility Investigation Three-Mile Ditch and Evaporation Ponds, Phase II (Revised), Navajo Refinery, Artesia, New Mexic,* prepared for U.S. EPA, Region VI, Dallas, TX, 163 p., five volumes, College Station, TX, November.

Mariah Associates, Inc., 1990. *RCRA Facility Investigation Three-Mile Ditch and Evaporation Ponds, Phase I, Navajo Refinery, Artesia, New Mexic,* prepared for U.S. EPA, Region VI, Dallas, TX, two volumes, Laramie, WY, October.

Morgan, A. M., 1938. *Geology and Shallow-Water Resources of the Roswell Artesian Basin,* New Mexico State Engineer Bulletin No. 5, Santa Fe, NM.

Lyford, F. P., 1973. *Valley Fill in the Roswell-Artesia Area, New Mexico,* Open File Report 73-163, USGS Open File Services, Denver, CO.

National Oceanic and Atmospheric Administration, 1982. *Monthly Normals of Temperature, Precipitation, and Heating and Cooling Degree Days 1951-1980,* Natural Climatic Center, Asheville, NC.

RE/SPEC, Inc., 1993. *RCRA Facility Investigation Work Plan (Revised) North Colony Landfarm Navajo Refining Company Artesia, New Mexico,* Amended 3/94, submitted to New Mexico Environment Department, Santa Fe, 100 p.

Shomaker, J. W. Inc., 1990. *North Colony Landfarm - Alternative Source Demonstration, Navajo Refining Company,* April 9 Submittal to NM Environmental Improvement Division, 23 p, Albuquerque, NM.

U.S. Department of Agriculture Soil Conservation Service, 1971. *Soil Survey Eddy Area, New Mexico,* U.S. Government Printing Office, Washington, DC.

Welder, G. E., 1983. *Geohydrologic Framework of the Roswell Ground-Water Basin, Chaves and Eddy Counties, New Mexico,* USGS Technical Report 42, University of New Mexico Printing Plant, Socorro, NM.

3.0 PROJECT MANAGEMENT PLAN

This section provides brief discussions of the technical approach, scheduling, and project personnel. Detailed discussion of the data collection strategy, project responsibilities and overall management approach to the RFI can be found in Section 4.0, the Data Collection Strategy and Standardized Procedures. Reference to specific topics are provided with the discussion below.

3.1 Technical Approach

Navajo Refining Company will perform sediment and water sampling of the Pecos River and additional groundwater investigation at the Three-Mile Ditch and the active evaporation ponds to determine the extent of release of hazardous constituents from these units. Additional shallow groundwater monitoring wells and piezometers will be installed along the TMD, and two deep wells (in excess of 50 ft) installed downgradient from the evaporation pond area.

3.2 Scheduling

The schedule of RFI activities for the North Colony Landfarm Work Plan is shown in Figure 3-1. Unless otherwise agreed to by NCR and U. S. EPA, the schedule for all primary project activities associated with the revised RFI Work Plan will adhere to the time intervals shown in the schedule. All necessary field activities will be completed within 4 months of final approval of the work plan by U. S. EPA, and all report preparation and submittal activities will be completed within 2 months subsequent to the completion of field activities. Total project duration will be a maximum of 6 months.

3.3 Project Personnel And Budgeting

The overall responsibility for the successful completion of the RFI lies with NRC who have allotted sufficient funds for timely completion of this work. The project coordinator for NRC assigned to this investigation is Mr. David G. Griffin, Superintendent of Environmental Affairs. All communications in regards to this investigation will be directed to Mr. Griffin. The project team will also include Mr. David G. Boyer, Hydrogeologist and Environmental Manager, who is the designated RE/SPEC Project manager. Additional staffing will be provided by RE/SPEC science and engineering personnel experienced in conducting RCRA RFI studies, including groundwater modeling. Field drilling activities will be performed by a licensed driller, and surveying will be conducted by registered professional surveyors. Analytical work will be performed by a contract analytical laboratory qualified in performing environmental sample analyses to EPA Contract Laboratory Program (CLP) standards of precision and accuracy, and who participate in laboratory performance evaluations. Additional details concerning overall project and subcontractor responsibilities are described in Section 5.2 of this workplan.

Figure 3-1. Schedule of RFI Phase III Workplan Activities, Three-Mile Ditch and Evaporation Ponds

	WEEK																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
RFI WORKPLAN APPROVAL	■																									
EXISTING DATA REVIEW, H&S PLANS, FIELD WORK 1 SCHEDULING	■	■	■																							
FIELD WORK 1 - MONITOR WELL SAMPLING, RIVER WATER AND SEDIMENT SAMPLING				■																						
LABORATORY ANALYSIS, FIELD WORK 2 SCHEDULING					■	■	■	■																		
FIELD WORK 2 - NEW PIEZOMETER AND MONITOR WELL INSTALLATION, SAMPLING									■	■																
LABORATORY ANALYSIS											■	■	■	■												
DATA EVALUATION/QA, REPORT WRITING/REVIEW															■	■	■	■	■	■						
REQUIRED QA/QC AUDITS, REPORTS		■		■			■		■	■					■				■							
SUBMITTAL OF DRAFT RFI REPORT TO NAVAJO																					■					
SUBMITTAL OF RFI REPORT TO USEPA																								■		

RE/SPEC INC.
RESEARCH SPECIALISTS

prepared for:

Navajo

Schedule of RFI Phase III Workplan Activities, Three-Mile Ditch and Evaporation Ponds

PROJECT: 318/2.1
LOCATION: NAVAJO REFINERY, ARTESIA, NM
APPR:
DATE:
DRAWN BY:
SCALE: AS SHOWN
DATE: 8/16/93
FIGURE: 3-1

4.0 DATA COLLECTION STRATEGY AND STANDARDIZED OPERATING PROCEDURES

Region VI EPA, in their letter of May 19, 1994, required that a Phase III RCRA Facility Investigation be conducted at the Three-Mile Ditch and the active evaporation ponds adjacent to the Pecos River. Correspondence and discussions between Navajo Refinery personnel and their consultants, and EPA Region VI technical staff have led to development of a Phase III workplan for further investigations at these units. Presented below are the strategies to be used in conducting additional investigation at the SWMUs, and the procedures to be used to ensure quality in the collection of field data. The section is organized into a presentation of workplans for each SWMU plus the Peco River identified for study (Sections 4.1.1 through 4.1.3) followed by the standardized operating procedures.

4.1 Data Collection Strategy Plan

The proposed investigation strategies for Three-Mile Ditch and the evaporation ponds are presented in this section. The investigation will focus on identifying the type and extent of potential releases of contaminants to groundwater and will include sediment and water quality sampling of the Pecos River.

4.1.1 Three-Mile Ditch

The following sections present Phase III investigation plans for groundwater in and adjacent to Three-Mile Ditch.

4.1.1.1 Groundwater Investigation

The Phase II RFI included installation of four new monitor wells and three piezometers along the ditch with the locations selected based on the proximity of groundwater, or whether the extent of visibly contaminated hydrocarbon had been delineated, or both, as reported in the Phase I investigation report. The results of groundwater monitoring of these new wells did not show evidence of hazardous organic constituents, or metals concentrations at levels above drinking water standards.

The Phase III groundwater investigation in the vicinity of the ditch will be conducted in two stages. The first stage (field work 1) will be resampling of the TMD monitoring wells while the second stage (field work 2) will be the installation of additonal wells and piezometers. The TMD portion of the Phase III groundwater investigation will include the following activities:

- Measurement of water levels in all available monitor wells and piezometers (Field Work 1)

- Collection of samples from existing TMD monitor wells (Field Work 1)
- Installation of five monitor wells to determine if groundwater contamination has occurred in areas of the ditch where deep soil contamination and/or intersection of the water table has been documented (Field Work 2)
- Installation of two piezometers array to further define groundwater flow geometry in the vicinity of the ditch (Field Work 2)
- Performing borehole aquifer tests, as necessary, to determine *in situ* hydraulic conductivity of new wells (Field Work 2)
- Collection of samples from new monitor wells (Field Work 2)

4.1.1.1.1 TMD Field Work 1

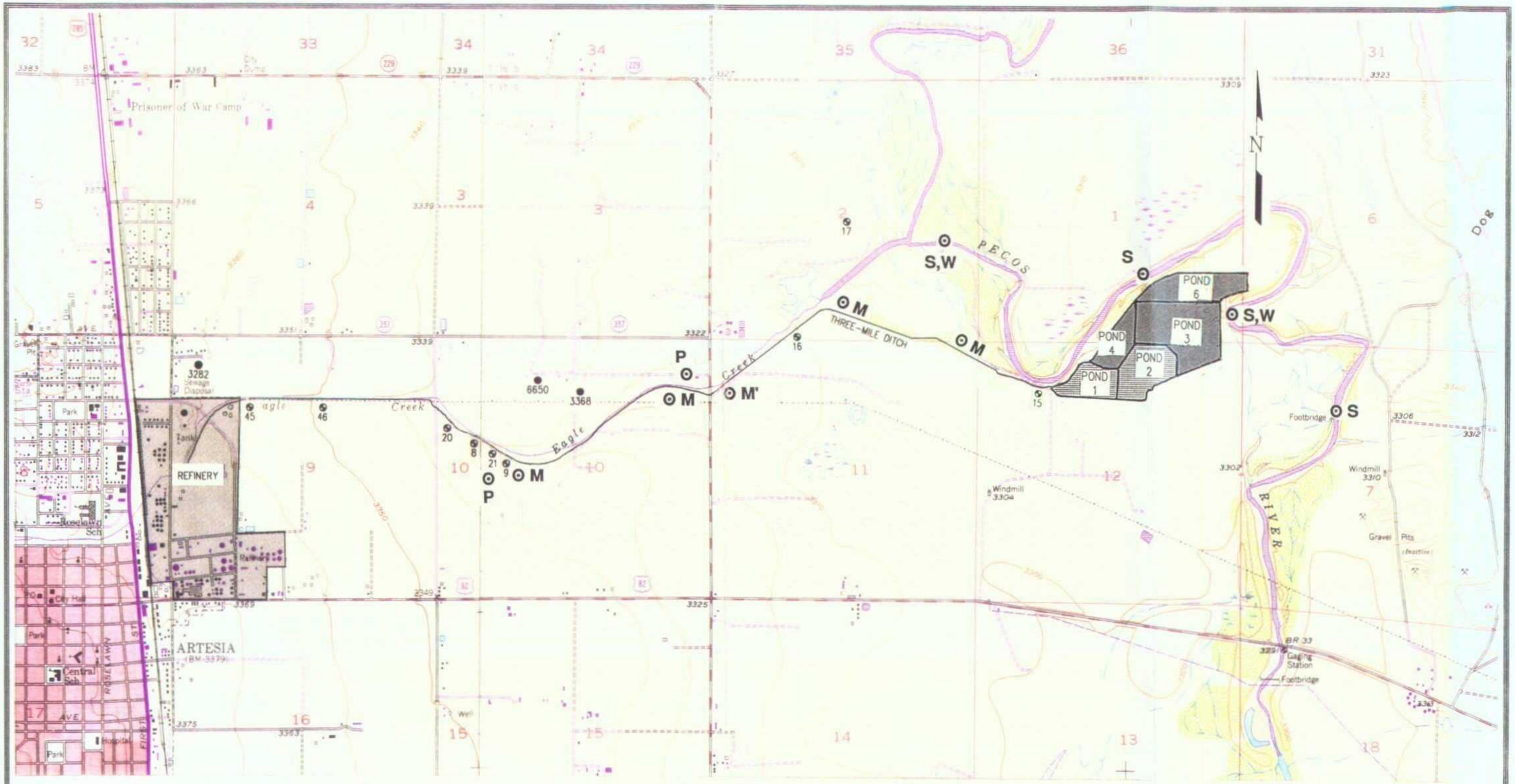
Groundwater elevations of existing TMD monitor wells and piezometers will be measured to determine flow direction and hydraulic gradient in the vicinity of the ditch (Figure 4-1). A description of procedures for making well measurements can be found in Section 4.2.2.1.

TMD monitor wells will be purged and water samples collected pursuant to EPA RCRA guidance. A description of these procedures are presented in Section 4.2.3. Chemical analyses will focus on determination if constituents detected in ditch sediments have impacted adjcent or underlying groundwater. Constituents of concern include volatiles, semi-volatiles, and the heavy metals arsenic, chromium, lead and nickel. For comparison purposes, filtered and unfiltered samples will be collected for metals determination in wells with, or suspected of having, turbidity problems. Filtered samples will be field filtered using a 0.45 micron filter before sample preservation. Additionally, unfiltered samples will be obtained for determination of general water chemistry parameters, as needed, that will allow characterization and comparison with other shallow waters and well water used for drinking and irrigation. Quality assurance procedures to be used in collection and preservation of samples are discussed in Section 4.2.3. Table 4-1 shows the constituents that are to be analyzed for the Field Work 1 groundwater sampling.

4.1.1.1.2 TMD Field Work 2

Two piezometers will be installed along TMD/Eagle Creek. The first location is south of existing monitor wells 8, 9 and 21; and the second is west of Haldeman Road on the north side of Eagle Creek. The proposed locations are shown on Figure 4.1. The purpose of the piezometers, together with measurements of water levels in new and existing monitor wells, will be to determine the relationship between groundwater in the first near-surface saturated zone and Three-Mile Ditch. In the unlikely event that contamination is found while drilling, the piezometers will be completed as monitor wells.

Figure 4-1. Location Map for Proposed Monitor Wells, Piezometers, Three-Mile Ditch; and Sediment and Water Sampling Locations, Pecos River, RFI Phase III.



LEGEND

- ● DOMESTIC WELLS SAMPLED
- ⊛ MONITOR WELL LOCATIONS THREE-MILE DITCH
- ⊙ PROPOSED MONITOR WELL (M) PIEZOMETER (P), SEDIMENT SAMPLING (S) OR SURFACE WATER SAMPLING LOCATION

2000 0 2000 6000 FEET

NOTE: MAP COMPILED FROM USGS ARTESIA AND SPRING LAKE 7.5 MINUTE QUADRANGLE (1973). MONITOR WELLS ADJACENT TO EVAPORATION POND NOT SHOWN

RE/SPEC INC.
RESEARCH SPECIALISTS

prepared for:
Navajo

Location Map for Proposed Monitor Wells, Piezometers Three-Mile Ditch; and Sediment and Water Sampling Locations, Pecos River. RFI, Phase III

PROJECT: 318/2.1
LOCATION: NAVAJO REFINERY
APPR:
DATE:
DRAWN BY:
SCALE: AS SHOWN
DATE: 4/26/93
FIGURE: 4-1

Table 4-1. Basic Elements of the Proposed Groundwater Sampling for Three-Mile Ditch.

Field Work 1

- Water level elevations of all piezometers and monitor wells
- Groundwater sampling of existing monitor wells along Three-Mile Ditch from refinery to Pecos river, including MW-1 and MW-15. Constituents to be sampled are:
  - Field Parameters: pH, temperature, specific electrical conductance
  - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
  - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
  - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
  - Water chemistry: As needed to characterize aquifer water quality

Field Work 2

- Water level elevations of all piezometers and monitor wells
- Groundwater sampling of new monitor wells installed along Three-Mile Ditch. Constituents to be sampled are:
  - Field Parameters: pH, temperature, specific electrical conductance
  - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
  - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
  - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
  - Water chemistry: Sampling of new wells to characterize aquifer water quality.

4.1.1.1.2 TMD Field Work 2

Two piezometers will be installed along TMD/Eagle Creek. The first location is south of existing monitor wells 8, 9 and 21; and the second is west of Haldeman Road on the north side of Eagle Creek. The proposed locations are shown on Figure 4.1. The purpose of the piezometers, together with measurements of water levels in new and existing monitor wells, will be to determine the relationship between groundwater in the first near-surface saturated zone and Three-Mile Ditch. In the unlikely event that contamination is found while drilling, the piezometers will be completed as monitor wells.

The Phase I investigation determined that ditch contamination intersected groundwater or that visibly contaminated material extended an indeterminate distance at a number of trenches. These trenches were NMD-TR-004, -005, 006, 008, 009, 010, 012 and 013 east of the refinery (RFI Phase I Report, 1990). The Phase II investigation determined that material in trenches TMD-TR-001 and 002 was in close proximity to groundwater. During Phase II, MW-20 was installed in the area of trench NMD-TR-004. NMD-TR-005 was investigated in Phase I using previously installed monitor wells MW-8 and MW-9 and in Phase II with the installation of MW-21. The Phase II investigation included installation of an additional shallow monitoring well (MW-16) at the NMD-TR-009 location, and adjacent to TMD-TR-001. The current proposal is to install additional wells (Figure 4-1) near the location of NMD-TR-005, 008, 010 and between NMD-TR-012 and TRD-TR-002. No wells are proposed for NMD-TR-006 and 013. At NMD-TR-006, the hydrocarbon impacted zone was less than 5 in. thick and no groundwater was encountered. Trench NMD-TR-013 is located at the entrance to Pond 1 whose materials and groundwater impacts were extensively characterized in Phase II. Proposed drilling and construction procedures are presented in Section 4.2.1. The new monitor wells will be sampled for BTEX volatiles; semivolatiles; metals arsenic, chromium, lead and nickel; and general water chemistry constituents (Table 4-1). Both filtered and unfiltered metal samples will be analyzed. Samples will be field filtered using a peristaltic pump and 0.45 micron filters. Sampling and field measurement procedures are detailed in Section 4.2.3.

Unless significant contamination is found and verified during the Phase III study, installation of deeper monitoring wells is not anticipated. However, if necessary, deep monitor wells can be installed to define vertical extent of contamination and provide hydrogeologic baseline information. When necessary, deep wells will be completed in the next lower saturated zone and are expected to be approximately 40- to 60-ft-deep. Construction of these wells will include precautions to prevent cross contamination of the water bearing zones. Confining layers encountered will be sampled for permeability analysis. Deep monitor wells will be sampled for those constituents of concern which are elevated in the overlying zone plus water chemistry parameters.

Borehole aquifer tests will be performed on selected monitor wells and on any deep wells which may be installed. Rising level permeability (slug) tests will be performed as explained in Section 4.2.2.2.

The newly installed piezometers and monitoring wells, plus existing piezometers and monitor wells, will be used to obtain static water level measurements for use in preparing groundwater flow direction maps. They will provide detailed information on the potentiometric surface of the near surface groundwater in the vicinity of the Three-Mile Ditch from the refinery eastward. The measurements will be taken with an electric or steel tape to determine groundwater flow direction. Prior to mapping water level measurements, elevations of new and existing monitor wells and piezometers will be verified by a land survey using a registered professional surveyor. Procedures for obtaining static water levels are included in Section 4.2.2.1.

4.1.2 Pecos River Characterization

The following sections present Phase III investigation plans for characterization of sediment and water quality in the Pecos River. The sampling to perform these characterizations will occur during Field Work 1.

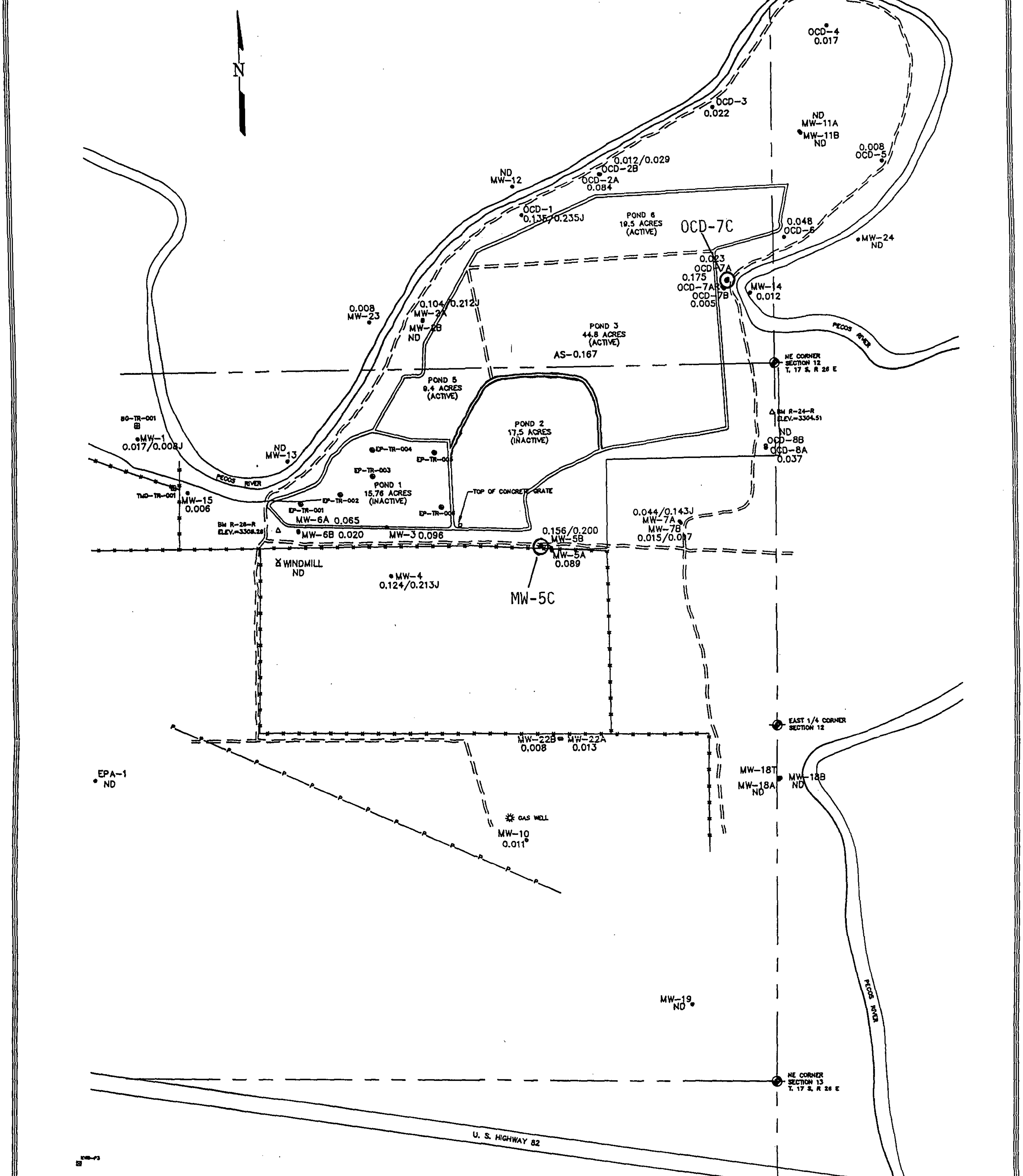
4.1.2.1 Sediment Sampling

Proposed sediment sampling locations on the Pecos River are presented in Figure 4-1. Sediment samples will be collected from the Pecos river at four locations, including: an upstream background location located approximately 1,000 feet downstream from the confluence of the Pecos River and Eagle Creek; two locations situated at points where the river is in close proximity to the unit; and a downstream location situated approximately 4,800 feet downstream from the most downstream point where the unit is proximal to the river. The two locations close to the unit will be located between monitor wells OCD-1 and MW-12, and between monitor wells OCD 7 and MW-14 (Figure 4-2).

At each sediment sample location, a sludge sampler consisting of a stainless steel core (2 by 6 inch) equipped with a butterfly closure valve and attached to a standard hand auger cross handle and extension will be used to collect a representative sediment sample. In order to ensure that a representative, undisturbed sediment sample is obtained, the sample collector will access the river at a point slightly downstream from the target sample location, and will slowly proceed upstream to the sample location. Collected samples will be quickly brought to the river bank, where they will quickly be transferred to appropriate sample containers. In the event that sample analytical needs necessitate the collection of more than one sample per location, the sampler will continue to move upstream for short distances (10-20 feet) upstream of preceding sample locations.

At each location, the sludge sampler will be rinsed with deionized water between successive sample grabs, and will also undergo a thorough decontamination with detergent and deionized water rinse between sampling events at each of the four designated sample locations.

Figure 4-2. Proposed Deep Monitor Well Locations, Evaporation Pond Area, RFI Phase III.



EXPLANATION:

⊞ BG-TR-001 TMD-TR-001	BACKGROUND TRENCH EXPLORATORY TRENCH, THREE-MILE DITCH
● EP-TR-001	EXPLORATORY TRENCH, EVAPORATION POND 1
• MW-4 0.124/0.213J	MONITOR WELL WITH TOTAL ARSENIC CONCENTRATION (mg/l), KWBES/PRC SPLIT SAMPLE (WHERE PERFORMED)
⊠	PIEZOMETER
J	ESTIMATED VALUE
ND	NOT DETECTED AT 0.005 (mg/l)
⊙	Proposed Deep Monitor Well Location

NOTE: MAP COMPILED FROM NAVAJO REFINERY AND USGS SPRING LAKE 7.5 MINUTE QUADRANGLE. WELL LOCATIONS AND ELEVATIONS FROM NAVAJO REFINERY CONTROL. WELL LOCATIONS SURVEYED 2/93, JAQUESS & ASSOCIATES.

LOCATION T 17 S, R 26 E, NMPM, EDDY COUNTY, NM

NOTE: KWBES ARSENIC CONCENTRATION SHOWN IS THE VERIFICATION ANALYSIS OR AVERAGE OF TWO VERIFICATION ANALYSES; IF NO VERIFICATION ANALYSIS WAS PERFORMED, VALUE SHOWN IS ORIGINAL CONCENTRATION.

800 0 800 2400 FEET

RE/SPEC INC.
RESEARCH SPECIALISTS

Proposed Deep Monitor Well Locations, Evaporation Pond Area, RFI Phase III

prepared for:
Navajo

PROJECT: 318/2.1
LOCATION: NAVAJO REFINERY, ARTESIA, NM
APPR:
DATE:
DRAWN BY:
SCALE: AS SHOWN
DATE: 4/27/93
FIGURE: 4-2

Sediment samples will be analyzed for the same suite of volatile and semivolatile organic constituents, and metals as will be sampled for in the groundwater (Table 4-1). Sample handling, documentation and analytical methods are described in Sections 5.5 - 5.7 of this workplan.

4.1.2.2..Surface Water Quality Sampling

Surface water samples will be collected at midstream at two locations: an upstream background location located approximately 1,000 feet downstream from the confluence of the Pecos River and Eagle Creek; and at a location situated adjacent to the final downstream point at which the unit is in close proximity to the river. The downstream location will be located between monitor wells OCD-7 and MW-14 (Figure 4-2).

The sample collector will obtain the surface water samples as grab samples collected directly into appropriate sample containers. If collected by a person present in the water, the sample shall be collected upstream of the collector to avoid possible contamination. The samples will be analyzed for the same suite of volatile and semivolatile organic constituents, and metals as will be sampled for in the groundwater (Table 4-1), except that only total metal concentrations will be determined. Field parameters will be measured and samples for water chemistry analyzes will be obtained. Sample handling, documentation, and analytical methods are described in Sections 5.5 - 5.7 of this workplan.

4.1.3 Active Evaporation Ponds

The following sections describe the RFI Phase III investigation plans for groundwater adjacent to the active evaporation ponds (AEP 3,5,6).

The groundwater investigation in the vicinity of the ponds will include the following activities:

- Measurement of water levels in shallow and deep paired monitor wells and piezometers
- Sampling of selected shallow and deep monitor wells to update and verify constituent concentrations found in the Phase II study
- Sampling of the pond windmill
- Installation of two deep monitor wells to delineate vertical extent of contamination at depths greater than 50 ft, if any, and to provide hydrogeologic baseline information on deeper water zones
- Performing borehole aquifer tests to determine *in situ* hydraulic conductivity, and
- Collection of water quality samples from new monitor wells

4.1.3.1 AEP Field Work 1

Static water level measurements will be obtained from shallow and deep paired monitor wells at the evaporation ponds. The measurements will be taken with an electric tape to update and verify the vertical hydraulic gradient. Procedures for obtaining static water levels are included in Section 4.2.2.1.

Wells selected for sampling (Table 4-2) will be purged and water samples collected pursuant to EPA RCRA guidance. A description of these procedures is presented in Section 4.2.3. At the same time, a grab sample for pond water quality will be obtained from a location midway between the current discharge into Pond 3 and the furthermost end of combined ponds 3 and 6.

Chemical analyses will focus on verification of constituents detected in earlier sampling, mainly metals and BTEX volatile organics. Metal constituents of concern include arsenic, chromium, lead and nickel. For comparison purposes, filtered and unfiltered samples will be collected for metals determination in wells having or suspected of having turbidity problems. Filtered samples will be filtered in the field using a 0.45 micron filter before sample preservation. Additionally, an unfiltered sample will be obtained from the pond for determination of volatiles, semivolatiles, target metals and general water chemistry parameters, including fluoride, that will allow characterization and comparison with other shallow waters and well water used for drinking and irrigation. Quality assurance procedures to be used in collection and preservation of samples are discussed in Section 4.2.3. Table 4-2 shows the constituents that are to be analyzed for the verification sampling.

4.1.3.2 AEP Field Work 2

In addition to the ten deep wells (10 ft screens generally set between 40 and 50 feet beneath the land surface) installed during the RFI Phase II, two additional monitor wells will be installed at locations MW-5 and OCD-7. These will be screened for a length of at least 5 ft beginning at a depth approximately 10 ft beneath the bottom of MW-5B and OCD-7B. Therefore, the depths of these wells are expected to be between 60 and 70 ft but exact depth and screened interval will be determined in the field based on boring lithology. If discrete lithologic intervals are found and are separated by a confining layer, the deep well will be screened opposite the first transmissive zone beneath the confining layer. If no confining layer is found, the well will be screened in a transmissive zone at least 15 ft beneath the deepest contaminated zone as determined by the observation of drill cuttings. Since a secondary objective for the deep wells is determination of vertical gradient, the screened interval will be a maximum of 10 ft in length.

Table 4-2. Basic Elements of the Proposed Groundwater Sampling for the Active Evaporation Ponds.

Field Work 1

- Water level elevations of all shallow and deep paired monitor wells
- Groundwater sampling of deep and shallow monitor wells MW 1-7, 10,11,14,18,19,22; deep and shallow OCD wells1-7, and the pond windmill. Constituents to be sampled are:
    - Field Parameters: pH, temperature, specific electrical conductance
    - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
    - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
    - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
    - Water chemistry: As needed to characterize aquifer water quality

Field Work 2

- Water level elevations of all shallow and deep paired monitor wells
- Groundwater sampling of new deep wells installed at locations MW-5 and OCD-7. Constituents to be sampled are:
    - Field Parameters: pH, temperature, specific electrical conductance
    - Volatiles: Benzene, ethylbenzene, toluene, xylenes, carbon disulfide, and 2-butanone (MEK) using SW-846 method 8240.
    - Semi-Volatiles: Polynuclear aromatic hydrocarbons (PAHs) using SW-846 method 8270.
    - Metals: Total and dissolved arsenic, chromium, lead and nickel using SW-846 methods 7061, 7191, 7421, 7520, respectively.
    - Water chemistry: Sampling of new wells to characterize aquifer water quality.

Construction details for the proposed monitor wells are provided in Section 4.2.1. Construction of deep wells will include installation of a surface casing through the upper zones to prevent cross-contamination of sediments and groundwater, and to prevent short-circuiting of flow that can influence vertical hydraulic gradient measurements.Borehole *in situ* permeability tests (slug tests) will be performed on the two newly installed monitor wells as described in Section 4.2.2.2.

The newly installed monitoring wells, plus the existing paired monitor wells sampled during Field Work 1, will be measured using an electric or steel tape to obtain static water level measurements for verification of vertical hydraulic gradient. Prior to mapping water level measurements, elevations of the new paired monitor wells will be verified by a land survey using a registered professional surveyor. Procedures for obtaining static water levels are included in Section 4.2.2.1.

Newly installed monitor wells will be sampled using procedures described in Section 4.2.3. Analytical tests to be conducted on the samples are shown in Table 4-1.

4.2 Groundwater Investigation Procedures

The objectives of the groundwater investigation program at the Navajo Refinery are to determine the lateral and vertical extent and concentration of any contamination impacting on groundwater associated with Three-Mile Ditch and the evaporation ponds. This section describes the procedures to be followed during the groundwater portion of Navajo RFI Phase III investigation of these units. This includes descriptions of drilling and well installation, hydrogeologic characterization, and sample collection. The type, location, and number of samples to be collected are described in the previous section (Section 4.1).

The procedures presented below are designed to produce:

- Data that are of a consistently high quality, and tailored to the needs and goals of the project
- Samples that are representative of the media under investigation
- Samples that are identified, preserved, and transported in a manner that ensures that they remain intact and produce legally valid data
- Data that are compatible in both type and quality to that produced by previous investigations

All drilling, well installation, well development, groundwater sampling, and other related field activities will conform to state and EPA requirements. Well permits will be acquired from the appropriate agencies and well logs and construction forms will be filed by Navajo's consultant and its subcontractors.

4.2.1 Drilling Procedures

This section describes the specific procedures to be used when drilling soil borings and/or monitoring wells at Navajo Refinery. The objectives of the soil and groundwater investigation program at Navajo Refinery are to determine the areal and vertical extent and concentration of contaminants to facilitate future decision making. To meet these objectives, the drilling program will be performed by personnel following recognized protocols, with all steps, measurements, and anomalies permanently recorded in the field logbook.

The specific objectives of a soil boring program are to:

- Define vertical and areal extent of soil contamination
- Provide stratigraphic logs of each site
- Provide a data base for corrective measures study

The objectives of the monitoring well installation program are to:

- Define the vertical and areal extent of groundwater contamination
- Determine the hydrogeologic characteristics of each site
- Develop a data base for corrective measures study
- Supplement the existing monitoring well network

4.2.1.1 Drilling Methods

Drilling will be conducted using a CME 55™ truck-mounted rig (or equivalent) with 8- or 12-inch hollow-stem augers. Subsurface samples will be collected ahead of the auger flight with a Shelby tube or split spoon sampler, in accordance with ASTM D1587 and D1586, respectively. Samples will be collected at intervals of 5 ft or less, or when changes in lithology are observed. Visual observations of chemicals, discoloration, strong odors, and PID readings, will be noted and logged.

Prior to drilling, each site will be inspected and cleared as necessary to allow access by the drilling rig and crews. Public utilities will be advised of the drilling operations and locations beforehand so that activities do not interfere with subsurface communications or utility lines. Proposed field locations of all monitoring wells and soil boreholes will be marked during the planning/mobilization phase of the field investigation. The RFI program manager will approve all final drilling locations before drilling is commenced.

A geologist will be present at each operating drill rig to log samples, monitor drilling operations, record depth to water table and other groundwater data, prepare borehole logs and well construction diagrams, and record well installation procedures.

All soil cuttings produced during the installation of monitoring wells and piezometers will be collected and placed in the appropriate containers for disposal by refinery personnel.

4.2.1.2 Borehole Logs

Core samples and lithologic descriptions acquired during the drilling of both monitoring wells and soil borings will be recorded on a standard borehole log. The following information will be entered in the log or attached to it:

- Project name and number
- Borehole location and number
- Name and initials of borehole logger
- Description of drilling equipment used, driller's name and company, rig size and manufacturer, and method of drilling
- Special problems encountered and their resolution
- Distinct boundaries between soil types and/or lithologies and depths of occurrences
- Depth of first-encountered groundwater or hydrocarbons, along with method of hydrocarbon determination
- Estimated depth interval for each sample taken or classified, length of sampled interval and length of sample recovery, sampler type and size
- Description of each soil sample taken, according to the methodology in ASTM D2488-84 "Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)". Soil sample descriptions will include the following:
    - Soil type
    - Grain size and shape
    - Grading of the predominant fraction (poor, moderate, or well sorted)
    - Color (according to Munsell Soil Color Charts)
    - Plasticity of fines (nonplastic, low, medium, high)

- Odor, if organic or unusual
- Other observations such as presence of roots or rootholes; mica, gypsum, caliche or other secondary precipitates, or surface coatings on coarse-grained particles
- Sample depths and sample numbers

4.2.1.3 Well Construction

Monitor wells are designed to:

- Allow sufficient groundwater flow for well sampling
- Minimize the passage of formation materials (turbidity)
- Provide sufficient structural integrity to prevent the collapse of the intake structure

After drilling, well casing, screen, filter pack, bentonite seal, and grout are placed within the borehole, and the wellhead is completed with a cement seal and locking surface casing. Typical installation are shown in Figures 4-3 and 4-4.

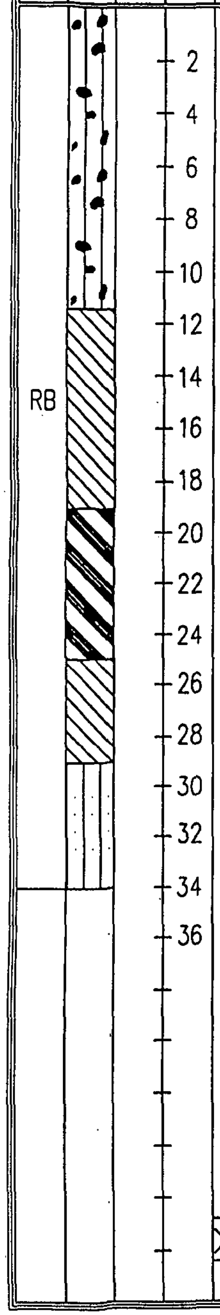
Monitoring wells will be completed with either 2- or 4-inch (I.D.) schedule 40 PVC casing with 0.01-inch machine-sloted screen using 8- or 12-inch (O.D.) augers, respectively. The larger casing size will be used in areas most likely to require future remediation. All piezometers will be completed with 2-inch (I.D.) schedule 40 PVC casing with 0.01-inch machine-sloted screen using 8-inch (O.D.) augers. Casing sections will be flush threaded with screw joints.

The screened interval will range from 5 to 10 ft and intercept the water table (allowing for seasonal fluctuations) in the case of an unconfined aquifer, or intercept the upper confining boundary in the case of a confined aquifer. An 18-inch sediment sump will be included below the screen on the casing of each 5 ft monitoring well and piezometer due to the silty nature of the aquifer. The endings, casings, and screens will be steam-cleaned prior to use in order that they are free of contaminants. Cleaned materials will be wrapped in plastic sheeting or placed on racks during storage. The geologist on site is responsible for the supervision of all steam-cleaning procedures.

A sand pack consisting of No. 2 quartz sand and extending from the base of the boring to 2 ft above the top of the screen will be placed using a tremie pipe to insure completely filling the annular space. If flowing sands are encountered in the saturated zone the well casing and sand pack will be installed within the auger-string to ensure annular integrity is maintained during their installation.

Figure 4-3. Single Cased Monitoring Well or Piezometer Completion Detail, RFI Phase III Work Plan, Navajo Refinery.

Samp. Meth.	Samp. Log	PID (ppm)	Depth (Feet)



Geologic Description

0-11.5' SILTY GRAVELS, sand and silt are tan, dry, gravel is well rounded.

11.5-19' SANDY CLAY, reddish/brown, moist, plastic, clay content increasing with depth.

19-25' CLAY, brown, moist, plastic.

25-29' SANDY CLAY, brown, saturated.

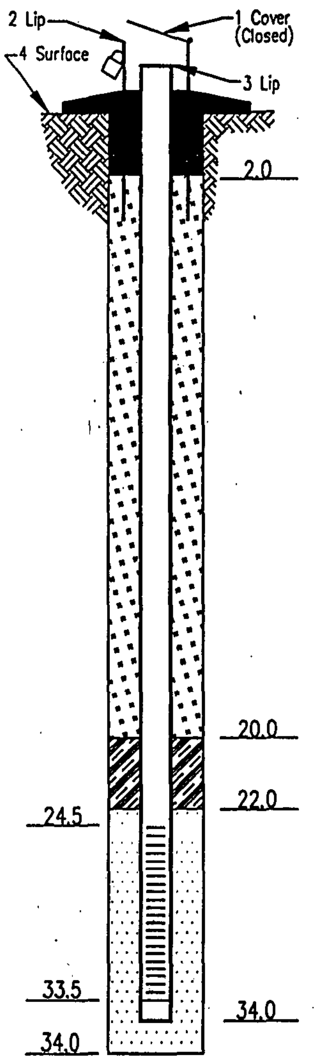
29-34' SILTY SAND, brown, saturated, fine grained.

TD = 34.0'

Sample Method Symbols

☒ RB=Recovery Barrel	☒ 5'	☐ ____	
ST=Shelby Tube	SS=Split Spoon	C=Cutting	

Monitoring Well		
Piezometer	X	
Protective Casing		NO



Depths in Feet from Ground Surface (Not to Scale)

LOG-1

Design Specifications

Elevations: 1 3345.01 2 3344.99
(feet MSL) 3 3344.84 4 3342.10
Coordinates: X 2960.65 Y 6120.29
Bore Hole Diameter: 8"
Type of Casing: ☒ PVC Sched. 40 Flush Thread ☐ Stainless Steel ☐ ____
Casing Diameter: ☒ 2" ☐ 4" ☐ 6" ☐ ____
Screen Slot: ☐ 0.008 ☒ 0.010 ☐ ____
Screen Style: ☒ Machine Slot ☐ Wire Wrap ☐ ____
Sand Pack: C.S.S.I. 20/40
Bentonite Seal: ☐ 1/4" Pellets ☒ 1/2" Pellets ☐ 1/2" Chips ☐ Hole Plug ☐ ____
Grout Type: Portland/Bentonite Weight: ____
Drill Rig: ☒ Hollow Stem ☐ Rotary ☐ ____
Drilled By: Pool Environmental Lic. #: WD 1266
Logged By: PWC
Completion Date: 01/23/93
Depth First Encountered Water: 25.0'

Date	D-T-W	D-T-P	Prod Thick	Field pH	Field EC
2/10/93	18.58				

Comments: Example of single cased monitoring well/piezometer.

RE/SPEC

FIGURE: 4-3

PROJECT: 318/2.1
LOCATION: ARTESIA, NEW MEXICO

Figure 4-4. Double Cased Monitoring Well Completion Detail, RFI Phase III Work Plan, Navajo Refinery.

Samp. Meth.	Samp. Log	PID (ppm)	Depth (Feet)	Geologic Description

Sample Method Symbols

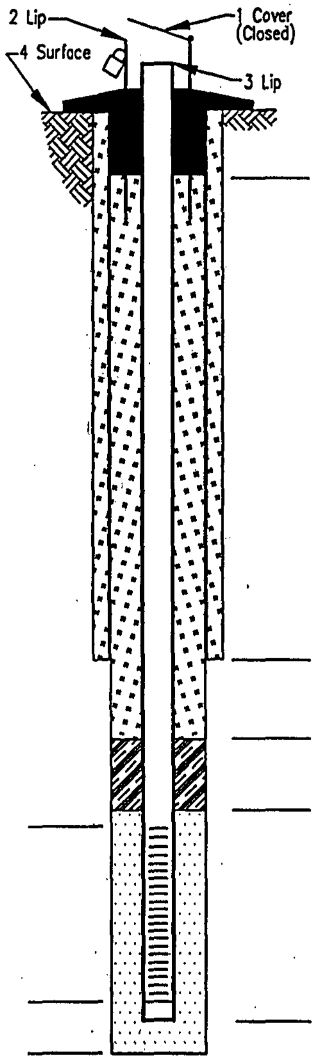
RB=Recovery Barrel ☐ 5' ☐ ______

ST=Shelby Tube | SS=Split Spoon | C=Cutting

Monitoring Well

Piezometer

Protective Casing



Depths in Feet
from Ground Surface
(Not to Scale)
LOG-3

Design Specifications

Elevations: 1 ______ 2 ______
(feet MSL) 3 ______ 4 ______

Coordinates: X ______ Y ______

Bore Hole Diameter: (Inner) ______ (Outer) ______

Type of Casing: (Inner) ☐ PVC Sched. 40 Flush Thread
☐ Stainless Steel ☐ ______
(Outer) ☐ ______

Casing Diameter: (Inner) ☐ 2" ☐ 4" ☐ 6" ☐ ______
(Outer) ☐ 2" ☐ 4" ☐ 6" ☐ ______

Screen Slot: ☐ 0.008 ☐ 0.010 ☐ ______

Screen Style: ☐ Machine Slot ☐ Wire Wrap ☐ ______

Sand Pack: ______

Bentonite Seal: ☐ 1/4" Pellets ☐ 1/2" Pellets
☐ 1/2" Chips ☐ Hole Plug ☐ ______

Grout Type: ______ Weight: ______

Drill Rig: ☐ Hollow Stem ☐ Rotary ☐ ______

Drilled By: ______ Lic. #: ______

Logged By: ______

Completion Date: ______

Depth First Encountered Water: ______

Date	D-T-W	D-T-P	Prod Thick	Field pH	Field EC

Comments: Example of double cased monitoring well/piezometer.

RE/SPEC

Navajo

FIGURE: 4-4

PROJECT: 318/2.1
LOCATION: ARTESIA, NEW MEXICO

The screened interval will range from 5 to 10 ft and intercept the water table (allowing for seasonal fluctuations) in the case of an unconfined aquifer, or intercept the upper confining boundary in the case of a confined aquifer. An 18-inch sediment sump will be included below the screen on the casing of each 5 ft monitoring well and piezometer due to the silty nature of the aquifer. The endings, casings, and screens will be steam-cleaned prior to use in order that they are free of contaminants. Cleaned materials will be wrapped in plastic sheeting or placed on racks during storage. The geologist on site is responsible for the supervision of all steam-cleaning procedures.

A sand pack consisting of No. 2 quartz sand and extending from the base of the boring to 2 ft above the top of the screen will be placed using a tremie pipe to insure completely filling the annular space. If flowing sands are encountered in the saturated zone the well casing and sand pack will be installed within the auger-string to ensure annular integrity is maintained during their installation.

The field geologist will record the start and stop times of the sand packing, the depth intervals that sand was packed, the amount of sand used, and any problems that arise. The geologist will also record the type of materials used for packing, including trade name, source, supplier, and typical grain size distribution.

A bentonite seal with a minimum thickness of 2 ft will be placed in the annular space above the sand pack using a tremie pipe and allowed to set-up for at least 30 minutes prior to grouting. The bentonite used will either be granular, or a slurry that is thick enough to prevent significant penetration of the underlying gravel pack. The geologist will record the start and stop times of the bentonite seal emplacement, the interval of the seal, the amount of bentonite that was used, and any problems that arose. The geologist will also record type of bentonite and the supplier.

All monitoring wells and piezometers will be grouted from the top of the bentonite seal to within 3 ft of the ground surface using a tremie pipe. The grout mixture placed above the bentonite will be composed of a 10:1 ratio of Portland cement to bentonite powder (by weight) and will contain only enough water for a pumpable mix. The grout will be allowed to set-up for 24 hours before surface completion in order to avoid problems related to settlement.

QA/QC measurements of various well dimensions will be completed for each well unless the depth of the well makes measuring the total length of the screens and casings on the ground surface impractical. QC measurements consist of the distances from the top of the well casing to the:

- Top of the bentonite seal
- Top of the filter pad
- Top of the screen

- Bottom of the well

If direct measurements to the screens and casings cannot be made, the number and length of screen and casing sections will be counted individually and summed to determine the total length of screens and casings.

Monitoring wells and piezometers will be completed at the surface with the well casing extending approximately 3 ft above grade wherever possible. A steel or aluminum protective cover with locking cap will be placed over the casing riser and extend 2 ft below grade. The well head will be surrounded by a 4-ft by 4-ft by 4-inch cement pad which slopes away from the center.

In the event a monitoring well or piezometer must be completed at grade the well casing will be cut-off at grade and a locking well cap will be placed on the casing. A protective steel sump with a water-tight cover will be placed over the casing and the locking cap. The sump will extend 2 ft below grade and allow at least 6 inches of vertical space between the top of the casing and the floor of the sump for water collection in the event of cover leakage. The cover of the sump will be at least 1 inch above grade and will be surrounded by a round 3-ft diameter by 4-inch cement pad which slopes away from the center.

The locks on the well caps will either have identical keys, or be keyed for opening with one master key. The lock keys will be turned over to Navajo Refinery personnel after the completion of fieldwork. Each well will be clearly identified with a permanent identification tag on the inside of the protective cover.

In areas subject to vehicle traffic, three, 3-inch diameter, cement-filled steel guard posts will be installed around each well completed above grade. The guard posts will be set in individual concrete footings and extend 2 ft below ground and 3 ft above ground.

The elevations and locations of all monitoring wells and piezometers will be determined by a land surveyor at the close of the fieldwork. The elevation of the ground surface and top of the well casing will be determined to 0.01 ft based upon a previously established benchmark. The location of each well will be determined to 0.01 ft relative to a previously established benchmark.

4.2.1.4 Well Completion Documentation

Information concerning drilling details, well construction, sample collection, and other pertinent information will be presented on a well completion form for each monitoring well and piezometer installed at the Navajo Refinery. The lithologic information from the soil boring log (Section 4.2.1.2) may be combined with the well completion form for a single borehole/well completion log. Following is a detailed listing of the information to be described on the logs:

- Project name and number
- Borehole or well identification number
- Name and initials of person(s) logging the well
- Drilling equipment used, driller's name and company, rig size and manufacturer and method of drilling
- Materials used for well casing, sand pack, grout, and surface completion
- Final well construction specifications including total depth of the well, depth of the screened interval, depths to the top of the sand pack, bentonite seal, and grout
- Elevation of the top of the well casing, top of the protective cover, top of the cement pad, and ground surface
- Any special problems encountered during well installation and their resolution
- All depth-to-water measurements to date (and depth-to-hydrocarbon if encountered)
- Complete lithologic description of geologic materials encountered (as presented in Section 4.2.1.2)
- Visual observations of contamination including presence of free-phase hydrocarbons, discoloration of geologic materials, and odors

4.2.1.5 Well Development

Well development is the process by which the aquifer's hydraulic conductivity is restored by removing mobile particulates from within and adjacent to newly installed wells. Well development substantially minimizes the amount of fine materials that may accumulate in the well between sampling events, thus reducing the amount of purging needed to obtain a clear sample.

The wells will be developed using a combination of bailing, surging, and pumping. The fine-grained materials accumulated in the well casing will be bailed from the well until the bottom of the well casing can be reached. After bailing a Grundfos^{TM} Redi-flo2 2-inch submersible pump will be used to develop the well. In the event the well appears to be producing at an unusually low rate, the pump will be removed and the well will be surged using a surge block. Surging will be accomplished by lifting and dropping the tool through the column of water in the well. The entire screened interval will be surged in 5-ft sections using approximately 10-20 iterations per section. Any fine sediments which entered the well during surging will be removed with a bailer prior to resuming pumping. If the discharge rate of the well remains low the purging process will be repeated.

Electrical conductivity, pH, and temperature will be monitored throughout the development process. After the parameters have stabilized (i.e., less than 10% variability between readings) and at least three well volumes have been removed the development process will be complete. A single well volume is considered to be the volume of water in the well casing plus the volume of water in the sand pack.

All fluids produced during development will be collected in drums provided by the refinery and disposed in the refinery wastewater treatment system.

4.2.1.6 Equipment Decontamination

All drilling equipment will be thoroughly steam-cleaned prior to each monitoring well and piezometer installation to prevent the possibility of cross-contamination. All steam-cleaning will be performed at the refinery steam rack and all runoff will enter the refinery wastewater treatment system. Any disposable materials which may be contaminated will be collected and placed in appropriate containers for proper disposal.

All well-development equipment will be decontaminated prior to use at each monitoring well and piezometer to prevent the possibility of cross-contamination. Decontamination will consist of washing equipment in Liquinox™ detergent. Equipment will be rinsed first with drinking quality water and then with distilled water. All decontamination solutions will be discharged into the refinery wastewater treatment system. Any disposable materials which may be contaminated will be collected and placed in appropriate containers for proper disposal.

4.2.2 Hydrogeological Techniques

This subsection reviews procedures for characterizing groundwater system associated with the evaporation ponds. These procedures include groundwater elevation measurements and the determination of various aquifer parameters related to flow velocity and transport of dissolved phase contaminants.

4.2.2.1 Groundwater Elevation Measurements

In this investigation, groundwater elevation will be measured at each monitoring well and piezometer prior to each sampling event using an electronic depth-to-water meter. The depth-to-water meter is accurate to 0.01 ft. Measurements will be taken from a clearly marked reference point on the top of the well casing. The elevation of the reference point will be established through surveying as described in Section 4.2.1.3.,Well Construction. The depth-to-water meter will be decontaminated prior to use at each well.

If a measurable layer of free-phase hydrocarbon (>0.01 ft) is encountered on the surface of the groundwater a hydrocarbon-water interface probe will be used to measure the depth to product and the depth to groundwater following the above protocol. The hydrocarbon-water interface probe is accurate to 0.01 ft.

4.2.2.2 Hydrogeologic Parameters

Well discharge rate is obtained by measuring the time necessary for the groundwater to fill a container of known volume. This rate will be recorded in the logbook in gallons per minute (gpm).

Hydrologic parameters such as hydraulic conductivity, transmissivity, and similar characteristics will be obtained as necessary from the tests described below or from the extensive hydrogeologic literature available on the site.

Aquifer tests will be conducted to quantify key hydraulic parameters such as transmissivity and hydraulic conductivity. Single or multiple well tests may be conducted, with tests using observation wells being the preferred approach to overcome small variations in pumping and friction losses in the pumped well. Single well tests are most useful for finer grained materials and the most common of these is the "slug" test. During a slug test, a known volume of material (a "slug") is instantaneously inserted or withdrawn while simultaneously recording borehole water elevations. Aquifer and slug tests will be conducted and the results analyzed using standard hydrogeological methods utilized by experts in the groundwater profession.

4.2.3 Groundwater Sample Collection

The following section describes the purging, sample collection and decontamination procedures for collecting groundwater samples from monitoring wells at the Navajo Refinery. Prior to purging or sampling, the groundwater elevation will be measured and recorded at each monitoring well using the protocol set forth in Section 4.2.2.1, Groundwater Elevation Measurements.

4.2.3.1 Well Purging

Prior to collection of groundwater samples each well will be purged to ensure that the sample will be representative of groundwater conditions. A minimum of three well volumes will be removed and the electric conductivity, pH, and temperature of the groundwater will be monitored during purging. Purging will continue until these parameters have stabilized and at least three well volumes have been removed. If the well is pumped dry before three well volumes have been removed, the well will be allowed to recover to within 90% of the original water level elevation and will be purged a second time. If the well is pumped dry a second time before three well volumes have been removed the well will be considered to be purged. The water level will be allowed to recover to within 90% of the original elevation and the well will be sampled.

4.2.3.2 Sample Collection

Groundwater sampling from newly-constructed monitoring wells will not commence until approximately 24 hours after well development to allow groundwater in the well to reach equilibrium conditions. Groundwater samples will be taken first from the least expected contaminated monitoring wells and proceed in the order of increasing expected contamination. Contamination levels will be estimated from available data and literature.

A groundwater sample will be taken only after purging is complete and the well has recovered to within 90% of the original water level elevation. A disposable Teflon bailer and nylon twine will be used to collect groundwater samples. Latex gloves will be worn at all times during sample collection to insure the safety of personnel and to prevent cross-contamination between wells. Plastic sheeting will be placed around the well-head to ensure that the bailer line does not touch the ground while raising or lowering the bailer in the well. The sample will be poured from the bailer directly into the appropriate sample container with any necessary preservatives previously added. If appropriate, the sample will then immediately be placed in a cooler containing ice. All QA/QC samples including trip blanks, field blanks, and duplicates will be added to the cooler at the time of sampling. Special precautions will be taken to insure sample integrity is maintained during transport.

Samples from water supply wells will be handled somewhat differently. For irrigation wells which are in operation at the time of sampling, a sample will be collected at the outlet pipe to the ditch or field. For drinking water/domestic wells, or irrigation wells not in operation, samples will be collected after pumping for at least 10 minutes. Domestic wells will be sampled from a faucet nearest the well and upstream of any water treatment equipment. If possible, the pressure tank also will be bypassed.

4.2.3.3 Equipment Decontamination

All groundwater sampling equipment will be decontaminated prior to use at each monitoring well and piezometer to prevent the possibility of cross-contamination. Decontamination will consist of washing equipment in Liquinox^{TM} detergent. Equipment will be rinsed first with drinking quality water and then with distilled water. All decontamination solutions will be discharged into the refinery wastewater treatment system. Equipment that is dedicated to a well will not require decontamination after use. Any disposable materials which may be contaminated will be collected and placed in appropriate containers for proper disposal.

5.0 QUALITY ASSURANCE PROJECT PLAN

5.1 Purpose and Scope

The purpose of this Quality Assurance Project Plan (QAPP) is to document the quality assurance requirements applicable to the work conducted by Navajo Refining Company and its subcontractors during the conduct of the facility investigation. This plan describes the requirements for organizing, planning, performing, reviewing and documenting activities which affect the quality of work conducted on the Navajo Refining site by personnel, consultants and subcontractors of Navajo. This plan is intended to incorporate the requirements of the EPA. The scope of this plan includes field sampling, analytical testing, equipment maintenance, data reduction and reporting.

The project QAPP as presented herein applies to all work performed by Navajo Refining and subcontractors whether performed at the site or in any office or laboratory.

All sampling and laboratory analyses will be conducted in accordance with protocols and guidelines set forth in this document. Specifically, this includes the following areas:

- Preparation of sample containers
- Sampling procedures
- Sample preservation
- Sample custody
- Sample holding time
- Analytical procedures
- Calibration procedures and frequency
- Data reduction validation
- Internal QC checks

5.2 Project Organization and Responsibility

5.2.1 Overall Responsibility

Navajo Refining Company's designated program manager is responsible for the overall management of the investigation. Although subcontractors may be used for some project tasks, Navajo assumes full responsibility for ensuring that their actions comply with all aspects of the approved workplan (e.g., SOPs, Health and Safety Plan, and Quality Assurance Project Plan).

The program manager will be Navajo's prime point of contact with the EPA and will have responsibility for technical, financial and scheduling matters. Furthermore, the program manager will coordinate the deployment of corporate resources required to successfully complete the project. In the program manager's absence, a designated representative will act as the point of contact.

5.2.2 Subcontractor Responsibility

The types of subcontractors which will be utilized in the monitoring and sampling field activities and their anticipated project task(s) are listed below:

Subcontractor	*Field Task*
Chemical laboratory	Chemical analysis
Drilling company	Subsurface exploration
Consulting geologist	Field/sampling coordination

Each subcontractor will be responsible for following the approved guidelines included in the RFI. The program manager will coordinate all field activities to ensure the safe and proper performance of all activities.

5.2.3 Quality Assurance

Overall QA Responsibility

The program manager has overall responsibility for establishing the QAPP and for its implementation in all project activities.

The Project Quality Assurance/Quality Control (QA/QC) Officer reports to the program manager, and coordinates with the program manager in the implementation of the QAPP. The project QA Officer has access to all project personnel. He has the responsibilities to monitor and verify that the project work is performed in accordance with the QAPP, and approved procedures, and to assess overall QA effectiveness.

Field QA Responsibility

The Project QA Officer has responsibility for the onsite field QA. The QA/QC Officer and/or an assigned representative will work closely with the field staff and subcontractors to ensure that they are in compliance with all field requirements of the QAPP.

Laboratory QA Responsibility

The Laboratory Director and/or Chief Quality Control Officer will be responsible to the program manager for completion of the analytical tasks and associated QAPP activities. Quality Coordinators will be assigned by the laboratories management to implement the project QAPP and to monitor project activities on a daily basis for conformance. They will report to the Project QA/QC officer on QAPP activities.

QA Reports to Management

Section 5.14 of this QAPP describes the periodic QA reporting requirements for the RFI.

After the field work has been completed and the chemical analyses and soil testing are completed and assessed, a final quality assurance report will be prepared to be included in the final RFI report. The report will summarize the QA and audit information, indicating any corrective actions taken and the overall results of the QAPP. The Project QA/QC Officer, in coordination with the laboratory Quality Coordinators, will prepare the summary.

5.2.4 Performance and Systems Audits

Internal audits are performed to review and evaluate the adequacy of the QAPP, and to ascertain whether it is being completely and uniformly implemented. The project QA Officer is responsible for such audits and will cause them to be performed according to a schedule planned to coincide with appropriate activities on the project schedule.

Section 5.9 and 5.10 of this QAPP describes the periodic field and laboratory assessments and performance and systems audits to be completed during the RFI.

5.3 Quality Assurance Objectives

The overall objective of the Navajo Refining RFI is to provide a complete, accurate, precise and representative summary of the current state of the site. The samples and the data generated from these samples and the site generated data must provide the information necessary to complete the site summary. However, all data are subject to some error such as inability to collect samples, sampling analysis errors, faulty selection of sampling sites or inappropriate data reduction. Control or recognition of these errors is important in analyzing the data and in preparing the final summary. Establishing appropriate levels of control over sources of error and quantifying these errors when possible will assist in assessing the impact of errors on the project.

5.3.1 Quality Assurance Objectives

Quality assurance objectives for measurement data are usually expressed in terms of accuracy, precision, completeness, representativeness, and comparability. Definitions and descriptions of how these characteristics will be obtained are as follows:

Accuracy

Accuracy is a measure of the system bias. Bias is defined as the difference between the mean (average) of the true sample values and mean (average) of the laboratory analyses. The exact system bias will never be known since the true sample values are not accessible, however, inferences can be drawn from an examination of field and trip blank analyses and laboratory matrix spiked sample analyses. Field blanks measure the bias introduced by contaminated equipment, sample handling and shipping and laboratory procedures. Trip blanks measure the bias introduced by field, shipping, and laboratory procedures. Spiked samples measure biases in laboratory analyses.

Acceptable accuracy measures are dependent on the sample matrix and are discussed in Section 5.3.5. Accuracy measures are not meaningful for the screening tests conducted in the field based on the semiqualitative/quantitative data acquired from the PID and FID and the nature of the pH and temperature conductivity meters. Accuracy of the pH and temperature/conductivity meters will be checked by calibrating prior to daily use and a calibration check at the end of the day's use.

Precision

Precision is the measure of the variability of individual sample measurements. Precision will be inferred through the use of duplicate samples. If duplicate samples contain identical contaminant concentrations, any variability in the laboratory analyses must be due to variability induced by sampling, handling, or laboratory procedures. Acceptable precision values are dependent on the sample matrix and are discussed in Section 5.3.5. Precision values for field screening are not meaningful based on the lack of reproducibility of the samples. Field screening will be in a real time mode making duplication very difficult for the PID and FID. The pH and temperature/conductivity meters are continuous readout instruments and duplicate readings of the same sample will not yield precision values. Duplicate geotechnical tests will not be run based on the heterogeneity and expected variations of the materials.

Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. Completeness is usually expressed as a percentage.

Navajo's goal for this project is 100% completeness. However, site access, sampling protocol problems, analytical problems, and the data validation process can all contribute to missing or suspect data.

Comparability

Comparability expresses the confidence with which one set of data can be compared with another. Comparability can be related to precision and accuracy as these quantities are measures of data reliability. At this site, no attempt will be made to quantify the relative reliability of data obtained during different studies.

Qualitatively, data subjected to strict QA/QC procedures will be deemed more reliable than other data. Field data will be obtained from a given procedure and will be reported in consistent units to allow for easy comparisons.

Representativeness

Representativeness is the degree to which a set of data accurately reproduce the characteristics of the population. Data are usually considered representative if the sample distribution is within statistically defined bounds of the population mean and variance.

Representativeness will be controlled by the preliminary data assessment and by performing all sampling in a meticulous manner in strict compliance with the procedures described in Sections 4.1 and 4.2.

5.3.2 Field Data Quality Objectives

The field data quality objectives (DQOs) can be broken into two major segments: those pertaining to field observations and field instruments and those related to sample selection, collection and shipping. Monitoring well sampling field activities and observations will be coordinated with the appropriate field instruments.

These activities will provide general and detailed information regarding the site condition that will be used in the final site evaluation.

All activities will be executed per the standard operating procedures found in Sections 4.1 and 4.2. Calibration of the field equipment adherence to operational procedures and documentation of all observations and readings will assure the accuracy, completeness and representativeness of the data. Because of the general and qualitative measurements from most of these procedures, accuracy and precision values are not applicable.

Groundwater, surface water and sediment will be sampled during the RFI. The results from sampling these media will be used to develop the analytical data base to provide answers to questions regarding the site and, ultimately, to generate the overall summary of the current state of this site. The analytical data must be sufficiently accurate and precise to identify the compounds present and the respective concentrations.

Field duplicates, field blanks, and trip blanks will be collected and submitted to the analytical subcontractor laboratory to provide data for assessing the quality of these data. Duplicate samples will be collected and analyzed to check for sampling and analytical reproducibility. Blank samples will be collected and analyzed to check for systematic errors in the sampling and analytical procedures and ambient site conditions.

The following paragraphs discuss the DQO's for each sample media.

Groundwater and Surface Water Samples

Groundwater samples will be collected from the existing and proposed monitoring wells associated with the Three-Mile Ditch and the Evaporation Ponds. Analysis of the groundwater samples will provide qualitative and quantitative data to assess the extent of groundwater contamination.

Surface water samples will be collected from sampling locations in the Pecos River. Analysis of the surface water samples will provide qualitative and quantitative data to assess any impact of the evaporation ponds on the Pecos River.

Water samples will be collected as described in Sections 4.1 and 4.2. Samples will be field screened for pH, temperature and conductivity. Accuracy of the field screening will be confirmed with pre-activity and post-activity calibration of the instrument. Representativeness will be controlled by the preliminary existing well assessment and attention to appropriate sampling procedures. Sampling deviation will be noted in the field log book.

Sediment Samples

Sediment samples will be collected from the Pecos River. Analysis of these samples will provide qualitative and quantitative data to assess any impact of the evaporation ponds on the Pecos River.

Sediment samples will be collected per Section 4.1.2.1. Representativeness will be controlled by proper documentation of the sampling locations and careful attention to the appropriate procedure. Sampling deviation will be noted in the field log book at the time of occurrence.

5.3.3 Analytical Laboratory Data Quality Objectives

All groundwater, surface water and sediment samples will be analyzed using ASTM and EPA procedures. The quality assurance goals for these analyses are established in the referenced procedures.

5.3.4 Level of Quality Assurance

The quality control procedures used for this project and their frequency for the target compounds are described in Table 5-1. The laboratory will report and submit QA/QC data identifying the samples used for matrix spikes and matrix spike duplicates, the surrogate spikes and the percent recoveries and laboratory duplicates.

5.3.5 Accuracy and Precision

The quality control limits of accuracy and precision for organic analyses are shown in Tables 5-2 and 5-3. Table 5-2 lists the organic surrogate spike recovery limits for volatiles for water and soil/sediment matrices. Table 5-3 lists the matrix spike recovery limits for water and soil/sediment for volatiles. These control limits will be completely without any outliers unless the results are deemed to be altered due to matrix effects. Any outliers will be evaluated so that matrix interferences effects may be determined. All such evaluations will be noted in the narrative for the respective set of samples. Table 5-4 lists the precision, accuracy and completion objectives for the inorganics.

5.3.6 Method Detection Limits

The method detection limits for the volatile and semivolatile organic parameters monitored are listed in Table 5-5. Table 5-6 lists the detection limits for the inorganics.

5.4 Sampling Procedures

The QC sample collection procedures are covered by this section. Sections are included regarding the methodology for documenting sample locations, sample numbers, sample containers, and sample preservation and decontamination.

5.4.1 Sampling Locations and Numbers

Preliminary sample locations have been predetermined for some tasks based on available data and/or the project data objectives (See Section 4.1). However, the exact location of all samples will be determined in the field based upon field conditions. The locations will be determined by either the program manager or the designated field coordinator. The EPA onsite coordinator(s) will be consulted, if present.

The exact locations of each sampling point will be described in the project logbook along with a sketch that includes a minimum of two, if possible three, distance measurements. The measurements will be referenced to marked grid stakes and/or from permanent ground features and landmarks which are included on the site map.

Table 5-1. Quality Control Procedures, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Table 5-1. Quality Control Procedures, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Parameter	Lab Blanks	Spikes or Surrogates	Lab Duplicates	Reference Samples
Volatiles	One per set of samples, every 12 hours or with every 20 samples, whichever is more	Surrogate added to each sample and blank, MS [a] for each set or every 20 samples, whichever is more MDS [b] for each set or every 20 samples, whichever is more	--	Quarterly
BN/A	One per set or every 20 samples	Surrogate added to each sample and blank, MS [a] for each set or every 20 samples, whichever is more MDS [b] for each set or every 20 samples, whichever is more	--	Quarterly
Metals	One per set or every 20 samples	One spike per set of samples or for every 20 samples, whichever is more	Duplicate for each set or every 20 samples, whichever is more	Quarterly

[a] MS Matrix Spike

[b] MSD Matrix Spike Duplicate

Table 5-2. Organic Surrogate Spike Recovery Limits, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Fraction	Surrogate Compound [a]	Low/Medium Water [b] (%)	Low/Medium Soil/Sediment [b] (%)
VOA	Toluene-d_8	88-110	81-117
VOA	4-Bromofluorobenzene	86-115	74-121
VOA	1,2-Dichloroethane-d_4	76-114	70-121
BNA	Nitrobenzene-d_5	35-114	23-120
BNA	2-Flurobiphenyl	43-116	30-115
BNA	p-Terphenyl-d_{14}	33-141	18-137
BNA	Phenol-d_5	10-94	24-113
BNA	2-Flurophenol	21-100	25-121
BNA	2,4,6-Tribromophenol	10-123	19-122

[a] Surrogate compounds listed are preliminary. Any proposed changes will be submitted to U.S. EPA for approval with the designated laboratories' internal QA/QC plan.

[b] These limits are for advisory purposes only. They are not used to determine if a sample should be reanalyzed. When sufficient data becomes available, the U.S. EPA may set performance based contract required windows.

Table 5-3. Matrix Spike Recovery Limits, Volatiles, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Fraction	Matrix Spike Compound	Water [a] (%)	Soil/Sediment [a] (%)
VOA	1,1-Dichloroethene	61-145	59-172
VOA	Trichloroethene	71-120	62-137
VOA	Chlorobenzene	75-130	60-133
VOA	Toluene	76-125	59-139
VOA	Benzene	76-127	66-142
BN	1,2,4-Trichlorobenzene	39-98	38-107
BN	Acenapthene	46-118	31-137
BN	2,4-Dinitrotoluene	24-96	28-89
BN	Pyrene	26-127	35-142
BN	N-Nitroso-Di-n-Propylamine	41-116	41-126
BN	1,4-Dichlorobenzene	36-97	28-104
ACID	Pentachlorophenol	9-103	17-109
ACID	Phenol	12-89	26-90
ACID	2-Chlorophenol	27-123	25-102
ACID	4-Chloro-3-Methylphenol	23-97	26-103
ACID	4-Nitrophenol	10-80	11-114

[a] These limits are for advisory purposes only. They are not used to determine if a sample should be reanalyzed. When sufficient multi-lab data becomes available, standard limits will be calulated.

Table 5-4. Precision, Accuracy and Completeness Objectives, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Measurement Parameters:	Arsenic Chromium	Lead Nickel
Methods:	Atomic Absorption (AA) Spectroscopy Gravimetric Determination Colorometric Determination	
Reference:	"Test Methods for Evaluating Solid Waste", SW-848, U.S. EPA	
Experimental Conditions:	Spiked and unspiked field samples	
Precision:		
Relative Percent Difference	± 20%	
Accuracy:		
Percent Recovery	75%	
Completeness:	90%	

Table 5-5. Hazardous Substance List (HSL) and Required Detection Limits (RDL) for Volatile and Semivolatile Compounds, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Volatile Compounds	CAS Reg. No.	Practical Quantitation Limits[a] Low Water (ug/L)	Low Soil (ug/kg)[b]
Benzene	71-43-2	5	5
2-Butanone (MEK)	78-93-3	10	10
Chlorobenzene	108-90-7	5	5
1,2-Dichloroethane	107-06-2	5	5
Dibromomethane (ethylene dibromide)	106-93-4	5	5
Ethylbenzene	100-41-4	5	5
Pyridine	110-86-1	5	5
Tetrachloroethene	127-18-4	5	5
Toluene	108-88-3	5	5
1,1,1-Trichloroethane	71-55-6	5	5
o-Xylene (1,2-dimethylbenzene)	95-47-6	5	5
Xylenes (total)	1330-20-7	5	5

Semivolatile Compounds	CAS Reg. No.	Practical Quantitation Limits[1] Low Water (ug/L)	Low Soil (ug/kg)[2]
Acenaphthalene	- -	NA[c]	NA
Anthracene	120-12-7	10	500
Benzenethiol	108-98-5	NA	NA
Benzo (a) anthracene	56-55-3	10	500
Benzo (b) fluoranthene	205-99-2	10	500
Benzo (k) fluoranthene	207-08-9	10	500
Benzo (a) pyrene	50-32-8	10	500
Bis (2 ethylhexyl) phthalate	117-81-7	25	1250
Butyl benzyl phthalate	85-68-7	10	500
2-Chlorophenol	95-57-8	10	500
Chrysene	218-01-9	10	500
Cresols, (o,m,p) totals	- -	NA	NA
Dibenz (a,h) acridine	226-36-8	NA	NA
Dibenz (a,h) anthracene	53-70-3	10	500
Dibenzofuran	132-64-9	10	500

Table 5-5 (Con't).

Semivolatile Compounds	CAS Reg. No.	Practical Quantitation Limits[1]	
		Low Water (ug/L)	Low Soil (ug/kg)[2]
o-Dichlorobenzene	95-50-1	10	500
m-Dichlorobenzene	541-73-1	10	500
p-Dichlorobenzene	106-46-7	10	500
2,4-Dichlorophenol	120-83-2	10	500
Diethyl phthalate	84-66-2	10	500
7, 12-Dimethylbenz (a) anthracene	57-97-6	10	500
2,4-Dimethylphenol	105-67-9	10	500
Dimethyl phthalate	131-11-3	10	500
2,4-dinitrophenol	51-28-5	25	1250
Di-n-octyl phthalate	117-84-0	25	1250
Di-n-butyl phthalate	84-74-2	NA	NA
Fluoranthene	206-44-0	10	500
Fluorene	86-73-7	10	500
Indene	95-13-6	NA	NA
Methyl chrysene (total)	- -	NA	NA
1-Methyl naphthalene	90-12-0	NA	NA
2-Methyl naphthalene	91-57-6	10	500
o-Cresol (2-methylphenol)	95-48-7	10	500
p-Cresol (4-methylphenol)	106-44-5	10	500
Naphthalene	91-20-3	10	500
p-Nitrophenol (4-nitrophenol)	100-02-7	10	500
Phenanthrene	85-01-8	10	500
Phenols (total)	108-95-2	10	500
Pyrene	120-00-0	10	500
Quinoline	91-22-5	NA	NA
2,4,6-Trichlorophenol	88-06-2	10	500

Other Constituents	CAS Reg. No.	Practical Quantitation Limits[1]	
		Low Water (ug/L)	Low Soil (ug/kg)[2]
1, 4-dioxane	123-91-1	150	- -
Sulfides (total)	18496-25-8	50	- -

Table 5-5 (Con't).

[a] Practical quantitation limits (PQLs) listed in SW-846 Methods 8240 (volatiles) and 8270 (semivolatiles). Specific PQLs are highly matrix dependent. The listed detection limits are provided as guidance and may not always be achievable.

[b] PQLs listed for soil/sediment based on wet weight. The detection limits calculated by the laboratory for soil/sediment, calculated on a dry weight basis, will be higher.

[c] NA - PQL not available. However, PQLs for these constituents should be comparable to PQLs for semivolatile constituents for which PQLs are available.

Table 5-6. Detection Limits for Elements Determined by Inductively Coupled Plasma Emission or Atomic Absorption Spectroscopy, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Parameter	Detection Level Soils (mg/Kg)	 Water (μg/L)
Arsenic	0.5	5
Chromium	2	20
Lead	1	10
Nickel	1	10

There will be two identification numbers used for each sample. One will be the serial identification number assigned by the laboratory. The other identification will be an in-house number designed to incorporate site specific field data into an alphanumeric code. The in-house numbering will consist of the following four components:

- Project and SWMU identification
- SWMU
- Sample type
- Sample location
- Sample number

The project and SWMU identification is a three-letter designation unique to the site and SWMU sampled. (For sampling purposes, the Pecos River is assigned a SWMU alpha identity code.) For this project, the identification will be designated as follows:

- NEP — Navajo Evaporation Ponds
- TMD — Navajo Three-Mile Ditch
- NPR — Navajo-Pecos River

Each sample type collected during the sampling program will be identified by one of the following two- to three-digit alpha codes:

- MW or OCD — monitoring well groundwater sample
- SD — sediment sample
- PW — pond water sample
- RW — river water sample
- XXB — XX (matrix type) blank

A three-digit number will be used to indicate the sampling location. Thus, the identification system will require that all sampling locations be given a separate number. The field ties to these sampling locations as well as other pertinent data will be kept in the field sampling notebook.

A two-digit number will be used to consecutively number replicate samples taken at a sampling site. Examples of a sample number are:

- NEP-OCD-001-01 — Navajo evaporation ponds, OCD monitor well 1, first sample
- NEP-SDB-001-01 — Navajo evaporation ponds, sediment sample blank, location 001, first sample

5.4.2 Sample Containers and Sample Preservation

The required sample containers, filling instructions, sample preservation methods, and shipping instructions are summarized in Table 5-7 for each of the sample types.

The collected sample containers will be kept out of direct sunlight and, after decontamination and labeling, will be placed in coolers and stored at approximately 4° C until they are packaged for shipping to the proper laboratory. Samples designated for chemical analysis will be packaged and shipped within two days of collection.

5.4.3 Decontamination of Sampling Equipment

There are several categories of equipment which will require cleaning prior to use, and between sample events. These include:

- Hand sampling equipment
- Field monitoring equipment
- Drilling equipment

The procedures which will be utilized for each are included in Sections 4.2.

5.5 Sample Custody

Verifiable sample custody is an integral part of field and laboratory operations. Several steps will be taken in the field and laboratory to document and ensure that samples collected in the field have been properly acquired, preserved, and identified. The following sections describe these steps in detail.

5.5.1 Field Sampling Documentation

Documentation of Sample Acquisition

A key piece of information that will be documented is the sample acquisition data. All information pertinent to field observations, surveys, and sampling will be recorded in a bound logbook with consecutively numbered pages. Entries in the logbook will include at least the following:

Table 5-7. Sample Containers, Preservatives, and Holding Times for Low-Concentration Test Parameters, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Table 5-7. Sample Containers, Preservatives, and Holding Times for Low-Concentration Test Parameters, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Parameter	Container	Preservation	Holding time	Procedure
Water and Liquids				
Purgeable organic compounds (volatiles)	2 40 mL glass vials with Teflon-lined caps	Adjust to pH less than 2.0 with 1:1 hydrochloric acid, iced to 4°C	14 days for analysis	Fill completely to exclude air bubbles
Extractable organic (BNA semivolatiles)	2 one L glass bottles (amber) with Teflon-lined caps	Iced to 4°C	7 days for extraction Analysis within 40 days of extraction	Fill bottle to neck
Metals	1 one L high density polyethylene bottle	Adjust pH to less than 2.0 with nitric acid	Analysis within 6 months of collection, 28 days Hg	Fill bottle to neck
Soils and Solids				
Purgeable organic compounds (volatiles)	60 mL wide-mouth glass jars, Teflon-lined caps	Iced to 4°C	14 days for analysis	Fill completely
Extractable organic compounds (BNA semivolatiles)	250 mL wide-mouth glass jars, Teflon-lined caps	Iced to 4°C	14 days for extraction	Fill completely
Inorganics	6-8 ounce wide-mouth glass jars	Iced to 4°C	Analysis within 6 months of collection, 28 days Hg	Fill completely

- location of sampling activity and addresses;
- purpose of sampling (e.g., definition of contamination, waste analysis, etc.);
- type of process (if known) producing wastes;
- type of waste (e.g., sludge, liquid, etc.);
- number and approximate volume of samples taken;
- location of sampling point;
- description of sampling point;
- date and time of collection;
- collector's sample identification number(s);
- sample distribution (e.g., chemical laboratory, geotechnical laboratory etc.);
- sample preservation;
- filtering methodology;
- references such as maps or photographs of the sampling site;
- field observations;
- any field measurements made such as pH, specific conductivity or other field parameters; and
- weather conditions.

Since sampling situations can be quite diverse, the documentation in the logbook will be sufficient to reconstruct the sampling situation without relying on the collector's memory.

Documentation of Sample Preservation

Proper sample preservation is important in retaining the sample characteristics prior to analysis. Sample preservation will be performed by the sampling personnel as described in Section 5.4.2. Sampling preservation will be documented by the sampling personnel on the chain-of-custody form and also in the field logbook.

Chain-of-Custody

In addition to the field logbook, each sample sent offsite will be recorded on a chain-of-custody record. An identifying code will be assigned to each sample and this code will be used on the chain-of-custody and in the logbook to ensure that the sample description is identifiable. A brief description of the sampling point will also be placed on the chain-of-custody form.

Chain-of-custody forms will become permanent records of all sample handling and shipment. Samples will be collected in accordance with the sampling procedures designated in Sections 4.1 and 4.2. If standard sampling procedures are not used, a written justification for each deviation will be placed in the project file. Upon completion of sampling, the sample will be prepared for shipment in accordance with the applicable sample instructions including preservation, labeling and logging.

The person collecting a sample will initiate document(s) at the source of the sample and start the chain-of-custody procedure. Chain-of-custody documentation will include the following applicable data:

- field sample number, site name and project;
- date sample taken;
- date sample submitted to the laboratory;
- sample taken by (signature);
- information describing source of sample and sample itself;
- sampling method used;
- expected interferences, if any
- remarks;
- preservation technique;
- number and type of shipping containers;
- shipping and airbill numbers;
- signature of persons relinquishing and obtaining custody of samples; and
- indication of sample disposition.

The sample will be kept in limited access or locked storage at the proper temperature until custody is relinquished from the site and formal documentation of the transfer is completed.

The program manager or onsite coordinator will be responsible for sample storage and shipment and for completing the sample accountability records. Upon each transfer of custody, the person involved will verify sample numbers and condition and will document the sample acquisition and transfer. The field sample custodian will properly package the samples, indicate the shipping method and describe the sample accountability record, and obtain shipment documentation such as certified mail receipt or bill of lading number.

On transfer of custody of the samples to the transport agency, the field sample custodian will sign and retain a copy of the shipment documentation, witness the transport company custody signature, and send a copy of the chain-of-custody with the samples. On arrival at the laboratory, the sample custodian will sign for custody and return a copy of the completed chain-of-custody to Navajo. Laboratory custody procedures will then be conducted per Section 5.5.2.

Groundwater and soil samples will be shipped as environmental samples by commercial carrier following DOT regulations.

Tags

Each sample will be tagged and sealed.

Sample tags are necessary to prevent misidentification of samples. Gummed paper tags will be used. The tag will include at least the following information:

- name of collector;
- date and time of collection;
- place of collection; and
- collector's sample number, which uniquely identifies the sample.

Containers used to transport samples will be sealed to preserve the integrity of the samples from the time they are collected until containers are opened in the laboratory. Adhesive tape will be used to seal containers. The tape will be attached in such a way that it is necessary to break it in order to open the sample container ensuring that the samples have not been tampered with.

5.5.2 Laboratory Operations

The minimum procedures which will be used by the laboratory for sample receipt, chain-of-custody, sample identification, sample extract identification, tracking of sample analyses, laboratory data assembly and documentation control are described below. The internal QA/QC procedures for the designated laboratory will be submitted to EPA prior to the start of work.

Laboratory Sample Receipt Procedures: The following laboratory receipt procedures will be used:

- The samples will be delivered directly to the sample custodians on weekdays. On weekends, holidays or outside of regular working hours, the sample custodian or his authorized personnel (only sample custodian is mentioned hereafter) will receive the samples shipped directly to the lab.
- The sample custodian will examine the shipping container and record the following information on a Log-in Sheet (called the Sheet herein), one case per form(s):
  - presence/absence of custody seal(s) on the shipping container(s)
  - condition of custody seal (i.e., intact, broken)
- The sample custodian will open the shipping container, remove the enclosed sample documents and record on the sheet:
  - presence/absence of the chain-of-custody record(s)
  - presence/absence of airbills and/or bills of lading documenting shipment of samples
  - case and airbill numbers
- Remove sample containers and record on the sheet:
  - condition of samples (intact, broken, leaking, etc.)
  - presence/absence of sample tags
- If sample tags are present:
  - record sample tag numbers
  - compare with chain-of-custody record(s)
- Compare the following documents to verify agreement among the information contained on them:
  - chain-of-custody records
  - sample tags

- airbills or bills of lading

Document both agreement among the forms and any discrepancies found. If discrepancies are found, contact the project QA/QC Officer or Program Manager for clarification and notify appropriate laboratory personnel.

- If all samples recorded on the chain-of-custody record were received by the lab and there are no problems observed with the sample shipment, the custodian will sign the chain-of-custody record in the "received for laboratory by" box on the document. If problems are noted, sign for shipment and note problems in remarks box of the sheet detailing the problems. The project QA/QC Officer or Program Manager will be contacted for direction. The appropriate lab personnel will be notified. The problems and resolution will be detailed in the case narrative.

- Log-in Samples: The procedure for sample identification will be performed at this time. The information on the date and time of sample receipt, chain-of-custody record number, field sample numbers, lab numbers and sample tag numbers will be recorded on the Sample Log-in Sheet.

Laboratory Chain-of-custody Procedures: The National Enforcement Investigations Center (NEIC) of EPA defines custody of evidence in the following ways:

- It is in your actual possession, or

- It is in your view, after being in your physical possession, or

- It was in your possession and then you locked or sealed it up to prevent tampering, or

- It is in a secure area.

In order to satisfy these custody provisions, the following standard operating procedures will be implemented:

- Samples will be stored in a secure area

- Access to the laboratory will be through a monitored reception area

- Visitors will sign-in the reception area and be escorted while in the laboratory

- All transfers of samples into and out of storage will be documented on an internal chain-of-custody record

- After a sample has been removed from storage by the analyst, the analyst is responsible for the custody of the sample — each analyst must return the samples to the storage area before the end of the working day

Laboratory Sample Identification: The following procedures will be used to determine laboratory sample identification:

- During the sample receiving process, the laboratory sample custodian or other designated personnel will assure that each sample container is identified with a unique field sample ID number and that this number is recorded in the Sample Log-in Sheet.
- The sample custodian will remove the sample tag and place it in the appropriate case file. If stick-on labels are used instead of tie-on sample tags, this fact will be noted in the comment section of the log-in sheet.

Laboratory Tracking of Sampling Analysis: A system for tracking the sample through preparation and analysis is needed because of the evidentiary nature of the sample analysis results. The laboratory records may be used in court as evidence in enforcement proceedings. Consequently, the following procedure will be used to track sample analyses:

- Both the preparation and the analysis of samples will be documented.
- All notebook pages, computer printouts, and other laboratory documents will show the case/sample number, date, signature (initials) of the analyst and other pertinent information.
- Upon completion of analysis, data will be filed in the appropriate case or sample files.
- All sample preparation information will be documented in the laboratory notebook. All sample analysis data will be documented using log-books. When sample preparation or analysis is finished by an individual, the completed documents will be placed in the appropriate sample and/or case files.

Laboratory Data Assembly: The following procedures will be adhered to for assembly of the project data:

- A procedure for organization and assembly of all documents relating to each case will be implemented by the sample custodian or designated person.
- This procedure will ensure that all documents are compiled in one location for submission to Navajo in single case files, arranged by field sample number. Case file folders will be prepared as follows:

- using appropriate file folders, preferably assign one folder to each case according to field number;
- place all documents, sample tags, forms, and laboratory generated data pertaining to one case in the folder;
- documents should be arranged by document type within the case folders (i.e., all sample tags together, all traffic reports together, all deliverables, etc);
- these document case files will be filed in one location and stored in a secure area.

The internal QA/QC procedures for the designated laboratory will be submitted to EPA prior to the start of work.

5.5.3 Evidence Files

All controlled documents, logbooks, reports and data packages will be submitted to Navajo Refining, located in Artesia, New Mexico after the RFI completion. At this location the files will be stored in a secure area All transfers of data into and out of the storage area will be documented on an internal chain-of-custody record.

The files will be kept for a minimum of six years after the termination of the RFI. After the six-year period, the EPA will be notified within thirty (30) days prior to the destruction of any documents.

5.6 Calibration Procedures and Frequency

5.6.1 Field Calibration Procedures

The field environmental monitoring equipment was previously described in Section 4.2. Each instrument will be calibrated and maintained in accordance with the manufacturer's procedures.

5.6.2 Chemistry Laboratory Calibration Procedures

The calibration procedures and frequency of calibration will follow the specifications of the appropriate EPA and ASTM procedures. The use and frequency of these procedures will be verified by internal audit. Additionally, a project specific quality assurance audit will be conducted by the Quality Assurance Officer.

5.7 Analytical Procedures

Analytical methods which will be utilized for the water, soil, waste matrix samples during the RFI are described in:

- SW-846: Test Methods for Evaluating Solid Waste (Physical/Chemical Methods) Third Edition, September 1986
- Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, March 1983
- Annual Book of ASTM Standards

5.8 Data Reduction, Validation, and Reporting

The three types of data that will be generated by this project include: chemical data, geotechnical data, and geophysical data. The following guidelines will apply to each type of data.

5.8.1 Data Reduction

Data reduction will be carried out using prescribed documented techniques. Any statistical summaries of the data will be presented in such a manner that the reviewer can easily judge the validity of the procedure and any conclusions drawn. Assumptions made in performing any statistical analyses will be clearly stated, as will confidence/significance levels used for any test hypotheses. Data summaries will be checked against the raw data for consistency and summary statistics recalculated in the event of doubt.

Chemical data reduction will be done in conformance with the prescribed methods referenced in the appropriate analytical procedures.

5.8.2 Data Validation

Chemical, geotechnical, and geophysical data will be validated by the designated Quality Assurance Coordinator. The Quality Analysis Coordinator will perform a review of select data for each analytical task. This review will consist of the following elements: review of analytical program, examination of results, verification of results.

Review of Analytical Program

The responsible individual will review a select set of results to ensure that the required program elements, such as method blanks, surrogate spikes, and QC samples, have been accomplished according to the program design. The supporting data will be reviewed to ensure that analyses were performed under the correct conditions and that all required procedural steps were performed.

Examination of Results

The Analytical Coordinator will examine the results obtained along with the pertinent chromatogram, spectra absorption traces, and geophysical logs to ensure that the results are reasonable and that the analyst has interpreted the results correctly. Any unusual or unexpected results will be reviewed and a resolution will be made as to whether the analysis should be repeated or the results recalculated.

Recalculation of Results

The Analytical Coordinator will selectively recalculate results to ensure that the calculation was performed properly. Emphasis will be placed on the those results showing a significant concentration of one or more of the analytes of interest. At a minimum, one set of calculations will be checked for each batch of samples analyzed.

5.8.3 Data Reporting

Following data validation, the verified data will be transferred from the analytical data sheets to reporting forms. The Analytical Coordinator will be responsible for ensuring that all required information is recorded by reviewing the completed form for the accuracy of the transferred information. All data will be verified against the analytical data sheets, and the completed forms will be reviewed by the individual responsible for the analysis prior to submission of the results to the sponsor.

5.9 Internal Quality Control Checks and Frequency

Internal quality control checks will be made in the laboratory and the field. These checks are discussed in this section.

5.9.1 Internal Quality Control Checks and Frequency — Laboratory

Quality control sample frequency will follow the standard requirements cited earlier in this document. Internal quality control procedures for groundwater, surface water, soil and sediment samples will follow the appropriate EPA and ASTM guidelines. These procedures specify the number of laboratory blanks to be used, the number of calibration standards, the frequency that the calibration standards must be run, the frequency at which laboratory duplicate samples must be run, and the frequency at which spiked and referenced samples must be run. Field blanks (where applicable) will be collected to check for sample contamination due to field sampling equipment.

5.9.2 Internal Quality Control Checks and Frequency — Field

Combustible gas analyzers (PID and FID), analytical instruments, that will be used in the field, are scanning type instruments to approximate real-time concentrations. Calibration and standardization are done by span gases. Electronic field instruments are zeroed electronically as an internal electronic adjustment, which compensates for the aging of batteries and changes in instrumentation characteristics. Duplicates, spikes and splits are not feasible due to the nature of the instruments.

The pH and temperature/conductivity meters will also be used onsite. Calibration and checks of the pH meter are done by standard solutions. Several duplicate readings are generally used to improve data quality when using this instrument. The temperature/conductivity meter is factory calibrated for conductivity, while the thermometer is "air" calibrated prior to each use.

5.10 Performance and Systems Audits

Internal audits are performed to review and evaluate the adequacy of the QAPP, and to ascertain whether it is being completely and uniformly implemented. The Quality Assurance Officer is responsible for such audits and will ensure that they are performed according to a schedule planned to coincide with appropriate activities on the project schedule. Such audits may be supplemented by additional audits for one or more of the following reasons:

1. When significant changes are made in the QAPP.
2. When it is necessary to verify that corrective action has been taken on a nonconformance reported in a previous audit.
3. When requested by the program manager.

The objectives of performance and systems audits are to ensure that the quality assurance program developed for this project is being implemented according to the specified requirements, to assess the effectiveness of the quality assurance program, to identify nonconformances and to verify that identified deficiencies are corrected. Upon discovery of any significant deviation from the quality assurance program, the Program Manager shall be informed of the nature, extent, and the corrective action taken/needed to remedy the deviation.

5.10.1 Performance Audits

A performance audit can be defined as a review of the existing sample and quality assurance data to determine the accuracy of the total measurement system(s) or a component part of the system. The analysis of project specific performance evaluation samples and the participation in scheduled interlaboratory studies may be included as part of the performance audit.

Laboratory Performance Audit

The laboratory director will monitor and audit the performance of the QA procedures to ensure that the project is performed in accordance with the data quality objectives. The results of any EPA or state audits will be made available upon request to Navajo for subsequent review. Additional audits may be scheduled by Navajo at various times to evaluate the execution of sample identification, sample control and chain-of-custody procedures. Results from the analysis of any performance evaluation samples will be made available to Navajo for review. Any problems will be identified and corrective actions will be taken if necessary.

Field Performance Audit

At least one field performance audit will be conducted by the QA Officer or his designee. The field auditor will observe and review the procedures being used to ensure that they conform with the approved operating procedures. Specific attention will be given to sampling procedures and preservation to demonstrate that required methods are being used. Field instrumentation quality assurance procedures will also be verified to ensure that all proper procedures are being followed. Analytical results and quality assurance samples and analyses will be reviewed and recommendations on the adequacy and necessity for repetition of analysis will be made. The QA Officer will review the data for questionable results and will determine if repeat analyses are required. Significant analytical problems will be discussed with the QA Officer and Laboratory Manager.

The field auditor will report to the Navajo QA Officer orally within five days on the results of each audit to transmit any significant problems with the held quality assurance program. A written report will be made by the held auditor of each field audit within 10 days after each audit.

5.10.2 Systems Audit

A systems audit consists of an evaluation to determine if the components of the measurement system(s) were properly selected and are being used correctly. A systems audit includes a careful evaluation of field and laboratory quality control procedures.

Laboratory Systems Audit

A laboratory systems audit will be conducted on a regular basis by the Laboratory Manager. The Laboratory Manager will conduct an initial systems audit to ensure that all instruments proposed for use were properly selected for the given methods and are performing properly. This will include a review of the analytical methods proposed for use and the laboratory procedures prepared from these methods. Necessary changes will be confirmed in writing to the Navajo QA Officer, to ensure that the laboratory meets all of the measurement systems requirements of the quality assurance plan. After this initial systems audit is complete, the Laboratory Manager will:

- implement the analytical plan and ensure that all quality control measures are executed as written;
- ensure that all analysts and technicians are properly trained;

- verify on a routine basis that all instruments are performing properly and that conditions, etc., are as required; and
- conduct periodic evaluations of personnel and instruments during the course of the analyses to ensure that initial conditions persist.

The Laboratory Manager will report orally to the Navajo QA Officer if the systems audit shows a significant discrepancy from the QAPP. Each major systems change will require a written summary to the Navajo QA Officer to document the change made. All system changes will be documented in the project Quality Assurance notebook.

The Laboratory Manager, or his designee, will conduct the following as part of the routine analytical systems audit to ensure compliance with the workplan and quality assurance requirements:

- verify that incoming samples correspond to the chain-of-custody form or packing list that accompanies them;
- inspect the samples and document the condition of each sample, especially any circumstances which might have adverse effects on the analytical results;
- note the analyses required on each sample and transmit this information to the Analysis Coordinators;
- review all data generated to ensure that all analyses were run as specified, including quality controls; and
- prepare the data for submission to the sponsor or for entry into a computerized data bank, as appropriate.
- The Laboratory Manager will periodically review the data records to ensure that the requirements are being met.

The Laboratory Manager, or his designee, will perform the following functions to ensure the sample collection systems meet the requirements. He will:

- ensure that proper container cleanup procedures are followed prior to use and that containers are protected from contamination once prepared for use;
- provide a sample of containers to the analytical coordinator, who will determine if the containers are free of contamination;
- prepare field spikes, duplicates, and blanks, as called for in the workplan, and provide these for analysis along with held samples, ensuring that the analyst is unable to distinguish between actual and quality control samples; and

- maintain all records necessary including chain-of-custody information on the samples.

The Navajo QA Officer will conduct at least one detailed laboratory systems audit during the project. This audit will be described in Section 5.10.3.

Field Systems Audit

At least one field system audit will be conducted by the Navajo QA Officer, or his designee. The field auditor will review the field equipment selection and use to ensure that the equipment is capable of safely and accurately performing the desired functions. Equipment selection review will be based on the capabilities and limitations of the instrument/sampling device. Use will be reviewed based on observations and comparison of actual versus expected results. The first field systems audit is expected to be conducted soon after field start up.

The field auditor will meet with key field staff members to evaluate the field program and determine if changes are necessary to improve the results. A written record of these meetings will be placed into the project file within 10 days after the meeting and program revisions will be incorporated as necessary.

The field auditor will submit a written report within 10 days after each audit and will discuss significant changes with the project management prior to any major changes.

5.10.3 Detailed Laboratory Performance and Systems Audit

As part of the quality assurance program, the Navajo QA Officer will conduct a detailed laboratory performance and system audit during the project. The objectives of the detailed audit are to:

- determine that a quality assurance program has been put into use and documented in accordance with specified requirements;
- verify by examination and evaluation of objective evidence that the documented program has been implemented;
- assess the effectiveness of the quality assurance program;
- identify nonconformances; and
- verify correction of identified deficiencies.

The Laboratory Manager will be notified of the audit at a reasonable time before the audit is performed. This notification may be in writing and include such information as the general scope and schedule of the audit and the name of the audit team leader.

A brief pre-audit conference will be conducted at the audit site with laboratory management. The purpose of the conference will be to confirm the audit scope, present the audit plan, discuss audit sequence and plan for the post-audit conference.

Audits are performed on the basis of written checklists or list of questions prepared prior to the audit to ensure the depth and continuity of the audits. During the conduct of the audit, each item on the list is marked with one of the following entries:

- S — item is satisfactory
- U — item is unsatisfactory
- X — item is not applicable
- N — item was not audited

The audit checklist is intended for use as a guide and will not restrict the audit investigation when findings raise further questions that are not specifically included in the checklist. The checklist will include, as a minimum, review of QA data, laboratory procedures, chain-of-custody records, calibration records, and problem resolutions.

Selected elements of the quality assurance program shall be audited to determine whether they are being implemented effectively.

Conditions requiring immediate corrective action shall be reported immediately to the Program Manager and resolutions will be recommended to replace the faulty procedures.

At the conclusion of the audit, a post-audit conference will be held with laboratory management to present audit findings and clarify misunderstandings. Audit findings shall be concisely stated by the Navajo QA Officer on the Quality Assurance Audit Finding Report (Figure 5-1). The findings of the audit will be acknowledged by the Laboratory Manager signing the post-audit conference record.

An audit report will be prepared within 15 working days by the Navajo QA Officer and signed by the Laboratory Manager. The audit report will be addressed to the Navajo Program Manager and will include the following:

- description of audit scope;
- identification of the auditors;
- persons contacted during pre-audit, audit and post-audit activities;

Figure 5-1. Quality Assurance Audit Finding Report, RFI Phase III Work Plan, Navajo Refining Company.

Project ______________________________

Audit No. ____________ Audit Date ____________

Audit Finding No. ______________________

QUALITY ASSURANCE AUDIT FINDING REPORT

Audited

Organization ______________________________

Audited

Area ______________________________

10 CFR 50 Appendix B Requirement ______________________________

NQA-A ______________________________

QAM ______________________________

OBSERVATION/FINDING RECOMMENDATION

Corrective Action Required Yes Prepared By ____________

No ______________________________

CORRECTIVE ACTION REPLY Response Date Due ____________

Prepared By ____________ Title ____________ Date ____________

____

____

CORRECTIVE ACTION VERIFIED

By ______________________________

Title ______________________________ Date ____________

- a summary of audit results, including an evaluation statement regarding the effectiveness of the QA Program elements which were audited;
- details of findings and program deficiencies will be reported on a Standard Audit Report Format similar to Figure 5-2; each finding and program deficiency shall be identified and described in sufficient detail to assure that corrective action can be effectively carried out by the project organization; and
- recommendations for correcting the findings or improving the QA Program.

The Laboratory Manager or his designated representative will respond to the audit deficiencies by completing a corrective action plan in written form within 20 working days. The response will clearly state the corrective action for each finding, including action to prevent recurrence and the date the corrective action will be completed. If corrective action has been completed, supporting documentation will be attached to the reply.

Follow-up action will be performed by the Laboratory Manager or his designated representatives to:

- evaluate the adequacy of the response
- assure the corrective action is identified and scheduled for each nonconformance
- confirm that corrective action is accomplished as scheduled — re-audits will be conducted and reported in the same manner as the original audit
- follow-up action may be accomplished through written communication, re-audit, or other appropriate means

Records will be generated and retained for all audits. Records will include audit reports, written replies, the record of completion of corrective actions, and documents associated with the conduct of audits which support audit findings and corrective actions as appropriate.

5.10.4 Nonconforming Items and Disposition

The supervisory and staff personnel will, during the execution of their normal activities, make certain that the work is performed in accordance with the requirements of the QAPP, establish procedures or accepted professional practices. Rework or revision of work due to nonconformance is described in the applicable work procedure. Any irregularities and/or deviations will be reported in writing to the QA Officer and the Navajo Program Manager. Any person may originate a report on irregularities and/or deviations.

The originator of a Nonconformance and Disposition Action Report (NCR) will describe his findings on the form provided for this purpose (Figure 5-3). A nonconformance is defined as a deficiency which renders the quality of an item unacceptable or indeterminate. Depending on the nature of the nonconformance, the quality of the item in question may be accepted following an investigation of the nonconformance.

The work which has the irregularities and/or deviations may be temporarily stopped while the nonconformance is being investigated. Section 5.14 presents a summary of the written quality assurance reports that will be submitted to management.

Disposition

The Navajo Program Manager will be responsible for initiating disposition action on all nonconforming items. The procedure will be as follows:

- The Navajo Program Manager will review the nonconformance and disposition action reports and take the necessary action; he will complete the disposition section of the report.
- The Navajo Quality Assurance Officer or his designee will review, verify and countersign the Program Manger's disposition.
- The completed report will be filed in the appropriate file.

5.10.5 Schedule of Audits

A summary of the performance and systems audits to be performed is shown in Table 5-8.

5.11 Preventative Maintenance

5.11.1 Laboratory Maintenance

All instruments will be maintained in accordance with manufacturer's recommendations and/or normal laboratory practice. All maintenance will be documented and maintained in permanent records by the individual responsible for each instrument. This will include both routine, scheduled maintenance and unscheduled maintenance required by operational failures.

All nonroutine or scheduled maintenance will be reported to the Analysis Coordinator responsible for that instrument and will enter the communication scheme reported in Section 5.10. The Analysis Coordinators will review the maintenance records on a regular basis to ensure required maintenance is occurring.

Figure 5-2. Standard Audit Format, RFI Phase III Work Plan, Navajo Refining Company.

Project No. ____________________

To: ____, Project Director

Subject: Report of audit of ____________________, on ____________________

PURPOSE

State the type and objectives of the audit.

PERSONNEL CONTACTED

Give the name and title of the person conducting the audit, and list any individuals who may have assisted in conducting the audit.

CHECKLIST RESULTS

Present the checklist from which the audit was conducted, with the appropriate S, U, X, or N marking for each item on the list.

DISCUSSION

Indicate nonconformance noted. A nonconformance is defined as a deficiency in characteristic, procedure or documentation which renders the quality of an item unacceptable or indeterminate. Examples of nonconformance include incorrect or inadequate documentation or deviations from prescribed office, field, or laboratory procedures.

CORRECTIVE ACTION

Indicate action to correct and to prevent recurrence of nonconformances, and dates by which reply to audit must be received and corrective action completed.

RECOMMENDATIONS

Present suggestions regarding items or procedures which are not considered nonconformances, but which may result in nonconformances if allowed to continue, or for which relatively minor changes may result in improved quality.

Figure 5-3. Nonconformance and Disposition Action Report, RFI Phase III Work Plan, Navajo Refining Company.

Date: ______________________

NCR No.: ______________________

SUBMITTAL

To: ______________________

Description of Nonconformance and Cause: ______________________

Proposed Disposition: ______________________

Submitted by ______________________ Location: ______________

Approved by ______________________ Date: ______________

DISPOSITION (By Project Manager or designee)

Implementation of Disposition Assigned to: ______________________

Actual Disposition: ______________________

____

____

Disposition completed on ______________________
Date

____
Signature

VERIFICATION

Disposition reviewed and work inspected by ______________ on ______________

Disposition verified by ______________________ on ______________

(Use additional sheet or memo if needed.)

Table 5-8. Schedule of Audits to be Performed, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Figure 5-8. Schedule of Audits to be Performed, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Audit Type	Conducted	Area	Schedule	(Working days after audit report schedule)	Report Type
System start-up	Laboratory manager	Laboratory	Prior to project start or immediately following	5	Oral Written
System start-up	Navajo program manager or designee	Field	Following start-up	5	Oral Written
Performance	Laboratory manager	Laboratory	Weekly	5 Monthly	Oral Written
Performance	Navajo QA officer or designee	Field	Semimonthly	5 Monthly	Oral Written
In-depth systems and performance	Navajo QA officer or designee	Field and laboratory	Mid-project	15	Written
Audit follow-up	Navajo QA officer or designee	Field and laboratory	As needed	20	Written
Systems	Laboratory manager	Laboratory	Semimonthly	Monthly	Written
Systems	Navajo program manager or designee	Field	Semimonthly	Monthly	Written

5.11.2 Field Maintenance

All field instruments, sampling equipment and machinery will be maintained in accordance with manufacturer's recommendations and normal field practice. All maintenance will be documented in permanent records by the individual responsible for each item. This will include routine scheduled maintenance and unscheduled maintenance. Unscheduled maintenance will be reported to the Project QA/QC Officer and the Program Manager. The Project QA/QC Officer will review the maintenance records on a regular basis to ensure required maintenance is occurring.

5.12 Data Assessment

All data generated will contain a statement on the accuracy and precision of the methodology used to obtain them. The procedures and equations for determining the accuracy and precision are discussed in Section 5.7, Analytical Procedures, and Section 5.9, Internal Quality Control Checks and Frequency. These procedures will be reviewed during the performance audits described in Section 5.10, Performance and Systems Audits, to ensure that the procedures are being implemented and accurately followed. Field data will be assessed by the procedures referenced in this document and those respective operating procedures found in Sections 4.2. These procedures will also be reviewed during the performance audits.

5.13 Corrective Action

The ultimate responsibility for maintaining quality in the analyses lies with the Navajo Program Manager. The routine operation of the quality assurance program, however, falls upon the QA/QC officer, and the Laboratory Manager.

The Laboratory Manager will have the responsibility for ensuring that his personnel are adequately trained to perform analyses, that equipment and instrumentation under his control are calibrated and functioning properly, and that systems audits are performed on a regular basis.

The Laboratory Manager will have the responsibility for preparation and implementation of quality assurance plans. The Laboratory Manager or his designee will review the data generated to ensure that quality control samples are run as specified in the protocol.

The Navajo Quality Assurance Officer will have the responsibility for the preparation of SOPs and quality assurance guidelines for the project, and for conducting/evaluating the results from systems audits. The Quality Assurance Officer will review program plans for consistency with organizational and contractual requirements and advise the Laboratory Manager.

The Navajo QA Officer or his designee also have responsibility for conducting and evaluating the QA procedures for the field testing and ensuring that all necessary corrective action items will be completed.

5.14 Quality Assurance Reports to Management

Section 5.10 describes the periodic assessments and performance and systems audits to be completed during the Navajo RFI Site Project. Table 5-8 is a summary of the written quality assurance reports that will be submitted to management.

As reported in Section 5.10, weekly assessment of the sample and quality assurance for accuracy, precision and completeness will be conducted and reported orally to the QA Officer. All audits and quality assessments will be reported in oral and written form to the QA Officer to provide rapid response to quality assurance problems and documentation of the audit and response in the project files.

After the field work has been completed and the final analyses are completed and checked, a final quality assurance report will be prepared to be included in the final RFI report. The report will summarize the quality assurance and audit information, indicating any corrective actions taken and the overall results of the QAPP.

Table 5-9. QA Reports to Management, RFI Phase III Work Plan, Navajo Refining Company, July 1994.

Report	Responsibility	Schedule
Laboratory start-up systems audit results	Laboratory manager	10 days after audit
Field start-up systems audit results	QA officer	10 days after audit
Laboratory performance audit results	Laboratory manager	Monthly
Field performance audit results	QA officer	10 days after audit
Laboratory systems audit results	Laboratory manager	Monthly
Field systems audit results	QA officer	10 days after audit
In-depth performance and systems audit results	QA officer	Mid-project
Audit deficiency resolution	Field or laboratory personnel	As needed, 20 days after notice
Quality assurance summary	QA officer	At project conclusion

6.0 DATA MANAGEMENT PLAN

6.1 Data Management

The RFI will result in significant amounts of data, including results of chemical, physical, geotechnical, and/or biological analyses. This may involve analyses of many constituents, in different media, at various sampling locations, and at different times. Data management procedures have been established to effectively process these data such that relevant data descriptions (e.g., sample numbers, locations, procedures, methods, and analysts) are readily accessible and accurately maintained.

In order to ensure effective data management, a data management plan will be implemented to document and track investigation data and results. This plan addresses data and report processing procedures, project file requirements and all project-related progress reporting procedures and documents. This plan provides the format(s) to be used to present the data, including data reduction.

6.2 Data Presentation

RFI data will be arranged and presented in a clear and logical format. Tabular, graphical, and other visual displays (e.g., contaminant isopleth maps) will be incorporated for organizing and evaluating such data. Particular methods most applicable to the RFI will vary with the type of unit, the type of data, the medium under consideration, and other factors.

Table 6-1 summarizes the methods and information to be incorporated into the data presentation of this RFI.

Sample identification numbers as well as laboratory data management (i.e., designation of blanks, duplicates, spikes, replicates, and data flagging) and data reduction techniques are presented in Section 5.0.

6.3 Statistical Procedures

Due to the presence of background or anthropogenic levels of organics and inorganics in various media or matrices, statistical tools can be utilized to evaluate data sets or populations. For instance, the data resulting from the RFI may be evaluated utilizing a T-test which indicates mathematical dissimilarity between populations. The rationale behind the selection of a specific statistical method, along with the appropriate documentation, will be included with the evaluation of the RFI data.

Table 6-1. Uses of Tables and Graphs, RFI Phase III Work Plan, Navajo Refining Company.

Tabular Displays

1. DISPLAY SITE INFORMATION AND MEASUREMENTS TO BE PROVIDED
    - A. Water table elevations
        1. Field parameters
        2. Date/time
        3. Well coordinates used in determination
    - B. Sampling location coordinates
        1. Field parameters/lab parameters (gross)
        2. Date/time
        3. Person collecting samples
2. DISPLAY ANALYTICAL DATA
    - A. List of constituents of concern and other monitoring parameters with associated analytical measurements
    - B. Display sorted results (e.g., by medium, sampling date, soild type)
    - C. Compare study and background area data (statistical procedures)
        1. Statistical calculations
        2. Statistical reference charts
    - D. Report input data, boundary conditions, and output values from mathematical modeling

Graphic Displays

1. DISPLAY SITE FEATURES TO BE PROVIDED
    - A. Site layout and topographic map
    - B. Sampling locations map(s)
    - C. Stratigraphy and water table elevations (profile, transect, and/or fence diagram)
    - D. Potentiometric contour map of groundwater
2. ILLUSTRATE THE EXTENT OF CONTAMINATION
    - A. Areal extent of contamination for the SWMU and media

7.0 Personal Protection and Environmental Safety

RFI Phase III field activities to be conducted at the Navajo Refinery include water and sediment sampling, and drilling and installation of groundwater monitoring wells.

Prior to the initiation of field activities, a comprehensive safety plan will be developed which will address the safety and health hazards of each phase of site operations and include the requirements and procedures for employee protection. Further, the health and safety plan will also consider potential impacts to environmental receptors outside the zone of site activities.

The Site Health and Safety Plan will include the following components:

- Project objectives — general descriptions of each specific category of tasks associated with RFI Phase III site activities

- Site descriptions — listed items will include the expected date range of site activities, a listing of all potential hazards, including potential hazards to which both onsite personnel and surrounding potential environmental receptors potentially may be exposed

- Background information — a review of general information regarding analytical data from previous sampling efforts, land use history of all work areas, and any other information which may be helpful in determining the possible hazards associated with site work areas

- Onsite organization and coordination — names and responsibilities of the designated site Safety Officer, facility representatives, and subcontractors

- overnment contacts — names, titles and agencies of all government contacts involved in the project

- Onsite control — descriptions of any exclusion, support, decontamination or safe perimeter zones deemed to be necessary, and the approximate area of each zone, and security responsibilities

- Hazard evaluation — a description of the risks associated with each task, identification of environmental hazards as well as chemical hazards, and an evaluation of the likelihood of unknown chemical hazards

- Personal protection equipment requirements — a listing of the levels of protection required for each job function, with contingency criteria for upgrades to higher protection levels

- Environmental monitoring equipment — a description of the equipment to be used for periodic monitoring of the environment and personnel, and details on the frequency and purpose of the monitoring plan

- Communication procedures — a description of onsite communication devices to be used, (i.e., radios, cellular phones, and the hand signals) to be used in case of a failure of radio or audible communication

- Emergency procedures — a list of the standard emergency procedures to be used by onsite personnel and a description of emergency contingency plans and notification procedures

- A Site Safety Plan — a document listing persons who are responsible for safety recommendations onsite, and providing information on emergency medical care, first aid treatment, police, fire, ambulance and hospital assistance, including telephone numbers and directions to the nearest hospital

The Site Health and Safety Plan will be submitted for review to the EPA Technical Monitor assigned to the project no later than three weeks prior to the initiation of RFI Phase III site activities.

8.0 COMMUNITY RELATIONS PLAN

8.1 GENERAL

This community relations plan outlines procedures to be initiated to address community issues and foster communication among interested parties.

8.2 COMMUNITY RELATIONS OBJECTIVES

The objectives of the community relations program are to:

- Initiate and maintain open communication between the Navajo Refinery, the U.S. EPA, local, state and federal officials, the media and interested citizens and groups.
- Provide a central information contact and/or Community Relations Coordinator from whom interested parties can receive information on project activities and status.
- Develop a mailing list including involved agencies and organizations, elected officials and residents who indicate interest in the project.
- Provide information on project status in a timely, consistent and understandable manner.
- Provide a means for interested parties to express concern and make inquiries.
- Monitor changes in community concerns as the project progresses so that, if necessary, the community relations plan may be modified to address the changes.

8.3 COMMUNITY RELATIONS TECHNIQUES

The following techniques are to be used to inform citizens, public officials, and the media of RFI activities:

- Prior to initiation of RFI operations, Navajo Refining Company will provide public notice of the RFI via the local newspaper and ask that any questions or comments be directed to the Community Relations Coordinator.
- Based on public response to this notice, Navajo may release press releases and fact sheets to interested local newspapers to inform them of upcoming RFI activities, and present RFI findings and any corrective measures to be implemented at the facility.

- The Navajo Refinery Community Relations Coordinator will maintain ongoing contact with the refinery technical staff to keep informed of project progress, ensure that the staff is aware of community concerns and ensure that these concerns are addressed.
- Revise mailing lists as required to keep interested parties informed of project status.
- Establish a document repository so that all reports, data and information related to the RFI is easily accessible for public review.
- If community interest is high, conduct a public meeting (announced in a press release) at a convenient location in the community to give the general public a chance to give and receive feedback regarding site activities.

APPENDIX A

EXECUTIVE SUMMARY
RFI PHASE II REPORT
NOVEMBER 1993

1.0 EXECUTIVE SUMMARY

The objective of Phase II of the RCRA Facility Investigation (RFI) conducted at two solid waste management units (SWMUs) at the Navajo Refinery (EPA ID No. NMD 048918817) located in Artesia, New Mexico, was to expand upon the Phase I findings (submitted to the U.S. Environmental Protection Agency in May 1991) and thereby better define the source characteristics and the nature and extent of any contamination from the SWMUs. The two SWMUs are Three-Mile Ditch, an unlined wastewater conveyance channel that was operated for approximately 50 years, and a partially active evaporation pond system that covers approximately 115 acres.

The RFI Phase II investigation included sampling and chemical analyses of soils, soil gas, surface water and sediments, and groundwater within and around the two SWMUs. The investigation included 43 soil sampling points, 39 soil vapor points, and approximately 50 monitor wells (including 30 newly installed monitor wells and piezometers).

Key findings of the RFI Phase II investigation are as follows:

Three-Mile Ditch — Soils

- Results of the soils investigation at the ditch confirmed the findings of the RFI Phase I investigation concerning the presence of volatile organic constituents. The combined results of both the Phase I and Phase II investigations indicate that the presence of volatile constituents in ditch soils occur only sporadically and at concentrations significantly below applicable health-based numbers.
- With respect to semivolatile constituents, analytical problems caused higher than desired detection levels. However, available data from the Phase II investigation are not inconsistent with the results of the Phase I investigation, in which the presence of residual semivolatile organic compounds are indicated at various locations and depths along the length of the unit.
- The failure of the Toxicity Characteristic Leaching Procedure (TCLP) evaluation for organic constituents contained in soil samples from Three-Mile Ditch to yield any leachate concentrations that exceeded the toxicity characteristic (TC) limits demonstrated that organic constituents remain strongly sorbed to the soil matrix. Further, the processes of biodegradation will additionally minimize the availability of organic constituents to the water phase.
- The soils data for the ditch indicated the presence of elevated concentrations of certain metals (arsenic, chromium, and lead). However, maximum concentrations observed for these three metals were significantly less than the levels recorded for ditch samples obtained during the preceding Phase I investigation.Taken as a whole, the data from the RFI Phase I and II investigations indicate that the individual incidences of arsenic, chromium, and lead in excess of applicable health-based limits are generally neither widespread along the length of the ditch or throughout the entire contaminant zone profile at any given point within the unit.

- TCLP evaluation of the soil samples from Three-Mile Ditch failed to yield any exceedances for metals regulated under the TC rule, demonstrating the minimal leaching potential for metal contamination within the unit. Further, neither the preceding RFI Phase I investigation or the current Phase II investigation has revealed any data to indicate that unit soils in immediate proximity to, or potentially in contact with, the water table possess metal concentrations which could potentially serve as a source of an ongoing release of metal constituents to the water table.

Three-Mile Ditch — Groundwater

- In the vicinity of Three-Mile Ditch, no organic contaminants were observed in the groundwater monitor wells, with the sole exception of monitor well MW-45, in the vicinity of the refinery process area, which yielded one detection each of carbon disulfide and xylene. The detected levels for these two constituents were significantly below allowable health-based levels.
- Evidence of groundwater contamination by metals in the vicinity of Three-Mile Ditch was limited to the elevated levels of chromium and nickel in monitor wells MW-8 and MW-9. However, the available evidence indicates that the detection of these two constituents resulted from the corrosion of the stainless-steel casing used in the two wells. Groundwater samples obtained from PVC-cased monitor well MW-21, installed intermediately between MW-8 and MW-9, did not yield analytical evidence of elevated chromium and nickel contamination.
- The near-surface water zone in the vicinity of Three-Mile Ditch is too discontinuous to provide a potentially usable water source, and the quality of the groundwater is poor owing to excessive concentrations of total dissolved solids (TDS). The quality of the shallow water near the evaporation ponds is also very poor because of excessively high salt concentrations.
- A comprehensive comparison of groundwater water-quality parameters revealed that there are no similarities between shallow groundwater in the vicinity of Three-Mile Ditch and nearby deep domestic wells, which indicates that the shallow and deep zones are not hydrologically connected in the vicinity of the ditch.
- A similar comparison between the shallow groundwater quality and current and past wastewater quality does not identify similarities indicative of obvious mixing of the wastewater and shallow groundwater.

Evaporation Ponds — Pond 1 Soils

- Analytical results of the soils investigation for at Evaporation Pond 1 revealed that residual organic constituents are associated with elevated levels of oil and grease concentrated in the upper portion of the profile (within 3 ft or less of the soil surface). TCLP tests performed on soil samples from Pond 1 failed to yield any TC exceedances for organic constituents.
- Although the data suggest that localized occurrences of elevated levels of metal constituents of concern (i.e., arsenic, chromium, and lead) may be present within the soils of Evaporation Pond 1, the occurrence of these three constituents at levels that exceed health-based criteria apparently are not widespread within the unit.
- The soil contamination profile of Evaporation Pond 1 reveals a distinct trend in which the concentration of organic constituents diminishes abruptly with increasing depth. A similar trend was even more developed for metal constituents. Metal concentrations observed at all sample intervals below the 1-ft sample depth yielded values ranging from background concentrations to only slightly elevated above background. Metal

concentration values for all samples obtained below a depth of 1 ft were significantly below health-based criteria.

- Significant concentrations of organic and inorganic constituents were detected only at soil depth intervals well above the shallow groundwater zone underlying the unit. Further, TCLP evaluation of the Pond 1 soil samples did not yield leachate concentrations in exceedance of allowable concentrations for any TC-regulated organic or inorganic constituents. Overall, these findings demonstrate the minimal potential for groundwater contamination resulting from the migration of constituents present within this unit.
- Continued mechanical mixing and aeration of surface soils in Evaporation Pond 1 will enhance the degradation of residual organic constituents and the fixation of metal constituents. This has been demonstrated in those areas previously subject to such mixing.

Evaporation Ponds — Groundwater

- Benzene was the only volatile constituent detected in groundwater in the vicinity of the ponds that exceeded health-based drinking water standards. Benzene was reported in groundwater samples obtained from several monitoring wells located immediately south and southeast of Evaporation Pond 1 and in one monitor well immediately east of Evaporation Pond 2. The maximum detected values were approximately four times the federal drinking water standard for benzene.
- Of the metals tested, arsenic was the only metal repeatedly detected and verified in the groundwater in the area of the evaporation ponds. Slightly elevated levels of arsenic (approximately three times the level of the current drinking water standard) were detected in the groundwater immediately adjacent to the ponds.
- Relatively high concentrations of target volatile constituents in the groundwater southeast of the ponds were reported in a 1987 study using piezometers and summarized in the RFI Phase I Report. These previous findings are strongly contradicted by the Phase II investigation, which did not detect the presence of target volatile organic constituents in the groundwater in the vicinity of one 1987 sample location. Because the sampling and analytical methods used in the 1987 study are not identified in the RFI Phase I Report, these suspect results cannot be substantiated.
- Groundwater elevation data indicate that groundwater movement in the vicinity of the ponds is to the southeast. An aquifer test conducted in the valley fill alluvium southeast of the ponds indicates that the values of hydraulic conductivity and seepage velocity of the valley fill the aquifer at this location are in the range of the values reported for these properties in the RFI Phase I Report.
- A well point subsurface gas survey measuring headspace vapors from the degassing of water was employed to delineate the extent of hydrocarbon-impacted shallow groundwater downgradient of the ponds. The measurement of subsurface gas is the best method for detecting the overall presence of hydrocarbon contamination of soil and shallow groundwater. However, the type or level of individual constituents can not be determined using the method employed for this study.
- The results of the subsurface gas survey defined a hydrocarbon-impacted groundwater plume that extends approximately 3,000 ft south-southeast of the Pond 1/Pond 2 juncture. The well point survey data were used to define appropriate downgradient locations for the installation of additional monitor wells in the vicinity of the ponds.
- Comparison of groundwater elevations in shallow monitor wells with elevations in monitor wells screened at lower depths in the valley fill alluvium demonstrate the existence of an upward vertical gradient in the vicinity of the evaporation ponds. This

observation confirms the findings of a previous U.S. Geological Survey study of this area of the Pecos River. The presence of an upward vertical gradient greatly reduces the potential for any shallow groundwater contaminants to migrate to deeper zones of higher quality groundwater.

- The existence of an upward vertical gradient in the vicinity of the ponds is also verified by the presence of a natural discharge zone for the shallow aquifer located southeast of the ponds. Such zones are typically characterized by elevated TDS values which were observed for shallow groundwater in this area.
- Further evidence confirming the existence of an upward vertical groundwater gradient is provided by the integration of groundwater modeling results with the comparative analysis of groundwater chemistry data for various monitor wells in the vicinity of the ponds. The results and observations obtained from these two information sources are reciprocally validating, providing strong evidence that the downward vertical groundwater gradient underlying the ponds is in effect only to a limited depth. Thereafter, upwelling of deep alluvial groundwater redirects the downward-moving contaminated groundwater upwards to the shallow groundwater zone.
- The shallow groundwater in the vicinity of the ponds, as well as the water of the Pecos River, is naturally high in TDS. The salty nature of this groundwater renders it unusable for domestic, agricultural, or industrial purposes. As a result, there are no potential environmental receptors for any hydrocarbon-impacted groundwater that may exist downgradient of the ponds.

The results of groundwater sampling and analysis in the vicinity of the evaporation ponds indicate that the deeper groundwater in the river alluvium of the valley fill aquifer has not been excessively impacted by refinery activity. The southeastly flow direction of water in the alluvium moves contamination entering the groundwater from the ponds to the southeast, away from the better quality groundwater to the west. The prevailing upward vertical flow should also minimize the downward migration of any possible contamination to the deeper portion of the valley fill aquifer. Because of the lack of potential environmental receptors downgradient from the ponds and the restriction of any contamination to the uppermost portion of the river alluvium, the evaporation ponds do not currently pose a significant environmental risk to the area and are not likely to become such in the future.

Based on the results of Phase II (and Phase I) of the RFI, it can be concluded that the two-phase investigation has adequately characterized the nature and extent of contamination and releases from the SWMUs. The relatively low levels of organic and inorganic constituents beneath and in proximity to the SWMUs pose little threat to human health and the environment, as defined by federal and state criteria. Therefore, it is recommended that no further investigations are necessary beyond the routine monitoring of water levels and selected constituents to verify the nature and extent of releases from these units.