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13. ABSTRACT (Maximum 200 words)

THE SOUTH TANK FARM PLUME (STFP) IS LOCATED IN THE SOUTHERN HALF OF SECTIONS 1 AND 2. IT IS A COMPOSITE PLUME OF C6H6, MEC6H5, XYLEN, DCPD, AND BCHPD WHICH IS MIGRATING FROM THE AREA OF TANK 464A. RECENT INVESTIGATIONS HAVE SHOWN THAT THE STFP IS BEING BIODEGRADED NATURALLY AND WILL NOT MIGRATE INTO EITHER LAKE LADORA OR LOWER DERBY LAKE PRIOR TO IMPLEMENTATION OF THE FINAL REMEDY.

MONITORING WITH THE SPECIFIC OBJECTIVES OF 1) VERIFYING THE RATE OF MIGRATION AND 2) LOCATING THE LEADING EDGE OF THE PLUME OVER THE TIME FRAME OF THE IRA IS PROPOSED AS THE PREFERRED ALTERNATIVE ACTION.

SECTIONS OF THIS ASSESSMENT PROVIDE INFORMATION ON:

1. SITE DESCRIPTION - HISTORY, PREVIOUS INVESTIGATIONS, HYDROGEOLOGY, LNAPL PLUME
2. IRA OBJECTIVES AND EVALUATION
3. WORK PLAN OF THE IRA - WELL NETWORK, SAMPLING FREQUENCY.

APPENDICES INCLUDE COMMENTS AND RESPONSES.

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FINAL ALTERNATIVES ASSESSMENT
OTHER CONTAMINATION SOURCES
INTERIM RESPONSE ACTION
SOUTH TANK FARM PLUME

Prepared by
MK-Environmental Services
Denver, Colorado

Prepared for
Shell Oil Company/Holme Roberts & Owen
Denver, Colorado

08/16/90

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08/16/90

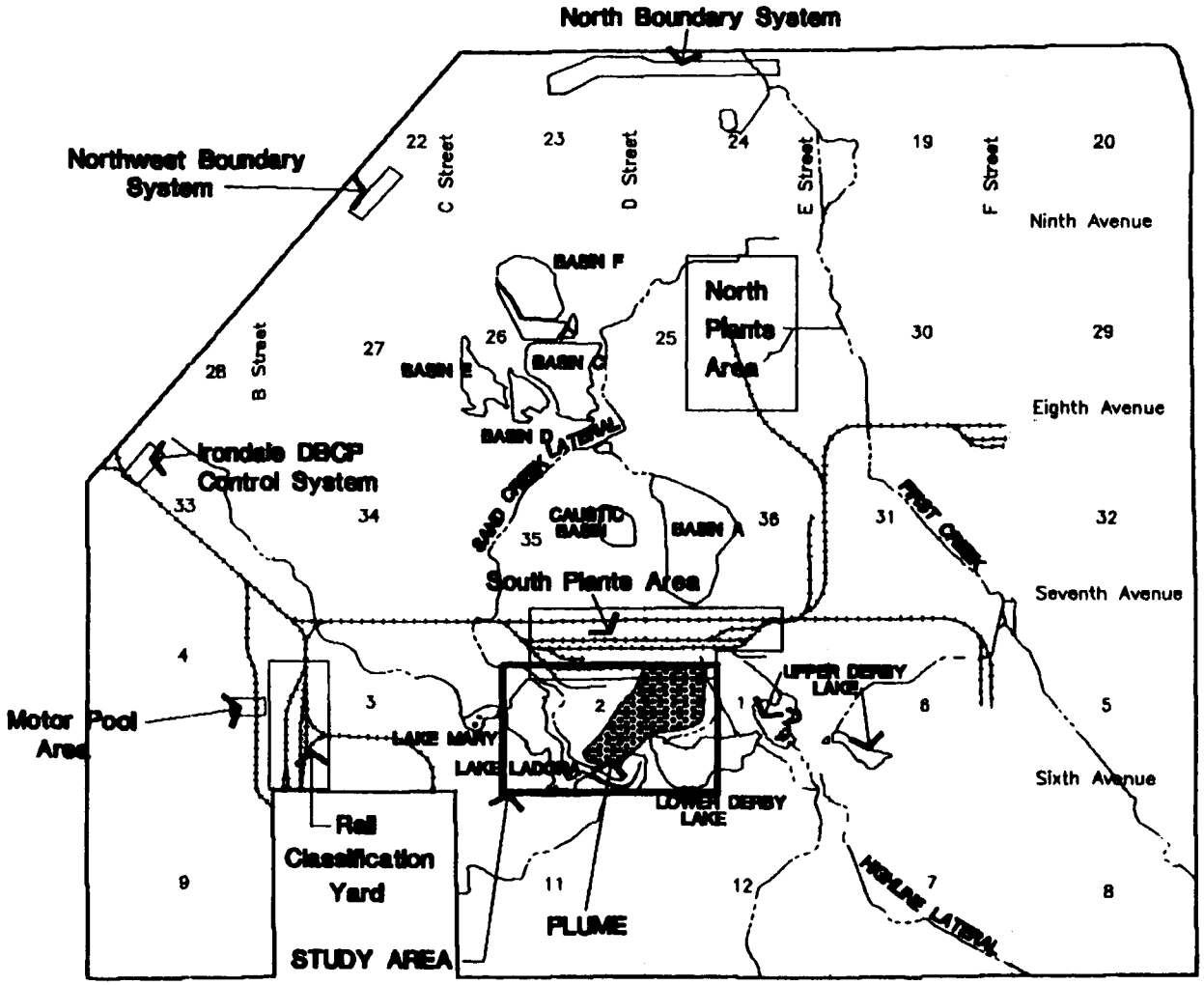
1.0 INTRODUCTION/EXECUTIVE SUMMARY

The South Tank Farm Plume (STFP) is located in the southern half of Sections 1 and 2 on the RMA (Figure 1-1). It is defined in detail in Section 2.4. The constituents of the STFP are those present in the Light Nonaqueous Phase Liquid (LNAPL) plume, which is one of the sources of the dissolved plume.

In 1989, Shell proposed, and the Army and EPA agreed, that the STFP be added to the list of RMA IRAs. The basis for the nomination and acceptance of this plume for an IRA was an apparent increase in concentration and areal distribution of the STFP compounds, notably benzene which defines the leading edge of the plume (Shell 1989a). The data suggested that benzene was migrating toward Lake Ladora rapidly enough to reach the lake prior to the implementation of the final remedy.

Based on this interpretation of the rate of contaminant migration, the original objective of the IRA was to prevent the STFP from reaching Lake Ladora prior to the implementation of the final remedy. However, recent investigations have shown that the STFP is being biodegraded naturally and will not migrate into either Lake Ladora or Lower Derby Lake prior to the implementation of the final remedy (Shell 1990).

Since there is no imminent threat of contamination to Lake Ladora or Upper Derby Lake by the STFP, interim response alternatives cannot be meaningfully developed or evaluated within the context of the original objective of this IRA. In accordance with Section 22.1(1) of the Federal Facility Agreement which addresses the "assessment and, as necessary, the selection and implementation of an IRA...", an evaluation of monitoring as the appropriate course for the interim response action has been conducted. This evaluation shows that: (1) the STFP poses no



Legend

- Railroad
- Stream/Drainage
- Study Area
- Plume
- Lakes

N

0 1/2 1 2

MILES

ROCKY MOUNTAIN ARSENAL
South Tank Farm Study Area

Figure 1-1

Study Area Location Map

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risk to human or non-human biotic receptors because it will not enter the lakes prior to the final remedy, and (2) there is no significant benefit in terms of cost or accelerated cleanup by conducting an IRA on the plume because of the low rate of contaminant migration and active biodegradation that are presently occurring in the plume. Therefore, monitoring with the specific objectives of verifying the rate of contaminant migration and ensuring current knowledge of the location of the leading edge of the plume over the time frame of the IRA, is the appropriate course for this IRA. The evaluation process is discussed further in Section 3.0.

During the summer of 1989, an additional study was conducted to preliminarily characterize the extent, apparent thickness, and composition of a plume of LNAPL previously detected in a monitoring well near Tank 464A in the South Tank Farm. The significant conclusion of this study was that the LNAPL plume was an active source of groundwater contamination and therefore should be included in the IRA (Shell 1989b). Routine measurements since 1989 indicate that the LNAPL is not migrating at a measurable rate or increasing in volume.

In an addition to monitoring the dissolved plume, an FS Treatability Study will be proposed by Shell on the LNAPL plume. This study has the objectives of (1) determining a workable combination of technologies for remediating the LNAPL plume in particular and (2) developing and evaluating those technologies for possible application to other sites on the RMA.

2.0 SITE DESCRIPTION

This section provides a summary of the site history of the STFP and the investigations performed to characterize the groundwater quality and hydrogeologic setting. Detailed information on groundwater quality and hydrogeology is provided in Ebasco (1987, 1988, 1989a, 1989b) and Shell (1989a, 1989b, 1990).

2.1 SITE HISTORY

The constituents within the STFP and LNAPL plume include compounds previously stored in the STF and used in the manufacture of pesticides and compounds potentially associated with other production, disposal, and storage activities in the South Plants. Between 1947 and 1978, Tanks 464A, 464B, and other tanks were used intermittently to store dicyclopentadiene (DCPD) and bicycloheptadiene (BCHPD) bottoms generated from pesticide manufacturing.

Tanks 464A and 464B were cleaned in 1956, 1966, and 1967. In 1956, BCHPD bottoms were "pumped" onto the ground, and the affected area was later cleaned up. In 1966, residue from a mixture of fuel oil and BCHPD bottoms containing DCPD was buried in the South Tank Farm area. In 1967, a mixture of DCPD bottoms and fuel oil was collected in a low spot in the South Tank Farm, and later drummed and shipped offsite. From 1960-1963, leakage of BCHPD/DCPD bottoms occurred from a pipe connected to Tank 464A, although the quantity spilled is unknown. Additional disposal and spill events involving BCHPD and DCPD occurred at unidentified locations in the South Tank Farm in 1964 and 1978, respectively.

Although records do not show that benzene, toluene, or xylene were stored in the South Tank Farm, a large spill of benzene

containing toluene and xylene impurities reportedly occurred at an unidentified location in the South Tank Farm in 1948. Toluene may also have been present in trace amounts in BCHPD.

2.2 PREVIOUS REPORTS AND INVESTIGATIONS

Field investigations were conducted between 1979 and 1984 to characterize groundwater quality and the hydrogeologic setting in Sections 1 and 2. These early investigations identified a significant groundwater contamination plume consisting primarily of benzene, toluene, and xylene extending from the South Tank Farm area southwest toward Lake Ladora and possibly south toward Lower Derby Lake (RMA-PMO database). Additional groundwater monitoring wells were installed by Shell in 1982 and 1984 along the axis of the plume to monitor contaminant migration.

A comprehensive groundwater sampling program in the South Plants area was conducted in 1988 (Ebasco 1989a). Concentrations of constituents in the STFP (most notably benzene) appeared to have increased by nearly one order of magnitude between 1983/84 and 1988. This apparent increase may actually have reflected differences in sampling procedures between 1983/84 and 1988, incomplete decontamination procedures in 1988 (several rinse blanks contained moderate concentrations of contaminants), or inadvertent entrapment of LNAPL in groundwater samples (the LNAPL plume had not yet been identified). However, as a result of this apparent movement, Shell expressed concern to the Organizations and State (OAS) that there was potential for the STFP to enter Lake Ladora.

Shell conducted a groundwater sampling program in the spring of 1989 to better define the hydrogeologic setting and contaminant distribution in Section 2, and determine whether a new IRA should be proposed for the STFP (Shell 1989a). Based on the assumption

that the groundwater quality data from 1983/84 and 1989 were comparable, Shell concluded that the "benzene plume" was migrating toward Lake Ladora at a sufficient rate that the plume might migrate into Lake Ladora prior to the implementation of the final remedy. An IRA was proposed by Shell and accepted by the Army and EPA.

An investigation was conducted by Shell during the summer of 1989 in the South Tank Farm to investigate the extent and composition of a light, non-aqueous phase liquid (LNAPL) previously detected in a well near Tank 464A. This investigation provided a preliminary characterization of the apparent thickness, composition, and lateral extent of a portion of the LNAPL plume which is believed to be a primary source of the dissolved constituents which comprise the STFP (Shell 1989b).

Another investigation was conducted by Shell during the fall of 1989 to better define both the leading edge and hydrogeologic setting of the STFP in Sections 1 and 2 (Shell 1989a). The results of the investigation failed to verify the conclusions of previous investigations regarding migration and extent of the STFP, especially benzene which defines the leading edge of the plume towards Lake Ladora.

During the spring of 1990, Shell conducted a comprehensive groundwater quality sampling program in the STFP area (Shell 1990a). The specific objectives of the investigation were to determine the present position and concentration of dissolved STFP constituents, evaluate the causes of temporal and spatial variation in contaminant concentrations near the leading edge of the dissolved plume, and assess the extent to which natural biodegradation may be affecting the present concentration and distribution of contaminants. The results of this investigation indicated that: (1) sampling methodology and natural

biodegradation cause significant temporal and spatial variability in the concentrations of benzene, particularly in wells located near the plume margin, (2) cross-contamination of wells probably occurred during the Spring 1988 sampling event resulting in an overestimate of the maximum extent and migration rate of benzene, (3) no STFP compounds were detected in monitoring wells located within 500 feet of either lake, and (4) contrary to earlier interpretations, STFP compounds are not expected to migrate into either lake before the final remedy can be implemented. Therefore, there is no imminent threat of contamination to Lake Ladora or Lower Derby Lake due to STFP compounds.

2.3 HYDROGEOLOGY

Two geologic units occur in the STFP study area: an upper alluvial unit underlain by the Denver Formation. The alluvium consists of brown, unconsolidated, silty sand with increasing silt and clay content at depth. It ranges from approximately 5 feet thick near the South Tank Farm to 25 feet thick near Lake Ladora.

The alluvium is underlain by brown to green, weathered and unweathered claystones, mudstones, and siltstones of the Denver Formation. These strata are referred to as the VCE and VC in the South Plants Study Area Report (Ebasco 1989a). The uppermost 4 to 6 feet of the Denver Formation is weathered and, in places, exhibits narrow joints and fractures. The variability of the subsurface lithology near the leading edge of the STFP near Lake Ladora is shown by the geologic cross-section in Figure 2-1.

The STFP is located in the uppermost water-bearing zone (WBZ1) as defined in the South Plants Study Area Report (Ebasco 1989a). WBZ1 comprises saturated sediments in both the alluvial aquifer and the uppermost Denver Formation. The top of WBZ1 is defined

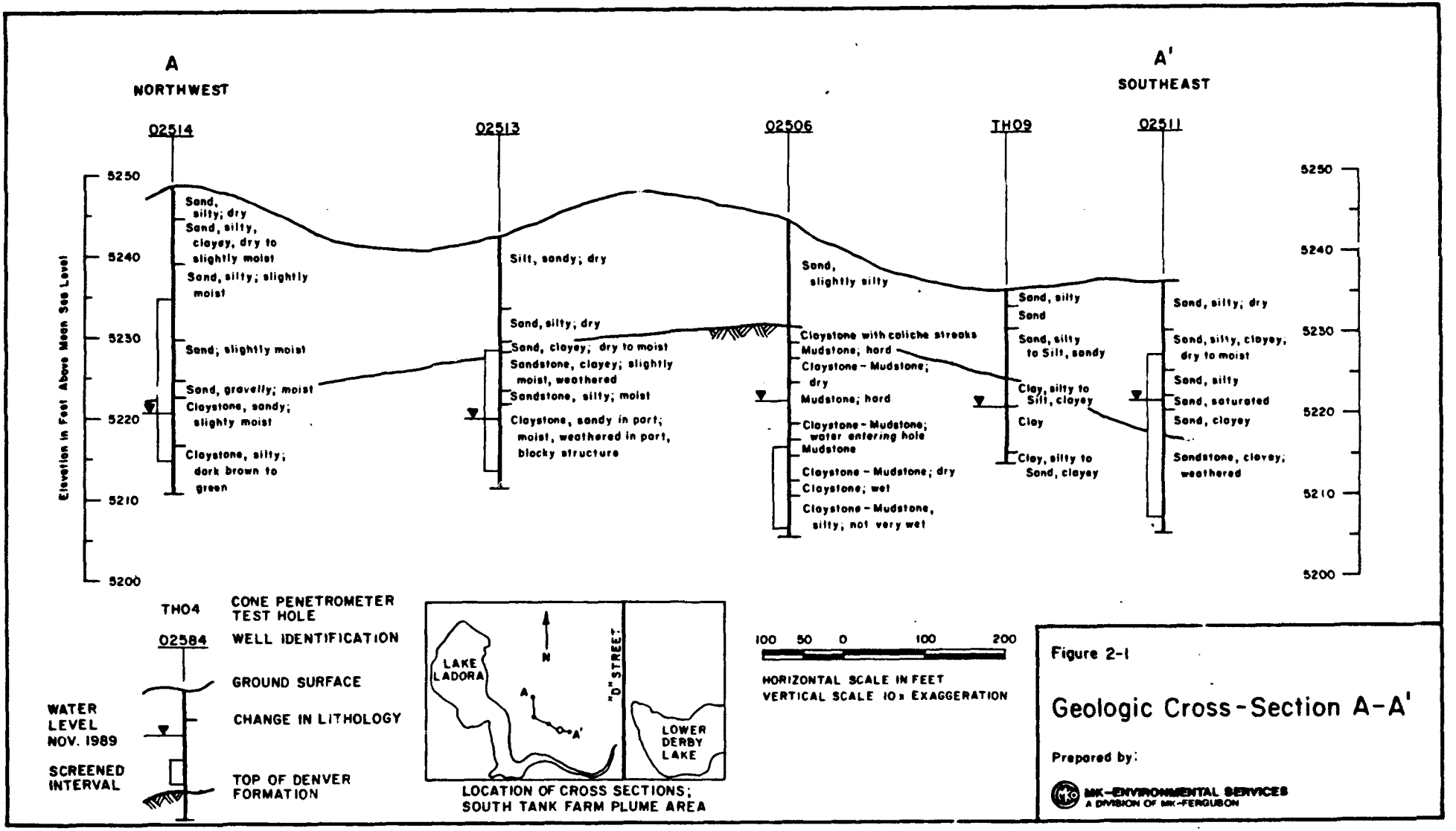

Figure 2-1

Geologic Cross-Section A-A'

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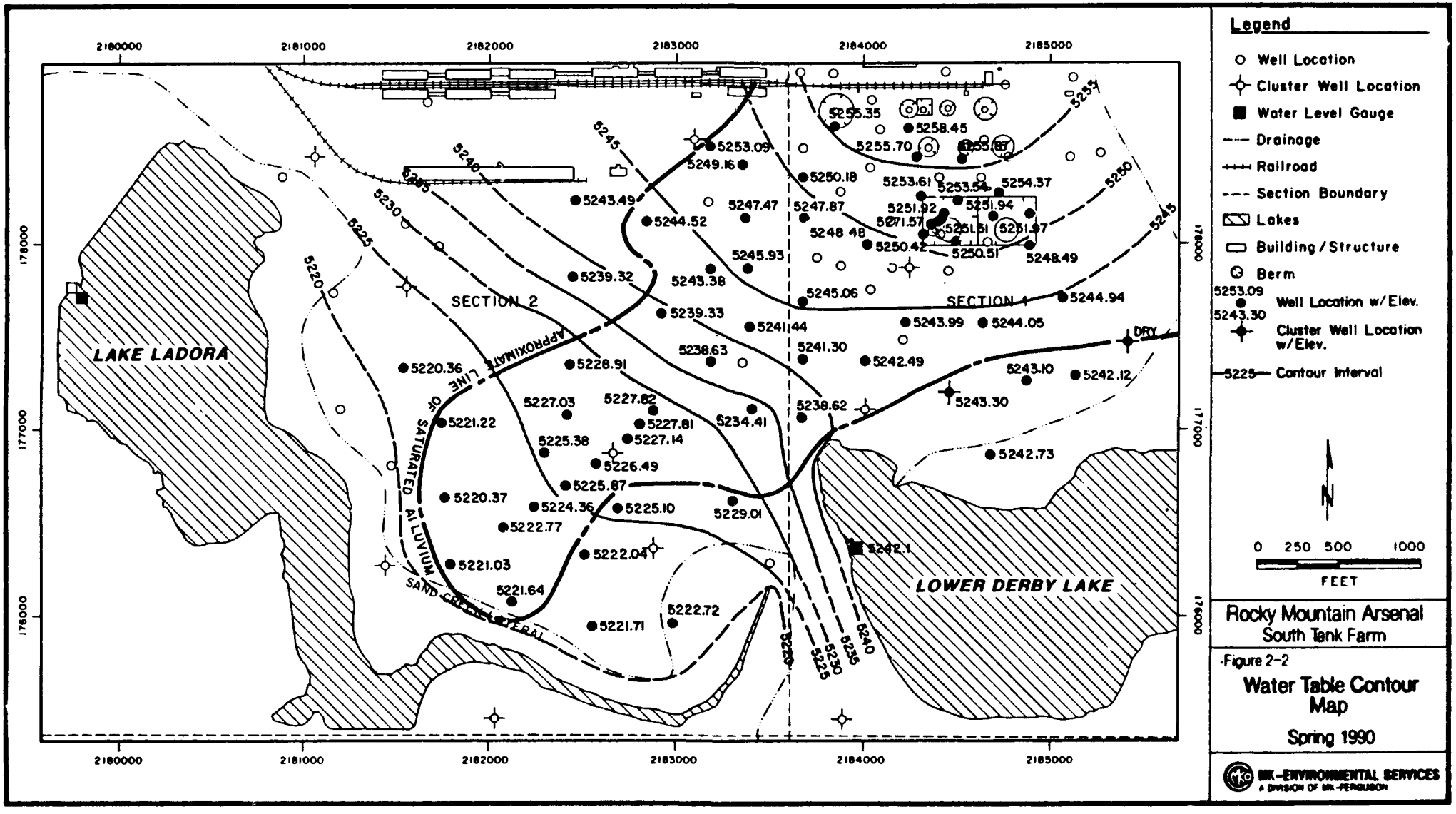
by the water table. The base is defined by the transition between weathered and unweathered sediments in the uppermost Denver Formation; it is identified by a green to brown claystone exhibiting a lesser degree of fracturing and weathering (Ebasco 1989a, Shell 1989b). In the STFP area, WBZ1 ranges in saturated thickness from 10 to 25 feet.

The water table occurs in the alluvium in the northwestern and southeastern portions of the study area, and in the weathered Denver Formation immediately southwest of the South Tank Farm and toward Lake Ladora (Figure 2-2). Groundwater in WBZ1 flows away from the South Tank Farm to the southeast, south, and southwest. The water table flattens near the lakes except near the northwest corner of Lower Derby Lake (near Well 01586) where groundwater flowpaths are deflected sharply towards the southwest around the spillway embankment.

Water levels in the STF area have declined historically (RMA-PMO database). Since the spring of 1988, water levels near the tank farm have declined as much as 5 feet, while water levels in wells near Lake Ladora have declined approximately 1 to 2 feet (Shell 1990).

The hydraulic gradient from the South Tank Farm area to Lake Ladora averages approximately 0.009 ft/ft based on the water table surface presented in Figure 2-2. Hydraulic conductivity estimates for the weathered Denver Formation were calculated from single-well injection (slug) tests conducted during the fall of 1989 near Lake Ladora and Lower Derby Lake. Hydraulic conductivity averaged 9.1×10^{-4} cm/sec from seven tests conducted in Wells 02505 and 02598 near Lake Ladora, and 3.7×10^{-4} cm/sec from four tests conducted in Well 01580 near Lower Derby Lake.



Rocky Mountain Arsenal
South Tank Farm

Figure 2-2

Water Table Contour Map

Spring 1990

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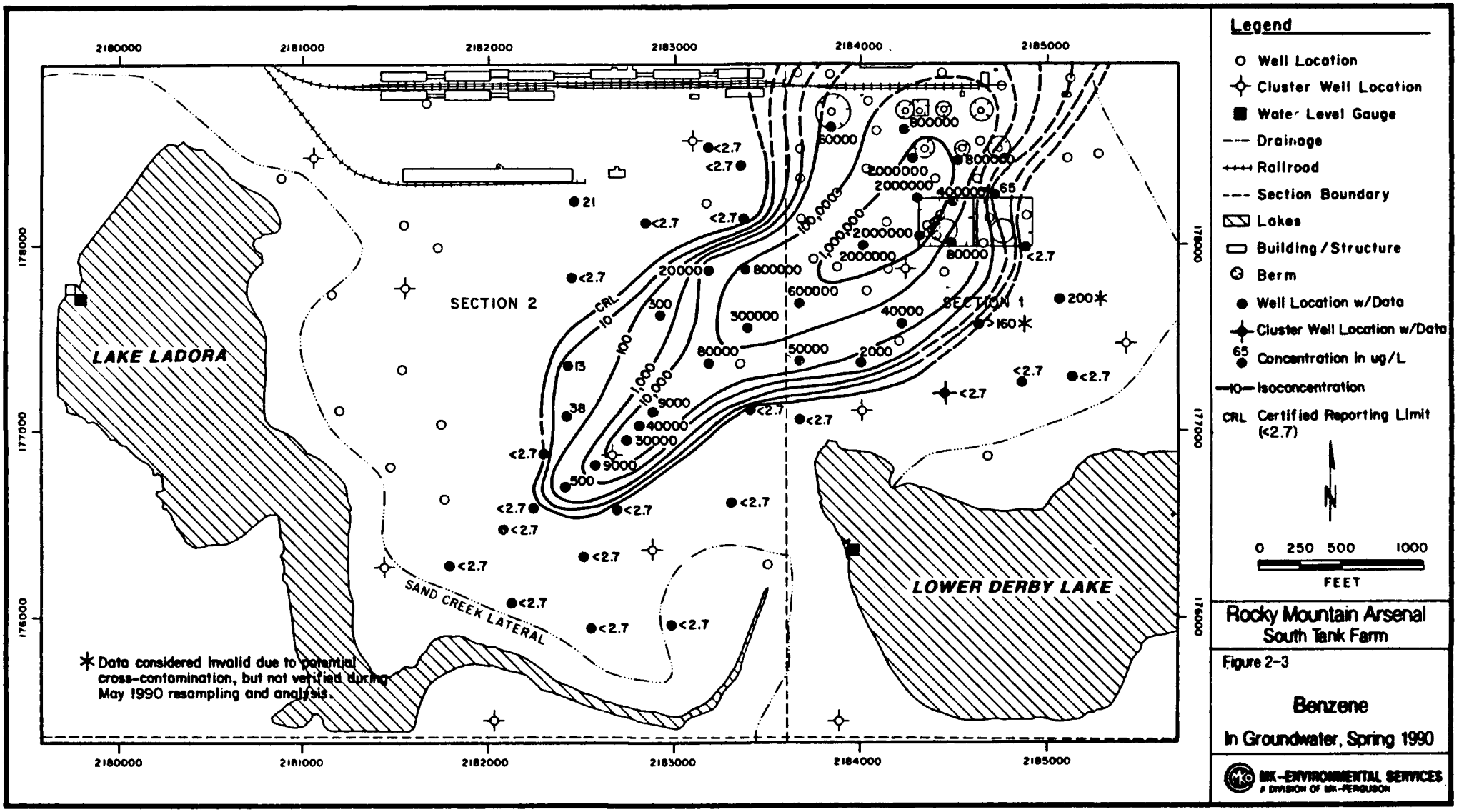
2.4 DISSOLVED GROUNDWATER PLUME

The STFP is defined as the composite plume of benzene, toluene, xylene, bicycloheptadiene (BCHPD), and dicyclopentadiene (DCPD) dissolved in groundwater in the uppermost water-bearing zone (WBZ1) and migrating from a plume of light non-aqueous phase liquid (LNAPL) near Tank 464A toward Lake Ladora and Lower Derby Lake. The highest concentrations of STFP contaminants dissolved in groundwater occur primarily near tanks 464A and 464B (Figures 2-3 through 2-7). High concentrations also occur near tanks 463A, 463E, and 463G, and Tanks 462A, 463B, and 463F may be potential sources of contaminants common to the defined STFP constituents. Benzene exhibits the greatest concentration and areal distribution of STFP compounds, and defines the leading edge of the STFP directed southwest toward Lake Ladora. DCPD is the most widely distributed contaminant within the south-southeastern component of the STFP and defines the leading edge of the plume towards Lower Derby Lake. None of the STFP compounds were detected in wells located within 500 feet of either Lake Ladora or Lower Derby Lake.

Natural biodegradation is occurring in the STFP, contributing to the variability and recent decrease in concentrations of benzene in wells near the margin of the plume (Shell 1990). Groundwater quality information obtained during 1988 and 1990 show an inverse correlation between dissolved oxygen (DO) and total concentrations of benzene, toluene, and xylene (BTX). This inverse correlation is consistent with data presented by Chiang et al. (1989), and indicates that these aromatic compounds are degraded when dissolved oxygen concentrations exceed 1-3 mg/L.

Additionally, laboratory studies conducted using saturated sediment samples from the STF area verified the existence of bacteria capable of degrading BTX and demonstrated the increased


2180000
2181000
2182000
2183000
2184000
2185000
178000
177000
176000
SECTION 2
SECTION 1
LAKE LADORA
LOWER DERBY LAKE
SAND CREEK LATERAL
CRL
10
100
300
1,000
10,000
100,000
1,000,000
<2.7
21
13
38
65
200*
>160*
* Data considered invalid due to potential cross-contamination, but not verified during May 1990 resampling and analysis.
Legend
Well Location
Cluster Well Location
Water Level Gauge
Drainage
Railroad
Section Boundary
Lakes
Building / Structure
Berm
Well Location w/Data
Cluster Well Location w/Data
65 Concentration in ug/L
10 Isoconcentration
CRL Certified Reporting Limit (<2.7)
N
0 250 500 1000
FEET
Rocky Mountain Arsenal
South Tank Farm
Figure 2-3
Benzene
In Groundwater, Spring 1990
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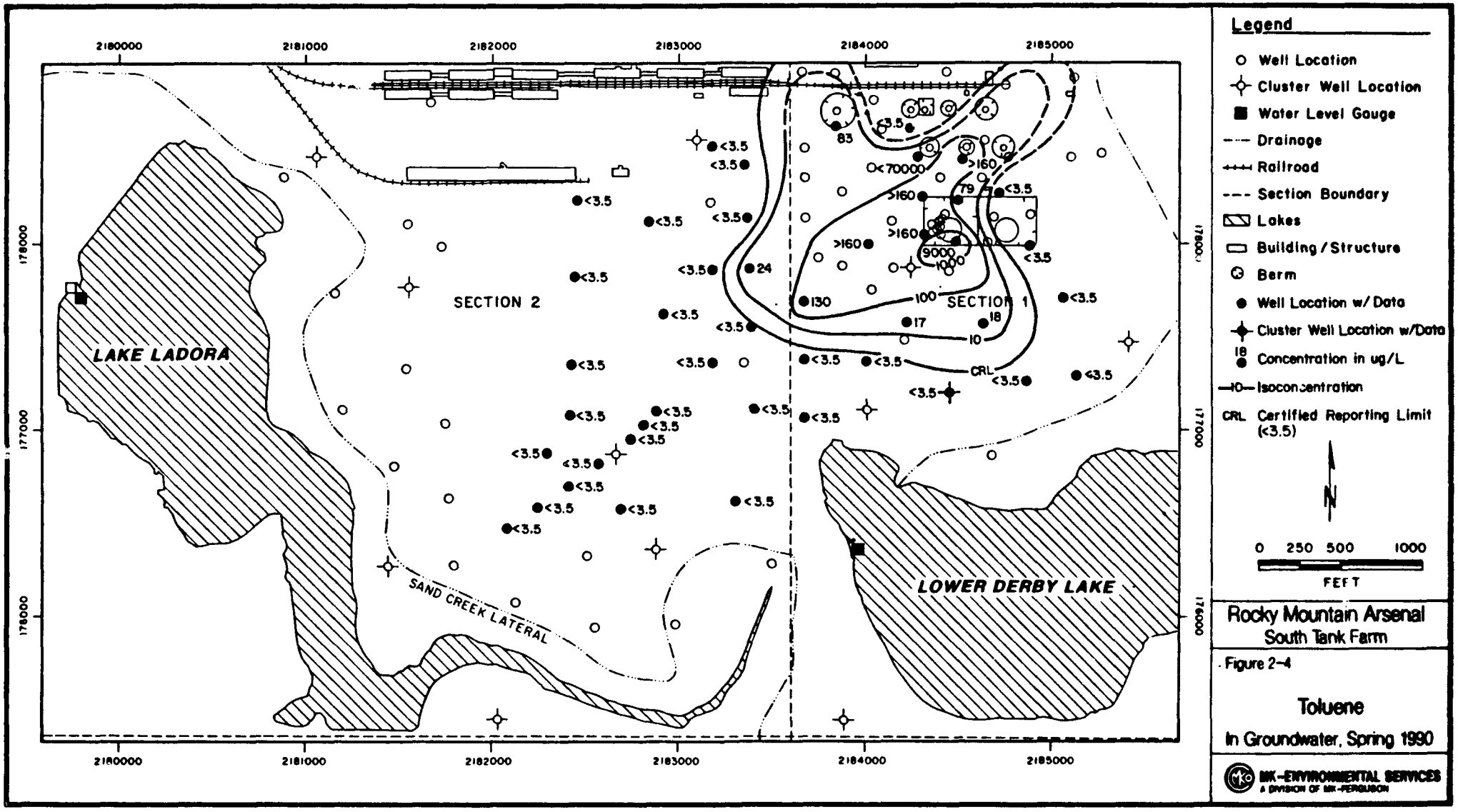

Rocky Mountain Arsenal
South Tank Farm

Figure 2-4

Toluene

In Groundwater, Spring 1990

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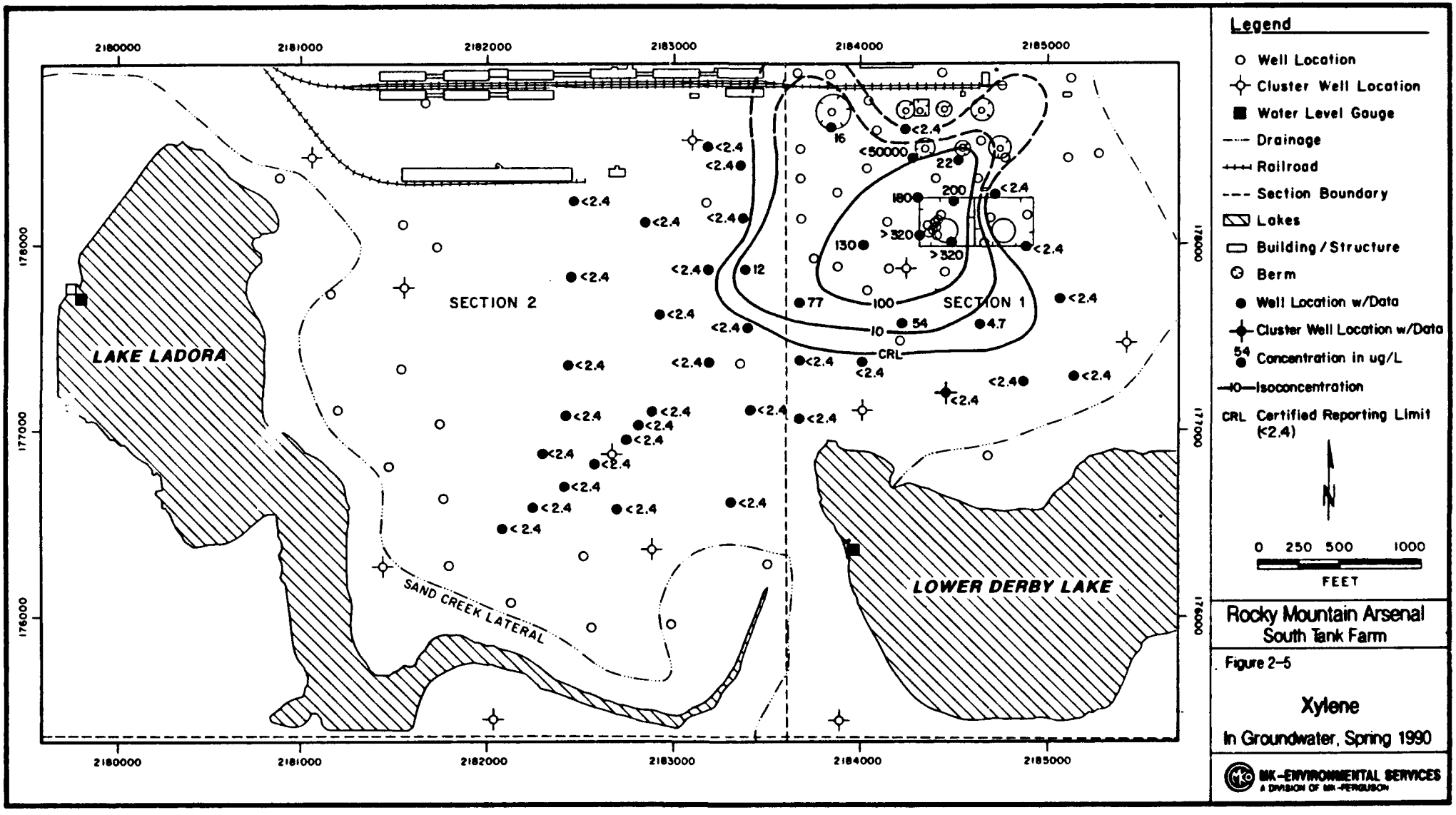

Rocky Mountain Arsenal
South Tank Farm

Figure 2-5

Xylene

In Groundwater, Spring 1990

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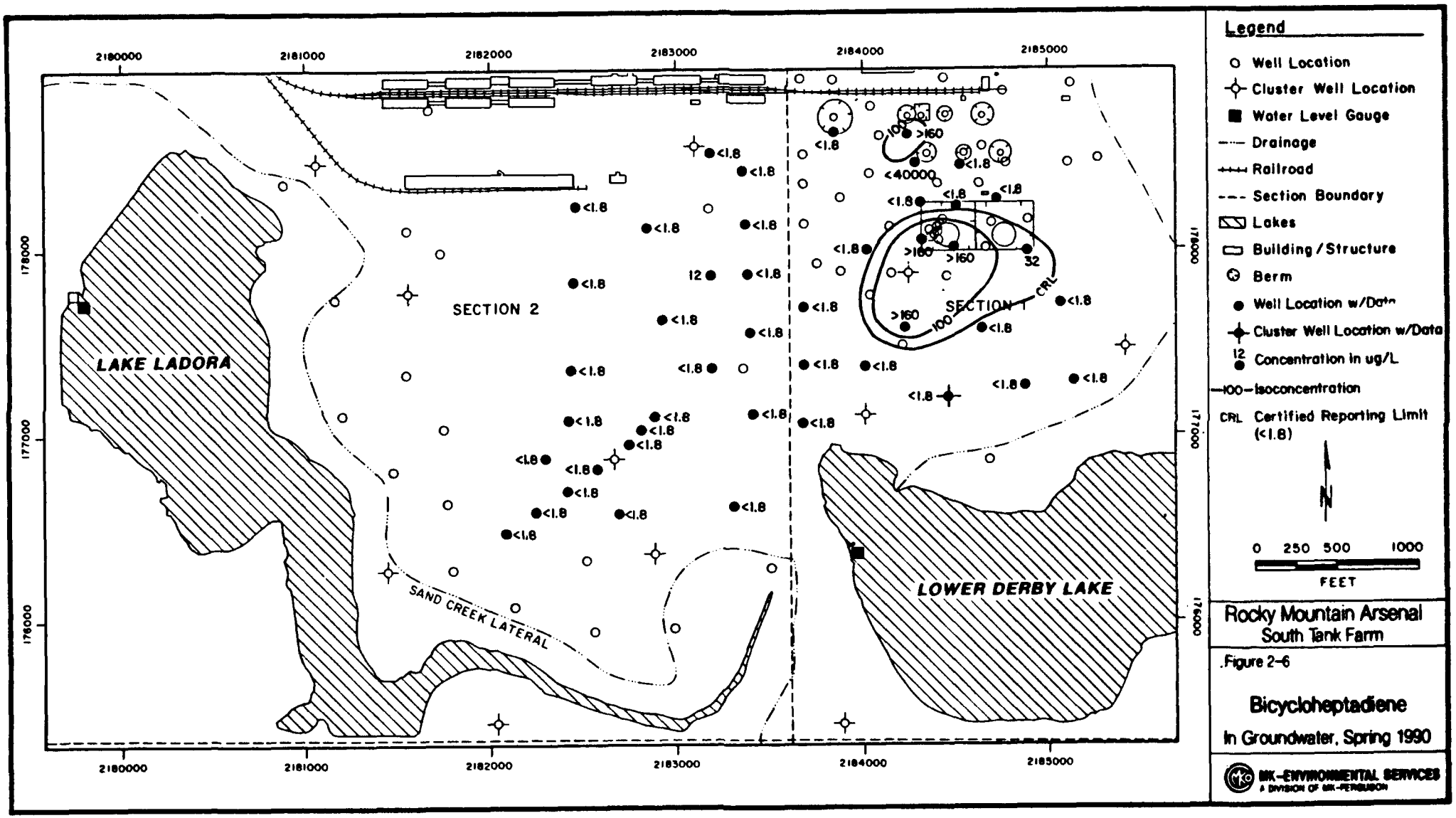

Rocky Mountain Arsenal
South Tank Farm

Figure 2-6

Bicycloheptadiene
In Groundwater, Spring 1990

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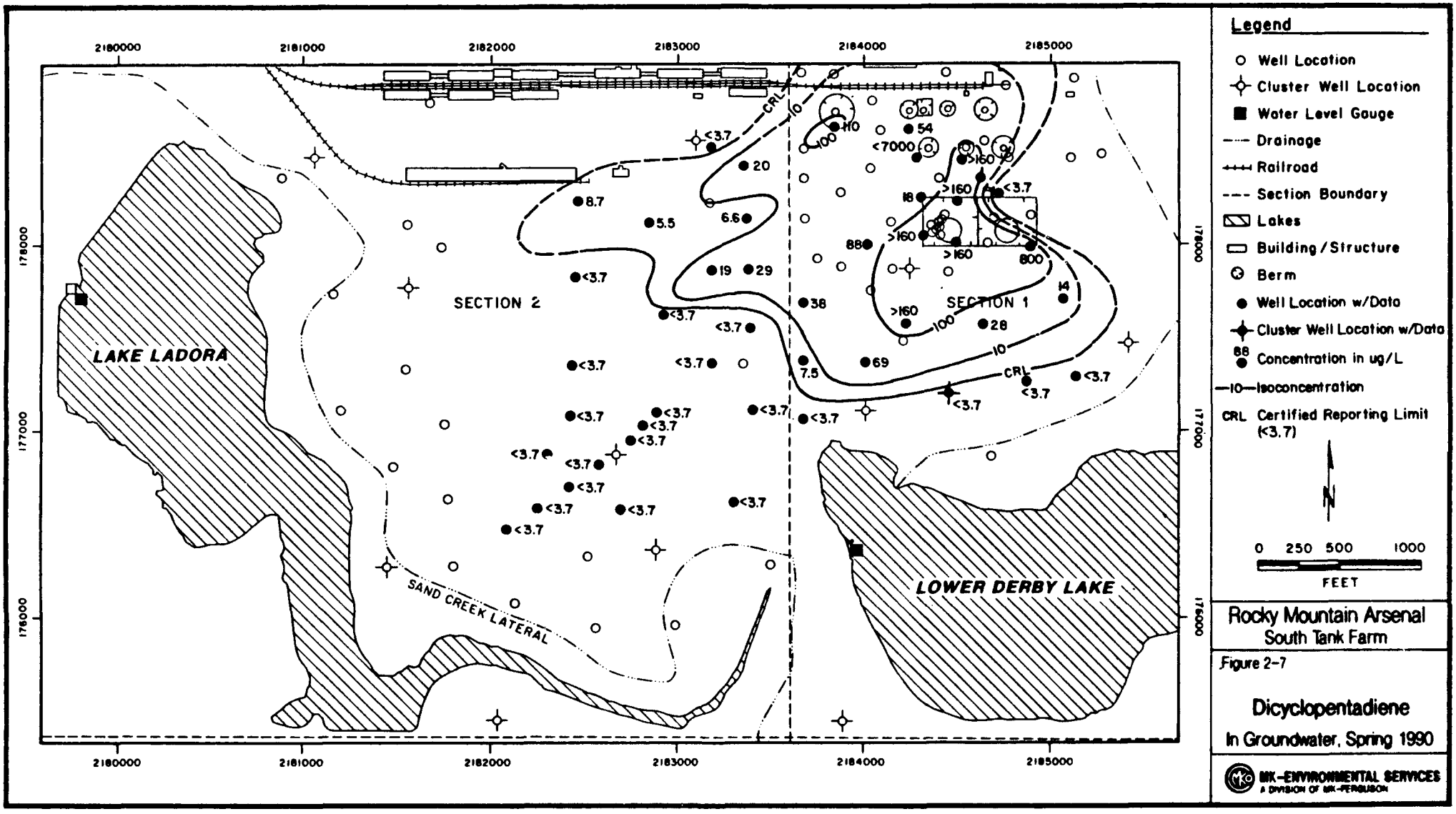

Rocky Mountain Arsenal
South Tank Farm

Figure 2-7

Dicyclopentadiene
In Groundwater, Spring 1990

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rate of degradation at higher concentrations of dissolved oxygen (Shell 1990).

Between 1983/84 and 1990, the benzene plume advanced at an approximate rate of 33 ft/yr. (This observed migration rate correlates well with the interstitial groundwater flow velocity of 28 ft/yr calculated using the estimated hydraulic conductivity of 9.1×10^{-4} cm/sec, groundwater gradient of 0.009 ft/ft taken from Figure 2-3, and an assumed effective porosity of 0.3). Based on the rate of contaminant migration observed at the leading edge of the STFP, the STFP will not migrate into Lake Ladora prior to implementation of the final remedy.

In summary, the results of the 1990 investigation indicated that: (1) natural biodegradation causes significant temporal and spatial variability in the concentrations of benzene, particularly in wells located near the plume margin, (2) cross-contamination of wells probably occurred during the Spring 1988 sampling event resulting in an overestimate of the maximum extent and migration rate of benzene, (3) no STFP compounds were detected in monitoring wells located within 500 feet of either lake, and (4) contrary to earlier interpretations, STFP compounds are not expected to migrate into either lake before the final remedy can be implemented. Therefore, there is no imminent threat of contamination to Lake Ladora or Lower Derby Lake due to STFP compounds.

2.5 LNAPL PLUME

The LNAPL plume near Tank 464A exists at shallow depths in Denver Formation sediments. The investigation completed in 1989 identified the western extent of mobile LNAPL near Tank 464A but did not define the eastern extent. Based on the evaluation of dissolved concentrations of STFP constituents, the eastern extent

of the mobile LNAPL plume is apparently beneath Tank 464A or 464B.

The LNAPL is comprised of DCPD and derivatives (58-70%), BCHPD (2.0-2.6%), benzene (0.2-2.1%), toluene (0.5-2.0%), and xylene (0.8-1.3%). Twenty-one to thirty-eight percent of the LNAPL constituents were not identified, but may be emulsified water (Shell 1989b).

The relative percentages of compounds identified in the LNAPL plume differed from the relative percentages of compounds identified in the dissolved STFP. Possible reasons include differences in aqueous solubilities and fate and transport characteristics of the individual compounds. Of the compounds which comprise the LNAPL plume, benzene has the highest solubility and is only slightly to moderately adsorbed. The combined water solubility and low organic partitioning of benzene results in moderate to high mobility in the aqueous environment. Thus one to two percent separate-phase benzene in the LNAPL can result in high dissolved concentrations with a large areal distribution as observed in the STFP.

The thickness of LNAPL measured in monitoring wells (the "apparent thickness") increased during 1989 and 1990 as water levels declined. Conversion of the "apparent thickness" of LNAPL to the actual thickness of LNAPL in the formation, using the method of Kemblowski and Chiang (1990), indicates that the thickness of free-phase (mobile) LNAPL in the formation is less than 0.5 feet and has not significantly changed since 1989. Routine monitoring of the areal distribution of mobile LNAPL during 1989 and 1990 indicates that the LNAPL is stagnant or migrating at rates below measurement.

3.0 INTERIM RESPONSE ACTION OBJECTIVE AND EVALUATION

The original objective of the STFP IRA was to prevent the STFP from migrating into Lake Ladora. This objective was based on the interpretation that the STFP may migrate into Lake Ladora prior to the implementation of the final remedy (Shell 1989a). However, recent investigations have shown that the STFP is actively being biodegraded and will not migrate into either Lake Ladora or Lower Derby Lake prior to the implementation of the final remedy (Shell 1990).

Therefore, interim response alternatives cannot be meaningfully developed or evaluated within the context of the original objective of this IRA. In accordance with Section 22.1(1) of the Federal Facility Agreement which addresses the "assessment and, as necessary, the selection and implementation of an IRA...," an evaluation of monitoring as the appropriate course for the STFP IRA has been conducted as specified in the Final Task Plan for Remediation of Other Sources Interim Response Action (Woodward-Clyde 1989). The results of this evaluation follow.

Figure 3-1 shows the questions that must be answered to determine whether monitoring is the appropriate course for 'hotspot' IRAs (Woodward-Clyde 1989). The answers to these questions for the STFP are as follows:

1. The LNAPL portion of the STFP is an active, primary source of contaminants; however,

2. Neither the LNAPL nor the leading edge of the dissolved plume pose significant risk to human or non-human biotic receptors since neither plume is migrating into the

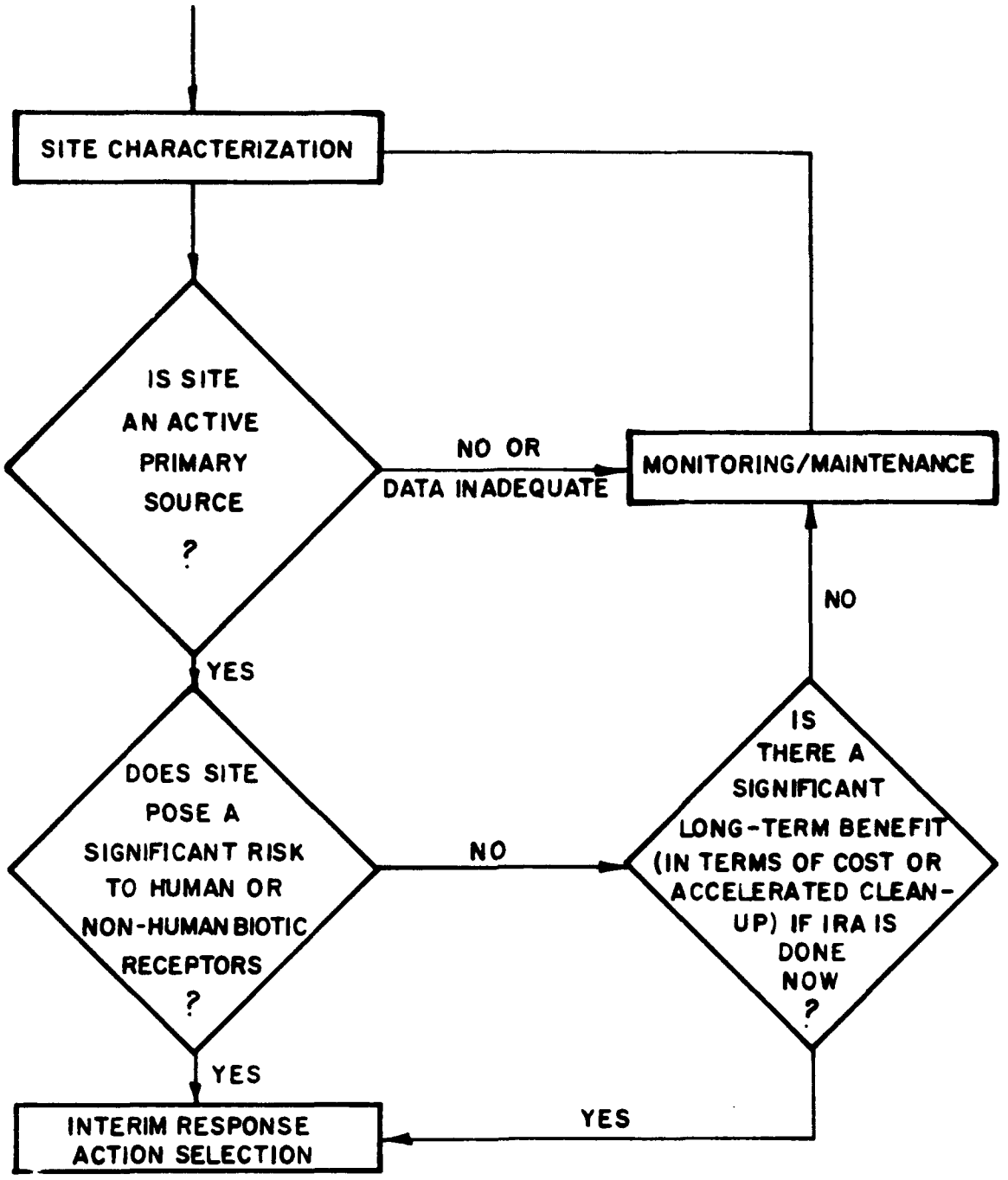

Figure: 3-1

DECISION FLOW CHART FOR INTERIM REMEDIAL ACTION VERSUS MONITORING/MAINTENANCE

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From: WOODWARD-CLYDE, 1989

lakes, nor expected to do so, prior to the final remedy (Sections 2.4 and 2.5); moreover,

3. There is no significant long-term benefit (either cost or accelerated cleanup) of conducting an interim response action on the dissolved or LNAPL plumes since migration is very slow, and natural biodegradation of the dissolved plume is occurring.

Therefore, according to the decision logic agreed upon by the Organizations and State, monitoring is the appropriate action for this IRA. Accordingly, the objective of this IRA is to monitor the STFP to: (1) verify the data upon which conclusions on the rate of contaminant migration have been made (Shell 1990), and (2) verify the location of the leading edge of the dissolved plume over time. The monitoring network proposed to achieve these objectives is described Section 4.

In addition to monitoring the dissolved plume, an FS Treatability Study will be proposed by Shell on the LNAPL plume. This study has the objectives of: (1) determining the optimal combination of technologies for remediating the LNAPL plume and (2) developing and evaluating those technologies for possible application to other sites on the RMA. Although the specifics of this study have not yet been finalized, they may included liquid extraction of mobile LNAPL, soil-vapor extraction of immobile LNAPL, and testing of a variety of ways to increase the efficiency of extraction/remediation. An FS Treatability Workplan will be submitted to the OAS for approval.

4.0 DESCRIPTION OF THE INTERIM RESPONSE ACTION/WORKPLAN

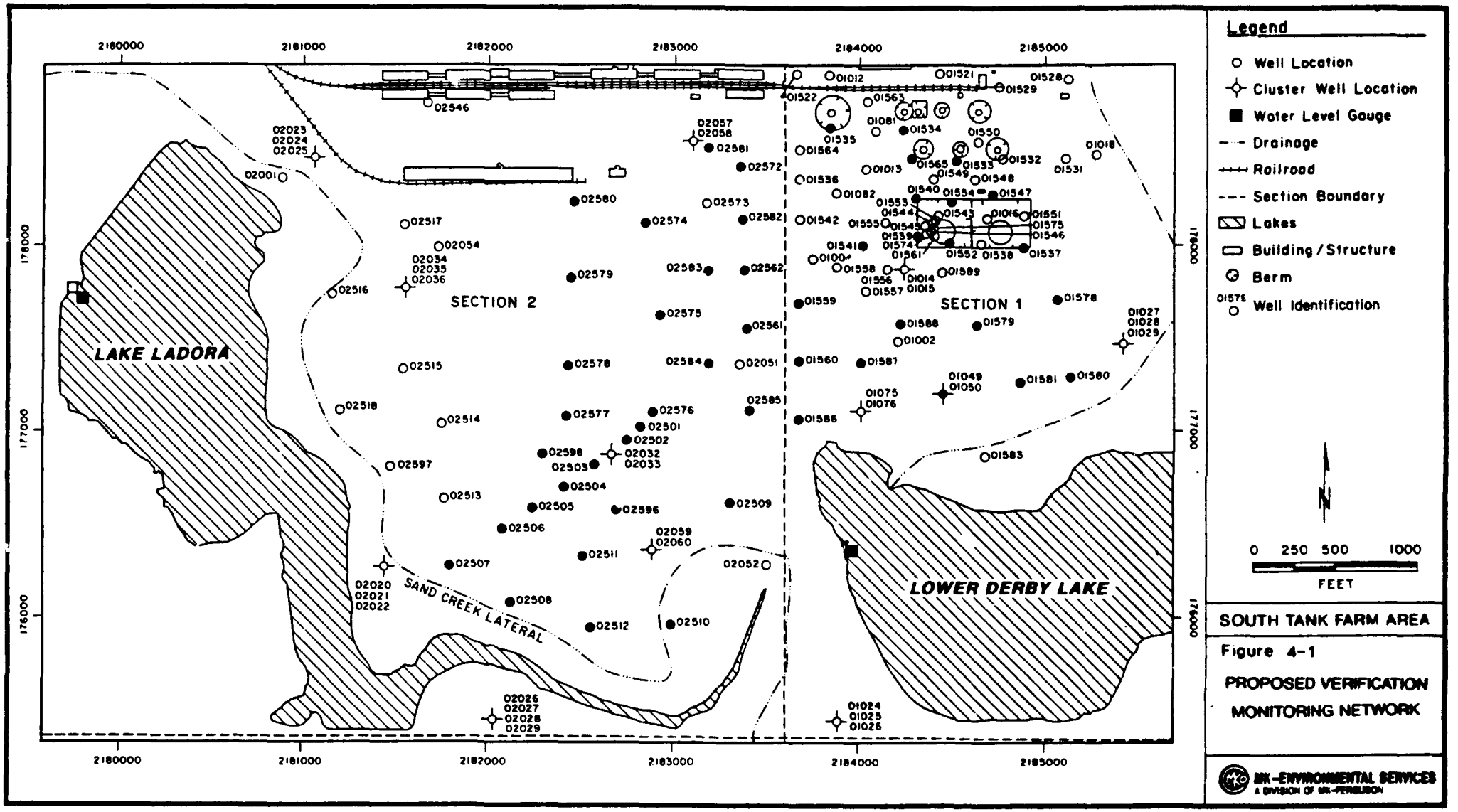
The monitoring network proposed to meet the objectives of the STFP IRA consists of three components:

- One-time comprehensive monitoring of groundwater quality throughout the STFP to verify conclusions regarding the rate of contaminant migration and occurrence of biodegradation presented in Shell (1990).

- Routine annual monitoring of selected wells to verify the location of the leading edge of the STFP with respect to the lakes.

- Semi-annual monitoring of the water table throughout the STFP area to identify changes to groundwater flow directions and gradients that may alter established contaminant migration patterns and/or rates.

The one-time comprehensive monitoring network consists of 50 wells located throughout the STFP area (Figure 4-1). (Recent construction activities associated with the Lower Derby Lake Spillway and Embankment Rehabilitation may require installation of new wells or other modifications to the proposed network). Target analytes will include benzene, toluene, xylene, BCHPD, and DCPD. Concentrations of target analytes will be determined using USATHAMA method UU-8 (volatile compounds). To prevent the loss of volatile compounds during sample collection, a submersible bladder pump will be used whenever possible. Wells will be sampled sequentially from areas of low contamination to areas of high contamination based on analytical data from the 1990 sampling event. Field measurements of dissolved oxygen will be made at the time of sample collection. Information from this monitoring program will be used to verify the extent and



Legend

- Well Location
- Cluster Well Location
- Water Level Gauge
- Drainage
- Railroad
- Section Boundary
- Lakes
- Building / Structure
- Berm
- 01575 Well Identification

SOUTH TANK FARM AREA

Figure 4-1

PROPOSED VERIFICATION MONITORING NETWORK

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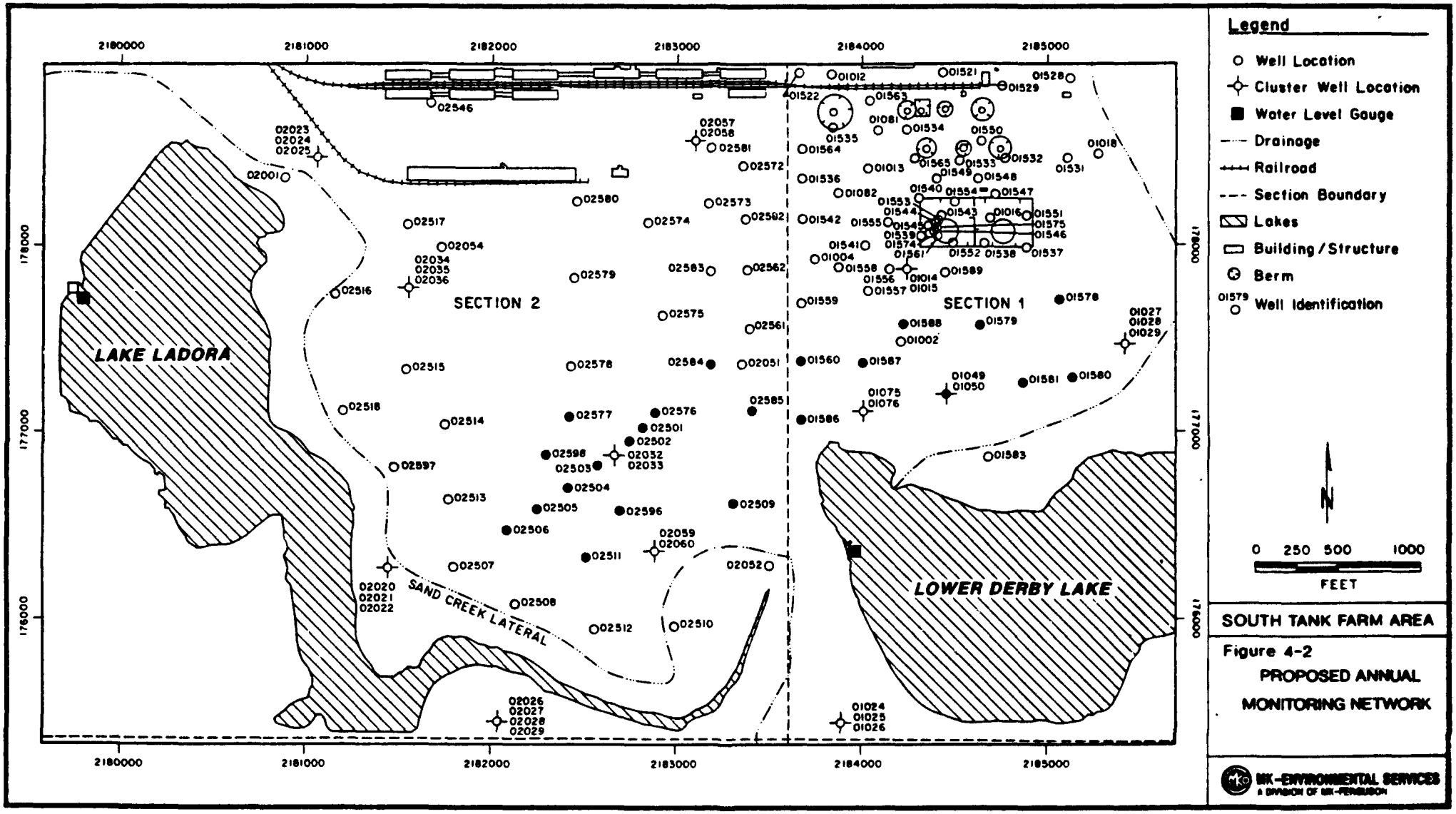
migration rate of STFP constituents and to verify biodegradation in the STFP.

Subsequent to verification of the conclusions regarding contaminant migration, routine monitoring will be performed to verify the location of the leading edge of the STFP (Figure 4-2). Groundwater quality will be monitored annually in 23 wells to meet this objective. The design of this monitoring program will be identical to that of the verification monitoring program with respect to target analytes, field measurements of dissolved oxygen, sampling and decontamination procedures, and analytical methods. Routine monitoring of the leading edge of the STFP will be performed annually until the ROD is issued.

In addition to groundwater quality monitoring, the water table in Sections 1 and 2 will be monitored semi-annually to identify changes in groundwater flow directions and gradients within the uppermost water-bearing zone that may alter established contaminant migration patterns and/or rates (Figure 4-3). The water-level measurements are recommended especially during and immediately after the construction activities related to the Lower Derby Lake Spillway and Embankment Rehabilitation.

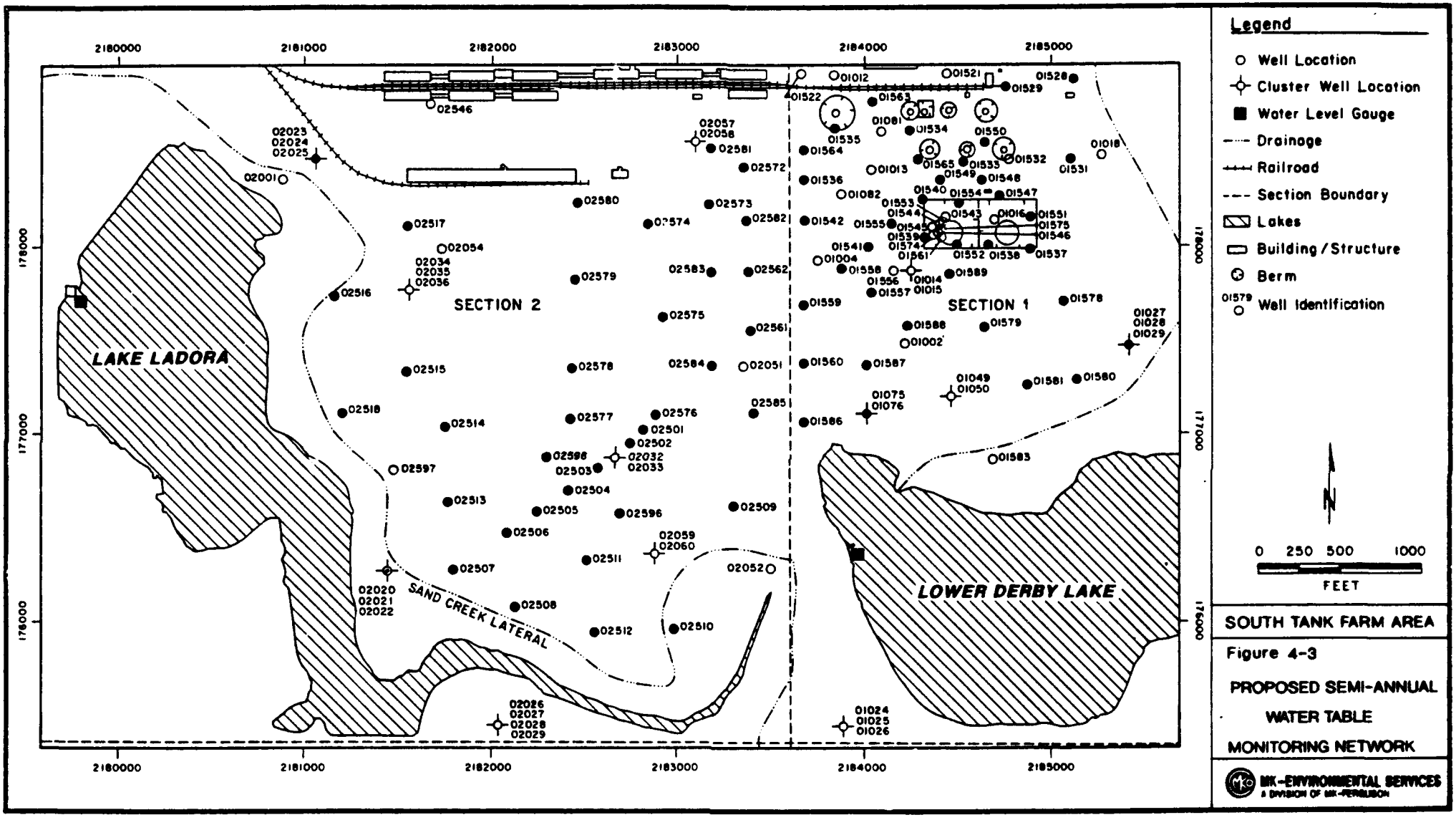


SOUTH TANK FARM AREA

Figure 4-2

PROPOSED ANNUAL MONITORING NETWORK

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON



Legend

- Well Location
- Cluster Well Location
- Water Level Gauge
- Drainage
- Railroad
- Section Boundary
- Lakes
- Building / Structure
- Berm
- 01579 Well Identification

SOUTH TANK FARM AREA

Figure 4-3

PROPOSED SEMI-ANNUAL WATER TABLE MONITORING NETWORK

MK-ENVIRONMENTAL SERVICES
A DIVISION OF MK-FERGUSON

5.0 REFERENCES

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APPENDIX A

COMMENTS AND RESPONSES ON THE
DRAFT FINAL ALTERNATIVES ASSESSMENT
OTHER CONTAMINATION SOURCES
INTERIM RESPONSE ACTION
SOUTH TANK FARM PLUME

RESPONSES TO U.S. DEPARTMENT OF INTERIOR
FISH AND WILDLIFE SERVICE COMMENTS
LETTER DATED JULY 23, 1990

1. COMMENT:

As this document is addressed "Alternatives Assessment," the inclusion of only one alternative does not seem appropriate. The presentation and evaluation of alternative technologies should be incorporated into this document. The selection and evaluation of only one alternative is more appropriately defined later in the decision process.

Response:

Because recent investigations indicate that the STFP contaminants will not migrate into either lake prior to the final remedy, the presentation and evaluation of alternative technologies to prevent the STFP from impacting the lakes is unnecessary. As specified in the Final Task Plan for Remediation of Other Sources Interim Response Action, an evaluation of monitoring as the appropriate course of action for the STFP IRA has been conducted (Woodward-Clyde 1989). The logic flow diagram was appropriately applied in this situation. Unfortunately, when monitoring is selected as the appropriate action, the Final Task Plan provides no guidance for modification of the document title to avoid semantic inconsistencies.

2. COMMENT:

In conjunction with the omission of other constituents found in the groundwater, the investigation of other sources of contamination has also not been adequately addressed. Limiting the scope of this IRA to only the contaminants in the LNAPL plume is not consistent with the original understanding of this IRA which was to address contamination threatening the lakes area in Sections 1 and 2. It is our understanding that this included all sources of contamination, not only the LNAPL plume contaminants.

Response:

The scope of the STFP IRA has been stated previously in documents and reiterated recently at meetings with the Organizations and State. The STFP IRA was never intended to include all sources of contamination from the South Plants. The nomination of the STFP as an IRA was based on the historical detections of a significant mass of dissolved benzene in groundwater in the STFP area and the belief that this compound might migrate into the lakes prior to the final remedy. Constituents present in the LNAPL plume were included within the scope of the IRA.

3. COMMENT:

Why has the 21-38% of unidentified constituents of the LNAPL plume never been identified? The U.S. Fish and Wildlife Service (Service) recommends these constituents be identified before any remedial decisions are made.

Response:

The composition of the LNAPL was determined using a modified Method (GC/MS) 8240 for volatile compounds with additional calibration for RMA target analytes. Identification of all compounds in the LNAPL is not possible due to the limitations of the chromatograph column and system. Target analyte concentrations are great relative to the numerous baseline peaks for the other compounds. To prevent damage to the analytical instrumentation, several dilutions are initially required to reduce the target analyte concentrations during analysis. The dilution results in the loss of smaller chromatograph peaks and prevents complete identification of all LNAPL constituents.

4. COMMENT:

In the draft final alternatives assessment, natural degradation is said to be occurring thereby contributing to the recent decrease in concentrations of benzene near the margin of the plume (page 8, paragraph 2). Sufficient justification has not been presented to support this statement. Furthermore, the case is presented for bioremediation but specific details of the experimental procedures used in the biodegradation studies are omitted. More information is necessary to evaluate the significance of this process to the South Tank Farm Plume.

Response:

Locations of saturated sediment samples sent to Shell's Westhollow Research Center for biodegradation studies are

shown on Plate 4 in the RMA Saturated Sediment Sampling Letter Technical Plan, May 10, 1988. Details of the experimental procedures used in the laboratory biodegradation studies will be presented in a report by Westhollow during the third quarter of 1990. The significance of biodegradation in the STFP will be further evaluated following completion of the verification monitoring program proposed in the Draft Final Alternatives Assessment for the STFP IRA.

RESPONSES TO USEPA COMMENTS
LETTER DATED JULY 23, 1990

GENERAL COMMENTS

COMMENT:

This document does not assess any alternatives; therefore, it is difficult to review it as an alternatives assessment. It merely presents a work plan for a monitoring alternative without presenting any information on any other alternatives that were evaluated.

Response:

See Response to U.S. Department of Interior Comment 1, page A-2.

SPECIFIC COMMENTS

1. COMMENT:

   Page 9, paragraph 2. Please refer to Comment 9 by the USEPA on the Hydrogeologic and Water Quality Report.

   Response:

   Refer to the response to Comment 9 of the USEPA on the Hydrogeologic and Water Quality Report.

2. COMMENT:

Page 10. The text states that 21 to 38 percent of the LNAPL constituents were not identified. EPA recommends that these constituents need to be identified.

Response:

See Response to U.S. Department of Interior Comment 3, page A-3.

3. COMMENT:

Page 11. This section defines the decision process that was used to arrive at the recommended IRA; however, it does not support any of the decisions that were made or demonstrate that they are indeed the logical choice.

Response:

The objective of this IRA is to ensure that neither the LNAPL plume nor the leading edge of the dissolved plume enter Lake Ladora or Lower Derby Lake prior to the implementation of a Final Remedy. The purpose of the monitoring program is to: (1) verify the data upon which contaminant migration rates and other conclusions are based; and (2) verify the location of the leading edge of the dissolved plume as it changes with time. Based on observations of the monitoring program, modifications to this IRA may be implemented, if warranted.

In accordance with the decision logic agreed upon by the Organizations and State (Woodward-Clyde 1989), monitoring

was determined to be the appropriate action for this IRA (see Section 3.0). Based on the 1983/84 and 1990 water quality data it has been determined that neither the STFP nor the LNAPL plume pose a significant risk to human or non-human biotic receptors. Due to the observed slow advancement of the dissolved plume there are no significant long-term benefits (either in cost or accelerated cleanup) to warrant another type of remedial action. The biodegradation occurring at the leading edge of the plume appears to be significantly retarding the migration, further justifying the selection.

The monitoring program is consistent with, contributes to, and facilitates the implementation of a final remedy. In addition, these monitoring data will be useful throughout the implementation and analysis of the LNAPL plume FS Treatability Study. This approach to the South Plants Area remediation will provide a more cost-effective and beneficial solution.

4. COMMENT:

Page 1'. The text states that the "plume poses no significant risk to human or non-human biotic receptors. . . ." No basis for this statement has yet been presented. The statement as such cannot be accepted. Please refer also to our previous comment on the extent of contamination and the velocity of the groundwater migration.

Response:

The information supporting this conclusion has been presented in the Hydrogeologic and Water Quality Conditions, South Tank Farm Plume, RMA report, issued May 1990. The monitoring program proposed in the Draft Final Alternatives Assessment is to verify these conclusions and provide additional supporting data. At this point, neither lake is contaminated with the STFP constituents, nor has there been contact between human or non-human biotic receptors and the defined contaminants which might contradict this conclusion.

The responses to comments prepared for both the Hydrogeologic and Water Quality conditions report and the Draft Final Alternatives Assessment provide further clarification of this issue.

5. COMMENT:

Page 12, paragraph 1. It is stated that ". . . the objective of this IRA is to monitor the STFP." This tends to indicate that it was predetermined that monitoring was to be the selected alternative; therefore, this document is not an alternatives assessment but more of a technical plan or work plan for monitoring the STFP.

Response:

See Response to the General Comment, and to Specific Comment 3, page A-6 .

RESPONSES TO THE COLORADO DEPARTMENT OF HEALTH COMMENTS LETTER DATED JULY 23, 1990

GENERAL COMMENTS

1. COMMENT:

Although the South Tank Farm Plume (STFP) was originally identified by Shell as consisting of eight primary contaminants (Report of Hydrogeologic and Water Quality Investigations in the South Tank Farm Plume, Section 2, RMA, July 1989 (July 1989 STFP Field Report), Shell and the Army have since redefined the plume to include five contaminants, with only one contaminant (benzene) common to both definitions. The State strongly objected to this apparent modification by Shell and the Army of the scope of the Interim Response Action (IRA) and the resultant ambiguity regarding the objectives of the IRA at the initial Alternatives Assessment stage of the IRA process (see Draft Final Alternatives Assessment Other Contamination Sources, Interim Response Action, South Tank Farm Plume, dated March 1990 (March 1990 Draft Alternatives Assessment).

The State continues to object to the Army and Shell's current restriction on the scope and objectives of this Interim Response Action (IRA). This Assessment's failure to consider those contaminants identified in Shell's July 1989 STFP Field Report and pointed out in Specific Comment 1 of the State's comments on the March 1990 Draft Alternative Assessment, constitutes a serious shortcoming of the revised document. Determination of extent and rate of migration of the omitted chemicals, (1,1 dichloroethane, trans-1,2-

dichloroethylene, carbon tetrachloride, chloroform, chlorobenzene, tetrachloroethylene, and trichloroethylene) as well as the identification of the remaining 21-38% of the LNAPL constituents which remain unidentified must be completed as soon as possible so that appropriate decisions can be made to protect the south lakes from harmful impacts.

Response:

See Response to U.S. Department of Interior Comment 2, page A-3. As discussed in the Response to Comment 3 of the U.S. Department of Interior, identification of the unidentified portion of the LNAPL may not be possible with existing technology.

2. COMMENT:

The light non-aqueous phase liquid (LNAPL) is the primary source of contaminants [specifically benzene, toluene, xylene (collectively BTX), dicyclopentadiene (DCPD), and bicycloheptadiene (BCHPD)] to groundwater in the STFP. However, despite the increase in upgradient dissolved benzene concentrations from Spring 1989 to Spring of 1990, the probable increase in the volume of LNAPL--contaminated soils, the apparent increase in product thickness, and the presence of the plume over a much greater area than predicted by Shell, Shell has not addressed LNAPL remediation as part of the STFP IRA. Instead, Shell has now proposed to undertake as part of the Feasibility Study, a treatability study to determine optimal techniques for plume remediation. The State insists that the results of this proposed program be immediately incorporated into this IRA. The objectives of this IRA should include remediation of the

groundwater and product-contaminated soils both above and at residual saturation.

The design of a monitoring well program for the LNAPL plume must also be incorporated. The use by Shell of wells screened below top of water table to determine the lateral extent of the LNAPL has resulted in an inaccurate characterization of the plume; the LNAPL is currently (Spring 1990) at least 400 feet downgradient of the western extent identified by Shell in the Report of the Investigation of the LNAPL Plume Near Tank 464A, Section 1, RMA, August 1989 (August 1989 LNAPL Report). The wells should be screened to the top of the historical high water table mark, as described in the August 1989 LNAPL Report.

Response:

Shell believes that the LNAPL is best investigated and controlled as an FS Treatability Study and full scale treatability test rather than as part of the IRA for the following reasons:

- The LNAPL does not present an imminent threat that requires immediate action.

- The test program will be a Research and Development effort subject to modification and will not conform to the IRA criteria for use of "off the shelf" technology and existing data.

- The processes which could potentially be effective have not been applied on several of the specific chemicals

or in the fine-grained, low permeability soils present in the STFP area. Testing to evaluate remediation technologies is not within the scope of an IRA.

- The test program will be designed to develop data for use on other RMA sites.

- The objective of the full scale treatability test will be to collect data to support the RMA FS.

- The time requirements for remediation will probably exceed tl IRA time table.

Shell disagrees with the implication that all wells in the vicinity of Tank 464A are inappropriately screened for monitoring LNAPL. As the State is aware from its review of the 1989 LNAPL report, Shell installed additional wells in the STFP area that are screened above the water table specifically to address the questions that the State raises. Additional wells will be installed, as required, to further characterize the LNAPL plume under the FS Treatability Study.

3. COMMENT:

The slug tests conducted by Shell in December 1989 on three wells in Section 1 (which incudes Lower Derby Lake) and Section 2 (which includes Lake Ladora) did not provide viable data for transmissivity calculations, and therefore should not have been used in determining STFP velocity rates. Shell, however, used the velocity estimates derived from these questionable data in the June 1990 Revised Draft Alternatives Assessment Document to estimate arrival times

of the plume at the south lakes, and to conclude, partially based on these estimates, that the STFP would not impact the lakes prior to implementation of the final remedy. Because of the importance of arrival time calculations in determining the impact of the STFP on the lakes, and reliance on these data in the selection of a remedial alternative for the STFP IRA, the State recommends that additional slug tests be conducted in both the unconfined Denver Formation and the saturated alluvium in Sections 1 and 2. If the velocities indicate the contaminants will impact the lake prior to implementation of the remedy, selection of a remedy other than monitoring would be necessary.

Response:

Estimates of groundwater flow velocities towards Lake Ladora were based on actual water quality data. As discussed in the Response to the State's Specific Comment 10, the State's estimate of 40-60 ft/yr is considered to be a realistic estimate, and superior to estimates derived from the slug test. The estimated velocity of 28 ft/yr derived from slug test results indicate that this estimate appears to be reasonable. The velocity estimate from the slug test was not used to replace the observed plume migration rates.

Data available for the Lower Derby Lake area in Section 1 indicate that the lake is not in immediate danger. The data depicted on Figures 2-3 through 2-7 of the "Draft Alternatives Assessment" show that the contaminant plume has traveled about 60 percent of the distance between the suspected source near Tanks 464A and 464B and the lake.

Considering that the suspected source has been present for years, Lower Derby Lake does not appear to be in immediate danger. As discussed in the Response to Comment 2 of the U.S. Department of Interior on the "Hydrogeologic and Water Quality Conditions" report, it is unlikely contaminant migration rates will significantly increase upon reaching the alluvial aquifer, and may decrease.

Accurate estimates of contaminant migration rates can be determined from water quality data collected over a period of time. As ascertained by the State, the use of slug tests is an approximate method. Therefore, conducting additional slug tests for determining aquifer flowrates does not seem justified at this point.

4. COMMENT:

As discussed above, in previous comment packages, and in the specific comments below, the current state of knowledge regarding South Tank Farm contaminants is insufficient to support a remedial alternative of monitoring. Accordingly, additional site characterization must be undertaken as specified information is available, responsible decisions regarding appropriate response actions can be made.

The State is also concerned that the future decision-making process (i.e., reopening the decision document) used by the Army and Shell to implement an alternative other than monitoring will not prove adequate to the State. This concern is based on past discussions with the Army regarding the complex disposal trenches monitoring-only alternative.

Response:

As discussed previously in numerous documents and presentations to the State, characterization of the contaminants associated with the STFP IRA is more than sufficient to warrant the selection of routine monitoring of the leading edge of the plume as the preferred course of action (see Response to Comment 3 by the USEPA). However, in the "Draft Final Alternatives Assessment," Shell has recommended an expanded monitoring program to verify the conclusions of the "Hydrogeologic and Water Quality Conditions, South Tank Farm Plume Report, May 1990," and thus corroborate the decisions made regarding response actions.

It should be noted that the STFP became an IRA due to Shell's initiative and Shell intends to see this IRA through to its proper and logical conclusion. Based on Shell's commitment to this IRA, the State does not have substantive reason to question Shell's intent or decision-making process.

5. COMMENT:

Shell has selected monitoring as the preferred remedial alternative for the STFP IRA. Although the State does not concur with this selection, the State believes that the following, at a minimum, must be included in the program:

a. Well 01075 (the well closest to Lower Derby Lake) must be included in the one-time comprehensive and the annual monitoring network;

b. Shell must agree to conduct an LNAPL remediation (based on the guidelines presented in General Comment 2) as soon as possible after the completion of the LNAPL treatability study;

c. Shell must conduct additional slug tests in Sections 1 and 2 in both the unconfined Denver Formation and the saturated alluvium.

If the calculated velocities or other data indicate that the STFP may impact Lake Ladora or Lower Derby Lake prior to implementation of the final remedy, selection of a remedial alternative other than monitoring would be necessary.

Response:

a. Well 01705 may have been damaged during the recent construction activities related to the Lower Derby Lake Spillway and Embankment Rehabilitation. This and other wells will be evaluated for integrity prior to the implementation of monitoring activities in the STFP and repaired or replaced as necessary.

b. Shell proposes to proceed with a treatability study and full scale treatability tests of processes suitable for remediation of the LNAPL near Tank 464A. The "Proposed Work Plan for the LNAPL Treatability Study and Full Scale Test" will be prepared and submitted for review and approval subsequent to issuance of the "STFP IRA Final Implementation Document." The objective of the full scale treatability test will be to collect data

for use in the RMA FS while reducing the LNAPL to the greatest extent practicable.

c. The State's comments indicating that calculated values of hydraulic conductivity derived from slug tests are questionable, suggests that additional slug tests are not appropriate. See the Response to General Comment 3.

6. COMMENT:

The State has repeatedly requested that the 1988 data not be used as a benchmark in the investigation of the dissolved STFP plume and instead be replaced with validated data from the Spring 1989 sampling event. Shell refused to use the 1988 data in its July 1989 STFP Field Report, citing rinse blank contamination and observing that "[t]hese data may not be accurate at low concentrations." (July 1989 STFP Field Report, page 9). However, despite both State requests and Shell's early recognition of the questionability of the 1988 data, Shell has consistently cited the data in its three STFP documents compiled subsequent to the July 1989 STFP Field Report (March 1990 Initial Draft Alternatives Assessment Document, Hydrogeologic and Water Quality Conditions South Tank Farm Plume, RMA, May 1990 [May 1990 STFP Hydrogeology Report], and the June 1990 Revised Draft Alternatives Assessment). Shell has then consistently questioned the validity of all conclusions regarding the STFP based on comparisons with the 1988 data. To prevent these uncertainties, 1988 data should not have been used in analyses regarding temporal changes in the STFP. The State

questions Shell's purpose in consistently utilizing the 1988 data, when validated Spring 1989 data are available.

Response:

Conclusions in the "Draft Final Alternatives Assessment" and the "Hydrogeologic and Water Quality Conditions" report are based on a comparison between the 1983/84 water quality data and the data presented in the 1990 "Hydrogeologic and Water Quality Conditions" report. Shell agrees with the State and sees no logic in using questionable data (1988 results) when more recent and reliable data exists. For this reason, Shell did not use the 1988 data when determining contaminant migration rates.

However, mention of the 1988 water quality data was included in the above-referenced reports in order to demonstrate the overestimation of the migration rate based on inaccurate plume geometry. Due to the overestimation of plume migration, the STFP was proposed (by Shell) as an IRA. The STFP would not be an IRA if this had not happened.

SPECIFIC COMMENTS

1. COMMENT:

Page 1. Shell states:

> [r]ecent investigations have shown that the STFP . . . will not migrate into . . . Lower Derby Lake prior to the implementation of the final remedy.

The State disagrees with this conclusion. As the State asserted in its July 23, 1990, State Comments on Report of Hydrogeologic and Water Quality Conditions South Tank Farm Plume, RMA, dated May 1990 (State Comments on the May 1990 STFP Hydrogeology Report):

a. Slug test data from Well 10580, which was the only well tested in Section 1, are not acceptable for the determination of transmissivities in that section. Because the calculated transmissivities are questionable, the average hydraulic conductivity and resultant velocity calculation from the slug test data are also questionable.

b. Well 10580 is located in the saturated alluvium; no slug tests were conducted in the unconfined Denver Formation in Section 1; and

c. Historical data are not available in Section 1 wells to calculate DCPD and benzene migration rates.

Therefore, data are not available to draw conclusions on the potential impact of the STFP on Lower Derby Lake prior to implementation of the final remedy. The State requests that additional slug tests be conducted in Section 1 wells in both the saturated alluvium and the unconfined in Section 1 wells in both the saturated alluvium and the unconfined Denver Formation to address this deficiency (see State Comments on the May 1990 STFP Hydrogeology Report, Specific Comments 3 and 4). If the velocities indicate the contaminants will impact

the lake prior to implementation of the remedy, selection of a containment remedy would become necessary.

Response:

a. Neither the migration rate of the plume nor the recommended alternative of monitoring were based on the transmissivity estimate from the slug test in Well 01580.

b. Agreed.

c. The State is correct that historical data are not available in Section 1 to determine the plume migration rates. However, data are available to show that even over many years the plume has not migrated to within 500 feet of Lower Derby Lake in flowpaths headed towards the lake. See Response to State General Comment 3.

2. COMMENT:

Page 2. Shell states:

> The significant conclusions of the [summer 1989 LNAPL field investigation] are that the LNAPL plume is an active source of groundwater contamination and therefore should be included in the [STFP] IRA.

Although this was Shell's conclusion in the summer of 1989, Shell subsequently ignored further characterization of the LNAPL plume and did not address remedial alternatives in either the March 1990 or June 1990 Initial and Revised Draft

Alternatives Assessment Documents. Shell is now, however, proposing to conduct a treatability study to select the optimal combination of technologies available. Upon completion of the treatability study, remediation of the LNAPL should be conducted in an expedited fashion.

In addition, because of the apparent misidentification of the downgradient extent of the LNAPL plume (see State Comments on the May 1990 STFP Hydrogeology Report, Specific Comment 7), further characterization of the plume distribution is necessary. The State requests a meeting with the parties to discuss further characterization.

Response:

See response to State General Comment 5(b). As part of the *Proposed Work Plan* for the LNAPL Treatability Study and Full Scale Treatability Test, Shell plans to further characterize the LNAPL distribution, as necessary, for remediation.

3. COMMENT:

Page 2. Shell states:

> Routine measurements since 1989 indicate that the LNAPL is not migrating at a measurable rate or increasing in volume.

and on page 9:

> The [LNAPL field] investigation completed in 1989 identified the western extent of mobile LNAPL near Tank 464A. . . .

and page 10:

> Routine monitoring of the areal distribution of mobile LNAPL during 1989 and 1990 indicates that the LNAPL is stagnant or migrating at rates below measurement.

The "routine measurements" and "routine monitoring" referenced by Shell have not been provided to the State nor presented in the June 1990 Revised Draft Alternatives Assessment Document. Unless these data are provided and verify Shell's conclusions, the text must be revised to incorporate the State's comments presented below.

The State currently disagrees with both of the conclusions regarding: (a) the volume; and (b) the migration rate and downgradient extent of the LNAPL. As pointed out in the April 25, 1990, State Specific Comment 10 on the March 1990 Draft Alternatives Assessment, Shell's own data collected over a 34-day period in June and July of 1989 indicated a 0.24-foot increase in LNAPL thickness in Well 01546, contradicting Shell's statement regarding LNAPL volume. Also, comparison of data presented in the August 1989 LNAPL Report to data in the May 1990 STFP Hydrogeology Report indicates that the western extent of the LNAPL plume in Spring 1990 is at least 400 feet farther downgradient than that determined by Shell in its August 1989 LNAPL Report. [See State Comment 7 on the May 1990 STFP Hydrogeological Report.] This indicates that the plume is either migrating at rates greater than 400 feet per year, or that the plume distribution has never been properly characterized by Shell.

Response:

Shell is currently processing and interpreting recent information for characterizing the LNAPL plume. These data are an integral component in defining and directing the LNAPL Plume FS Treatability Study. Upon completion, a Characterization Report of the LNAPL Plume will be issued. In addition, Shell will be conducting further investigations under the FS Treatability Study to more accurately and completely determine the extent of the LNAPL plume.

The State's use of the standard hydrostatic approach to estimating the formation hydrocarbon thickness leads to erroneous results. Recent articles present methodologies for estimating the actual formation thickness of LNAPL as opposed to using LNAPL thickness in observation wells (Kemblowski and Chiang 1990; Farr, Houghtalen and McWhorter 1990; Lenhard and Parker 1990). As can be seen from these derivations, estimation of hydrocarbon thickness in the formation is a rigorous endeavor requiring detailed information on soil properties, phase distributions, physical and chemical properties of the contaminants, and extensive historical hydrologic information. Much of this information is usually unavailable or difficult to measure. However, it is evident that the hydrostatic approach does not account for the conduit effect of a monitoring well, especially in low permeability formations such as the Denver. The monitoring well provides a preferred flowpath for hydrocarbon liquids and acts as a conduit within the formation allowing fluids to collect in the well would otherwise be entrapped in the soil matrix. Based on the

dieldrin, or endrin (see Response to U.S. Department of Interior Comment 2 on the Draft Final Alternatives

available data, the conclusions regarding LNAPL volume and migration rates are considered valid.

4. COMMENT:

Page 4. Shell states:

> [T]he apparent increase [in STFP contaminant concentrations] may actually have reflected differences in sampling procedures between 1983/84 and 1988, incomplete decontamination procedures in 1988 [several rinse blanks contained moderate concentrations of contaminants], or inadvertent entrapment of LNAPL in groundwater samples [the LNAPL plume had not been identified].

Because Shell has consistently qualified and questioned the 1988 data, the State has repeatedly requested that the 1988 data not be used in analyzing temporal changes in the STFP (see General Comment 5).

Response:

Although the 1988 data are probably valid at high concentrations, plume migration rates are based on the advancement of low contaminant concentrations at the leading edge of the plume. Therefore, Shell agrees with the State that the 1988 data not be used in analyzing temporal changes in the STFP. As a result, conclusions in the report regarding the observed rate of migration were based on a comparison of the 1983/84 data with 1990 data (see Response to General Comment 6).

5. COMMENT:

Page 6. Shell states:

> The results of the [spring 1990] investigation indicate that: (1) sampling methodology and natural biodegradation cause significant temporal and spatial variability in the concentrations of benzene, particularly in wells located near the plume margins. . . .

Shell must explain what sampling methodology is being referenced, and how it has caused significant temporal and spatial variability in benzene concentrations. This information was not provided to the State, and, therefore, cannot be verified.

Response:

Cross-contamination of samples during acquisition was indicated by the results of contamination of rinse blank samples collected during Phase I and implied by subsequent sampling conducted during Phase II to verify the results of Phase I. Contrary to the State's implication, this information has been provided in the "Hydrogeologic and Water Quality Conditions" report; results of QA/QC samples can be found in Appendix A and a discussion of these results found in Section 3.3.1. Of particular interest to the interpretation of cross-contamination are the results of rinse blank 02510R, discussed on page 12, paragraph 4.

6. COMMENT:

Page 8. Shell discusses the results of laboratory tests conducted on saturated sediment samples from the STFP, but again has not provided actual locations from which these samples were obtained. As requested in both the April 25, 1990, State Comments on the March 1990 Draft Alternatives Assessment, (Specific Comment 9), and the State Comments on the May 1990 STFP Hydrogeology Report (Specific Comment 10), Shell should provide both the sampling location(s) and laboratory data.

Response:

See Response to U.S. Department of Interior Comment 4, page A-3.

7. COMMENT:

Page 8. Shell lists five tanks that have high associated dissolved benzene, toluene, xylene, DCPD, and BCHPD groundwater concentrations: 464A, 464B, 463A, 463E, and 463G. Based on data presented in the May 1990 STFP Hydrogeology Report, Tanks 462A, 463B, and 463F are also probable past or current sources of the five contaminants to groundwater (see the State Comments on the May 1990 STFP Hydrogeology Report, Specific Comment 9). Please modify the text accordingly.

Response:

The text has been modified to indicate that Tanks 462A, 463B, and 463F may represent potential sources of contaminants common to the STFP IRA constituents.

8. COMMENT:

Page 8. Shell states:

> DCPD is the most widely distributed contamination within the south-southeastern component of the STFP and defines the leading edge of the plume towards Lower Derby Lake.

Although DCPD does appear to be distributed over a wider area than benzene in the southeastern component of flow in the Section 1 STFP, DCPD alone does not define the leading edge of the plume. The farthest downgradient well in which DCPD was detected (Well 01587 at a spring 1990 concentration of 69 ug/l) also had a benzene concentration of 2,000 ug/l; therefore, both contaminants define the leading edge of the plume towards Lower Derby Lake. The text should be modified accordingly.

Response:

The STFP may be divided into two components: the south-southeastern lobe which includes the region south of Tank 464A and east of the plane between Tank 464A and cluster well 01050; and the southwestern lobe in the area south and west of Tank 464A. The two flowpaths may be more clearly

visualized if one foot contour intervals are shown for the range 5240 to 5245 feet on the water Table Contour Map (Figure 2-2).

The groundwater flow in the vicinity of Well 01587 is sharply deflected to the southwest, around the Lower Derby Lake spillway embankment. The influence of the groundwater flow direction on contaminant distribution near this well is shown by the indented/deflected area of the benzene plume northwest of Lower Derby Lake (Figure 2-3). Contaminant migration for this portion of the plume goes in the direction of Lake Ladora and not towards Lower Derby Lake.

9. COMMENT:

Page 8. Shell states:

> None of the STFP compounds were detected in wells located within 500 feet of . . . Lower Derby Lake.

This statement is misleading since no well located within the known flow path of the STFP has been sampled within 500 feet of Lower Derby Lake. Well 01587, which is located approximately 500 feet from the lake did have spring 1990 benzene and DCPD detections of 2,000 ug/l and 69 ug/l, respectively. Well 01580, which is within 500 feet of the lake, is probably located to the east of the known contaminant flow path. Accordingly, this statement should be modified in the text, and additional data gathered to determine the imminence of contaminant impact on Lower Derby Lake.

Response:

The State appears to contradict itself in Comments 9 and 14. In this comment the location of Well 01587 is considered to be within 500 feet of Lower Derby Lake, however, in Comment 14 the State does not consider Well 01587 to be within 500 feet of the lake. Regardless of its location, Well 01587 is not on a flowpath towards Lower Derby Lake (see Response to Comment 8). Well 01587 is within the southwestern lobe of the STFP and this portion of the plume is flowing towards Lake Ladora.

Well 01580 is located within 500 feet of Lower Derby Lake and is directly along the flowpath of the south-southeastern lobe of the STFP (see Response to Comment 8). Well 01580 is required to monitor the DCPD and BCHPD plume migration toward Lower Derby Lake.

Sampling of both wells is proposed for the verification and routine monitoring programs for the STFP IRA.

10. COMMENT:

Page 9. Shell states that the observed migration rate of the Section 2 dissolved benzene plume (33 ft/yr) correlates well with the groundwater flow velocity calculated from the December 1989 slug tests on Wells 02505 and 02598 (28 ft/yr). However, as discussed in the State Comments on the May 1990 STFP Hydrogeology Report (Specific Comment 3), groundwater flow velocities cannot be determined from the December 1989 slug test data. Therefore, any confirmation

regarding the 28 ft/yr groundwater flow velocity is invalid. Additionally, the migration rate of benzene was based on an estimated migration distance of 200 feet. This distance appears to be underestimated; the actual distance probably ranges between 250 and 350 feet; the calculation results in a correspondingly higher migration rate (see Specific Comment 5 in the July 1990 State Letter). The text should be modified accordingly.

Response:

Shell does not disagree with the State's estimated migration rate of 250-350 feet in 6 years (approximately 40-60 ft/yr). The migration rate of 33 ft/yr presented in the report is an approximate rate and the text will be modified accordingly. However, it is important to note that this does not alter the conclusion that the plume is not likely to reach the lake prior to implementation of the final remedy. Assuming a future contaminant migration rate of 60 ft/yr and a distance of 900 feet from the leading edge of the plume to the lake, the estimated travel time to the lake is about 15 years. The final remedy should be implemented within that period of time. Therefore, based on the migration rates and the present position of the plume calculated by the State, Shell continues to conclude that STFP IRA constituents will not impact Lake Ladora prior to implementation of the Final Remedial Action.

11. COMMENT:

Page 11. There is insufficient data to conclude that no risk is currently posed or could be posed prior to implementation of the final onpost remedy to human or non-

human biotic receptors. As previously explained, Shell's velocity calculations are suspect and the analysis excludes consideration of other compounds which do not biodegrade and are located in closer proximity to the lakes than are the BTX and DCPD compounds.

Response:

The information supporting this conclusion has been presented in the "Hydrogeologic and Water Quality Conditions, South Tank Farm Plume, RMA" report, issued May 1990. The monitoring program proposed in the "Draft Alternatives Assessment" is to verify Shell's conclusions and provide additional supporting data. Shell's responses to comments on both documents should provide further clarification of this issue (see Responses to State General Comments 1 and 4, and Specific Comments 1, 8, 9, and 13).

12. COMMENT:

Page 11. Conclusions regarding the slow rate of migration of the LNAPL are unsupported. Additional characterization is necessary. Data indicates that the plume is migrating, and currently extends significantly further downgradient than estimated by Shell. Biodegradation of extremely high concentrations has not been demonstrated and cannot be assumed. The conclusion that there is no benefit to conducting an interim response action to extract LNAPL is also unsupported. Given the difficulty and length of time involved in cleaning up groundwater, and the current state of knowledge regarding the extraction of LNAPLs, expedited

extraction of these compounds would create a significant long-term benefit in terms of cost and accelerated cleanup.

Response:

Current data on the actual thickness of LNAPL in the formation indicate that: the volume of LNAPL has not increased significantly since 1989; the LNAPL thickness is less than 0.5 feet; and the appearance of LNAPL and increased thickness in monitoring wells is related to LNAPL drainage from the filter pack into the well under declining water table conditions. Based on this phenomenon, Shell expects the LNAPL is not migrating or increasing in thickness (see Response to Specific Comment 3).

Shell agrees that further characterization of the LNAPL plume is required and proposes that this be performed under the FS Treatability Study (see Response to Specific Comment 2). Further delineation of LNAPL plume geometry and evaluation of treatment technologies will provide the information required to select an appropriate and effective remedial technique consistent with the final remedy.

13. COMMENT:

Page 13. Shell states that the proposed STFP IRA target analytes include benzene, toluene, xylene, BCHPD, and DCPD. To adequately monitor the impact of any contaminants on the two south lakes, the State requests that the program be modified to include all RMA target analytes.

Response:

See Response to U.S. Department of Interior Comment 1.

14. and 15 COMMENT:

Figures 4-1 and 4-2 (after pages 13 and 14, respectively). The proposed one-time comprehensive monitoring network and the proposed annual monitoring network for the STFP IRA do not include wells closer than approximately 500 feet to Lower Derby Lake. To monitor the migration of contaminants from Well 01587 and to better analyze the potential impact of STFP contaminants on the lake, alluvial Well 01075 which is in close proximity of Lower Derby Lake, must be included in both monitoring programs. This well is currently not being sampled in the CMP.

Page 13 Shell states:

> Recent construction activities associated with the Lower Derby Lake Spillway and Embankment Rehabilitation may require installation of new wells or other modifications to the proposed network.

If spillway construction does include installation of new wells that may provide data regarding the impact of the STFP on Lower Derby Lake, or if construction activities affect existing wells currently proposed for the monitoring program, the State requests that the monitoring well network be reviewed by all parties for possible modification.

Response:

Wells that may have been damaged during the recent construction activities related to the Lower Derby Lake Spillway and Embankment Rehabilitation will be evaluated for integrity prior to the implementation of monitoring activities in the STFP and repaired or replaced, as necessary.

Well 01075 may have been damaged during the recent construction activities related to the Lower Derby Lake Spillway and Embankment Rehabilitation. Shell agrees that this well, or its replacement, should be incorporated into both the verification and routine monitoring programs proposed in the "Draft Final Alternatives Assessment" program.

APPENDIX B

COMMENTS AND RESPONSES ON THE HYDROGEOLOGIC AND WATER QUALITY CONDITIONS SOUTH TANK FARM PLUME, IRA

RESPONSES TO U.S. DEPARTMENT OF INTERIOR FISH AND WILDLIFE SERVICE COMMENTS LETTER DATED JULY 23, 1990

1. COMMENT:

Of major concern is the omission of other contaminants detected in one or more wells adjacent to or near Lake Ladora. Two compounds, chloroform and chlorobenzene, are included in the initial Report of Hydrogeologic and Water Quality Investigations (July 1989), but not mentioned in the more recent of Hydrogeologic and Water Quality Report (May 1990). Chlorobenzene was reported at levels exceeding the acute and chronic freshwater aquatic life criteria in the July 1989 report. Two additional compounds, dieldrin and endrin, are reported in the appendices of the May 1990 report, but not mentioned in the text. Detections of these compounds have been found in previous years as well. Both compounds exceed their respective acute and chronic freshwater aquatic life criteria. Based on these criteria, the possibility exists for considerable damage to existing natural resources either directly via water quality and toxicity or indirectly through loss of food sources if these compounds enter the lakes. We maintain that every precaution be taken to prevent these contaminants from entering either Lake Ladora or Lower Derby Lake.

Response:

As stated previously in other documents, the scope of the STFP IRA does not include chloroform, chlorobenzene,

dieldrin, or endrin (see Response to U.S. Department of Interior Comment 2 on the Draft Final Alternatives Assessment, page A-3). Additionally, application of numerical criteria for freshwater (surface water) aquatic life to groundwater is inappropriate.

2. COMMENT:

In the initial Hydrogeologic and Water Quality Report (July 1989) it is stated that contaminants will continue to migrate towards Lake Ladora and potentially spread more rapidly in the alluvium, since it is reached. The more recent report (May 1990) does not take into account this potential for reaching the alluvium, thereby enhancing the possibility of increased flow rate. The conclusion that the contaminants will not reach the lakes prior to a final remedy may not be accurate. As stated in the initial report (July 1989) and quoted in previous Service comments of April 20, 1990, the statement "The cost of remediating contamination in a relatively narrow plume might be less than the cost of remediating contamination in both alluvium and lake water" remains relevant to this IRA.

Response:

The velocity of travel of groundwater is related to hydraulic conductivity, hydraulic gradient, and effective porosity. Knowledge that water flows from one material into another material with differing lower hydraulic conductivity is not sufficient evidence that the velocity will increase or decrease. Only when the hydraulic conductivity and effective porosity are also considered can the hydraulic conductivity be used to determine whether the velocity

sets were discussed in the State's previous comments and enumerated below.

increases or decreases. As shown in Figure 2-2 of the Draft Final Alternatives Assessment, the hydraulic gradient is notably lower in the alluvial aquifer than in the Denver Formation aquifer. However, since neither the hydraulic gradient nor the hydraulic conductivity are precisely known in the alluvium adjacent to the South Lakes, perhaps a more useful way to assess the change of velocity is to make use of the fairly realistic assumption of continuity of flow as described below.

Along a given streamtube the groundwater flowrate is essentially constant. The groundwater velocity can be calculated by dividing the flowrate by the effective area of the aquifer through which the water flows (i.e., the width times the thickness times the effective porosity). In the case of the STFP, the width of the streamtubes flowing into the South Lakes is roughly constant, so the velocity is approximately inversely proportional to the thickness of the aquifer multiplied by the effective porosity. Consequently, the velocity of travel in the alluvium would only be greater than the velocity of travel in the Denver Formation if the product of the thickness and effective porosity of the alluvial aquifer is less than that of the Denver Formation aquifer. For the STFP area, this situation does not appear to be the case. Along the flowlines that the STFP follows, it seems more likely that the effective travel area is generally greater in the alluvium than in the Denver Formation. Consequently, the actual travel velocity may generally be lower in the saturated alluvium than in the Denver Formation aquifer.

RESPONSES TO USEPA COMMENTS
LETTER DATED JULY 23, 1990

GENERAL COMMENTS

1. COMMENT:

The documents still address only the contamination that is presumed to be emanating from the LNAPL plume in the South Tank Farm. The presence of other contaminants, such as chloroform, dieldrin and endrin, which are observed close to Lake Ladora, are not addressed. Previously unavailable analytical results for dieldrin and endrin which are presented in this document are not mentioned at all in the text. These contaminants could pose as serious a threat to the lake as benzene.

Response:

As stated previously in other documents, the scope of the STFP IRA does not include chloroform, chlorobenzene, dieldrin, and endrin (see response to Comment 2 by the U.S. Department of Interior on the Draft Final Alternatives Assessment).

2. COMMENT:

Except as pertains to pesticides, Shell's evaluation of the potential for bioremediation is basically correct and we agree with the information that is presented. However, since Shell does not present any of their experimental procedures, it is impossible to evaluate their

interpretation of the results. The report also does not make any connection between the suitable conditions for bioremediation that exist in the area and the mitigation of the environmental hazards presented by the STFP. Therefore, it is difficult to apply this report to the STFP IRA.

Response:

Details of the experimental procedures used in the laboratory biodegradation studies will be presented in a report by Shell's Westhollow Research Center. The significance of biodegradation in the STFP would be verified through the monitoring program proposed in the "Draft Final Alternatives Assessment" for the STFP IRA.

The connection between the suitable environmental conditions for enhanced biodegradation in the STFP area and mitigation of the environmental hazards is straightforward. Two competing forces determine the rate of advancement of the dissolved plume: hydraulic transport of contaminants from the source area and attenuation of the leading edge of the plume due to natural biodegradation. Should changing hydrogeologic conditions increase the rate of contaminant migration, the rate of biodegradation can be enhanced, given the suitable site conditions, to limit the advancement of the plume.

SPECIFIC COMMENTS

1. COMMENT:

Page 1, paragraph 2. There is evidence to indicate that there are other sources in the STFP area in addition to the LNAPL plume. Limiting the investigation to the contaminants in the LNAPL plume ignores other contaminants which could adversely impact the lakes. The text should indicate that there are other contaminants of concern in the STFP area such as dieldrin, endrin, and chloroform, to mention a few.

Response:

See Response to Comment 1 of the U.S. Department of Interior.

2. COMMENT:

Page 5, paragraph 4. It is unclear when the results of the March 1990 investigation will be presented. Please clarify.

Response:

The text has been modified to indicate that results of the March 1990 investigation are presented in the "Hydrogeologic and Water Quality Conditions, South Tank Farm Plume," May 1990 report.

3. COMMENT:

Figure 4. This figure shows water levels in the Denver Formation greater than the 4-6 feet of weathered Denver Formation. It is unclear if this water level is due to deeper water-bearing zones, or if it represents deeper zones that might be in communication with the Unconfined Flow System via weathered material or joints and fractures. The text should clarify this point.

Response:

The text has been revised to clarify this point. The thickness of the weathered portion of the Denver Formation averages 4-6 feet, but ranges up to approximately 20 feet in some locations.

4. COMMENT:

Section 3.3.4. This section which presents evidence of biodegradation focuses almost solely on benzene and says nothing about the other four contaminants (toluene, xylene, BCHPD, DCPD) which have been labeled in this report as being the constituents of the LNAPL plume. The report should also address the effects of biodegradation on these other four contaminants. Likewise, the report should discuss the effects of biodegradation on other contaminants which are posing a threat to the lakes, such as dieldrin, endrin, chloroform, etc.

Response:

Field evidence for the biodegration of benzene, toluene, and xylene in the STFP area is provided in Section 3.3.4.2 and Figures 21 and 22. The laboratory soil-microcosm studies provided information on the biodegradation of benzene. Degradation of toluene and xylene were not monitored in the laboratory investigations conducted by the Westhollow Research Center because these two compounds generally degrade more rapidly than benzene due to destabilization (deformation) of the benzene ring structure by the attached methyl group(s). BCHPD and DCPD are considered to be recalcitrant compounds resistent to microbial degradation. In addition, studies will be conducted in late 1990 by Shell's Westhollow Research Center to further evaluate the biodegradation of other STFP components (e.g., xylene, toluene, BCHPD, and DCPD).

Of the compounds that comprise the LNAPL plume, benzene has the highest solubility and is only slightly to moderately adsorbed. The combined water solubility and low organic partitioning of benzene results in moderate to high mobility in the aqueous environment. Thus, one to two percent separate-phase benzene in the LNAPL can result in high dissolved concentrations with a large areal distribution as observed in the STFP. Based on the location of the other compounds with respect to the lakes and the interstitial groundwater flow velocity, these compounds are not expected to impact the lakes prior to the final remedy.

5. COMMENT:

Page 13, paragraph 3. What are the dates of the dissolved oxygen measurements in Spring 1990? These values appear to be unusually high. Did the sampling times coincide with large storm events or is there another source of oxygenated water in the area?

Response:

Concentrations of dissolved oxygen (DO) were measured at the time of sample collection (Appendix A). As stated on pages 15 and 16, concentrations of DO measured during 1990 were higher than those measured in 1988. This is probably due to infiltration of oxygenated recharge from precipitation which occurred during the second wettest March on record (March 1990). Precipitation during winter and early spring generally has lower temperatures than at other times of the year, allowing for increased gas solubility (i.e., concentration). Since many of the monitoring wells were partially or completely dewatered during the March 1990 sampling event (due to the declining water table), it is likely that this highly oxygenated water yielded elevated values of DO.

6. COMMENT:

Section 3.3.4.2. Did the microcosm studies indicate a minimum threshold concentration of BTX below which the bacterial population did not metabolize these compounds?

Were there any microbiological studies done for the soil samples collected form the site to determine the bacterial population?

Since Shell has not presented any of the experimental procedures used in the biodegradation studies, it is impossible to evaluate their interpretation of the results.

Response:

See Response to U.S. Department of Interior Comment 4 on the Draft Final Alternatives Assessment.

During the biodegradation studies microcosms were set up with only 5 and 50 ppm benzene and no threshold for biodegradation was observed at these levels. Microbial populations (aerobes) were estimated from aquifer core samples taken from the Basin A area and varied 10^3-10^8 per gram wet weight soil.

7. COMMENT:

Section 3.3.4.3. The report should also address the potential toxic effect that the pesticides in the STFP area may have on the microbes that are responsible for the potential bioremediation of the STFP plume.

If there sufficient hydrogeologic control over the contaminated area to predict and control the effect of the injected nutrients and oxygen during any bioremediation efforts?

Response:

Toxic effects of pesticides in groundwater on soil microbes would not be expected. Studies by Trudgill et al. (J. Gen. Microbial., 69:1-13, 1971) have shown that dieldrin, aldrin and endrin do not inhibit growth of gram negative bacteria, the predominant microbial species in soil.

Groundwater flow velocities are within the acceptable limits for adequately transporting oxygen and nutrients to areas of contamination (Brubaker 1989). Optimization of design features (e.g., injection wells versus recharge trenches) for a biodegradation system would require further evaluation.

8. COMMENT:

Section 3.3.4.2. The text indicates that the microbes are capable of degrading BTX and other compounds. The report should identify what other compounds would be biodegraded.

Response:

The laboratory investigations performed by Westhollow indicated that chloroform was degraded in the soil-microcosm studies. These results are considered preliminary. Further information may be found in the forthcoming report by Westhollow. See Response to USEPA Specific Comment 4.

9. COMMENT:

Page 18, paragraph 1. Water level data in the RMA database indicate that the hydraulic gradient in 1982 was nearly the same as it is now: 0.011 in 1982 and 0.009 in 1989. This equates to a minimal difference in flowrate: 37 ft/year in 1982 and 28 to 33 ft/year in 1989. Assuming that contaminant migration began in 1947, the contaminants would be expected to move from 1200 to 1600 feet, rather than the 2800 feet that is observed in the STFP area. Consequently, Shell's conclusion that the contaminants will not reach the lakes before final remedy may not be accurate. The report should take into account this discrepancy in the potential flowrates.

Response:

Shell disagrees with the EPA's comment (see State Specific Comment 10 to the "Draft Final Alternatives Assessment"). The average migration rate since 1947 is approximately 60 ft/yr, and given the current position of the plume it will be approximately 15 years until the STFP IRA constituents impact Lake Ladora. Shell expects the final remedy to be implemented prior to the STFP impacting the lake.

10. COMMENT:

Page 19, paragraph 1. While it may be true that the benzene hits may be due to cross-contamination, verification of this statement is needed.

Response:

Direct verification of cross-contamination during the 1988 sampling event may not be possible at this time. However, the potential for cross-contamination of groundwater samples was demonstrated during the March 1990 STFP field investigation (see Section 3.3.1.1). Because the same sampling methodology was utilized during both the 1988 and 1990 sampling events, cross-contamination probably caused the anomalous detection in 1988. Continued monitoring would help to verify a reasonable range for concentrations of benzene in these wells and clarify anomalous detections.

11. COMMENT:

Page 19, paragraph 3. The migration rate of 28 ft/year is not necessarily appropriate. See Comment 9 above.

Response:

See Response to Comment 9.

RESPONSE TO THE STATE'S COMMENTS
LETTER DATED JULY 23, 1990

GENERAL COMMENTS

1. COMMENT:

As previously stated in comments at committee meetings, the State objects to the Army and Shell's current restriction on the Scope and objectives of this Interim Response Action (IRA). Therefore, this report's failure to consider those contaminants identified in Shell's July 1989 Report of Hydrogeologic and Water Quality Investigations in the South Tank Farm Plume, Section 2, RMA (1989 STFP Field Report), and pointed out in Specific Comment One of the State's comments on the initial Draft Final Alternatives Assessment, Other Contamination Sources, Interim Response Action, South Tank Farm Plume, March 1990 constitutes a serious shortcoming of the report. Determination of extent and rate of migration of the omitted chemicals (1,1-dichloroethane, trans-1,2-dichloroethylene, carbon tetrachloride, chlorobenzene, tetrachloroethylene, trichloroethylene, and especially chloroform) must be completed as soon as possible so that appropriate decisions can be made to protect the south lakes from harmful impacts.

Response:

See Response to U.S. Department of Interior Comment 2 on the "Draft Final Alternatives Assessment."

2. COMMENT:

The State's concerns regarding the inaccurate characterization of the light non-aqueous phase liquids (LNAPLs) have not been satisfactorily addressed in this report. These concerns have been previously explained in State comments on the initial Alternatives Assessment, as well as the State's Proposal to Improve the Remedial Investigation for the South Plants Study Area, and are again specifically described below. Additional characterization is necessary to facilitate proper remedial selection as soon as possible.

Response:

Shell agrees that additional characterization of the LNAPL is needed with respect to the extent of mobile LNAPL east of Tank 464A and the distribution of LNAPL in the vadose zone in the vicinity of Tank 464A. Shell recommends that additional characterization be performed iteratively under the FS Treatability Studies.

See responses to the State's General Comments 2 and 5(b), and Specific Comment 2 on the Draft Final Alternatives Assessment.

3. COMMENT:

Shell's apparently arbitrary reliance on questionable data and rejection of valid data that have been collected pursuant to this IRA is most disturbing. Specific objections to Shell's conclusions regarding various data

sets were discussed in the State's previous comments and enumerated below.

Response:

Responses to comments on the "Draft Final Alternatives Assessment" and the "Hydrogeologic and Water Quality Conditions" report (Appendices A and B of this document) will address these concerns.

SPECIFIC COMMENTS

1. COMMENT:

Page 2. Shell indicates that the 15 wells sampled in Phase II were all located adjacent to either Lower Derby Lake or Lake Ladora. Of these wells, five were only sampled in Phase II, and are adjacent to Lake Ladora. Of the remaining 10 wells (sampled in Phases I and II), only three are within the vicinity of Lower Derby Lake. Examination of the data in Appendix A indicates that all 10 wells had benzene detections in the Phase I sampling program. Benzene concentrations for the 10 wells are listed as below detection limits in the Phase II sampling episode. Thus, it appears that these Phase II wells were selected, not to characterize groundwater quality immediately upgradient of the South Lakes, but to determine whether Phase I detections were actually a result of cross-contamination of samples. If so, this should be stated clearly in the text.

Response:

As correctly identified by the State, that the objective of Phase II was verification sampling of the 15 wells adjacent to the lakes in order to assess cross-contamination and to determine the location of the leading edge of the plume. The rational for the second phase of sampling is discussed in Section 3.3.1, page 12, and the text has been modified on page 2 to clarify this point.

2. COMMENT:

Page 4, page 13. This report, like the initial "Draft Alternatives Assessment," compares the 1983/84 data with 1988 data, and then calls into question its own conclusions because the latter data had low concentrations of benzene in the rinse blanks. (See page 9 of the 1989 South Tank Farm Plume Field Report: "these data may not be accurate at low concentrations.") Although the 1988 data may be questionable at low concentrations, they are valid at high concentrations which were detected up to 1,000,000 ug/l (Figure 8). Furthermore, the 1988 results were confirmed by the Spring 1989 sampling event.

Shell's refusal to use the Spring 1989 data for its analysis is unacceptable, especially in view of the fact that its July 1989 STFP Field Report based conclusions on comparison between the 1983/84 data with that of 1989. As the State pointed out in its April 25, 1990 Specific Comment 2.b on the initial Draft Alternative Assessment, the 1989 STFP Field Report concluded that:

> The concentration level [of benzene] in groundwater within Section 2 is typically from two to ten times greater in 1989 than in 1982/83 [sic]. In addition, benzene contamination appears to extend up to several hundred feet further down gradient in 1989 than in 1982/83 [sic] . . .

Page 9

This report should be modified to include and discuss fully the Spring of 1989 data. Furthermore, the text should be clarified to indicate that the 1988 data are reliable at high concentrations; alternatively those data should be removed from the report.

Response:

Results of the May 1990 investigation clarified previous uncertainty regarding the position of the leading edge of the STFP. The final results indicate that the variability in benzene concentration is due to biodegradation of the dissolved plume and cross-contamination during sampling. Conclusions in the report are based on the comparison of the 1983/84 data with the more reliable 1990 water quality data.

Shell agrees that the 1988 data are probably valid at high concentrations, where the effect of cross-contamination is less noticeable. However, plume migration rates are determined from the advancement of the plume's leading edge where contaminant concentrations are low. The sampling methodology appears to have cross-contaminated low or zero concentration samples with higher concentrations, thereby creating an inaccurate plume geometry. Based on the observed (cross-contaminated) sample concentrations, the

extent of contamination and the plume migration rate were overestimated. These results led to the erroneous conclusions in the 1989 report and consequently the proposal of the STFP as an IRA. The purpose of presenting the 1988 data (Figure 8) was to illustrate the overestimation of the plume geometry as compared to the actual location of the plume.

3. COMMENT:

Page 9.

a. Shell has conducted 11 slug tests in three wells located in Sections 1 and 2. Using data from these wells, it has calculated transmissivities, and from that information derived hydraulic conductivity values and flow velocities. The slug test data were analyzed using the Cooper et al. method (Cooper, Bredehoeft, and Papadopulos, Response of a Finite Diameter Well to an Instantaneous Charge of Water, WRR, v.13, No. 1, 1967).

Because of the quick response times of wells during the initial few seconds of the slug tests, early time data are extremely important for calculation of transmissivity values when using the Cooper method. However, examination of Appendix D indicates that, with the possible exception of two tests run on Well 02505, early-time data are not available for the first 4 to 15 seconds, depending on the test. Without these data, the water level versus time curves generated from slug tests cannot be accurately matched to the Cooper curves necessary for transmissivity calculations and resultant

hydraulic conductivity determinations. Since this critical information is missing, conclusions drawn from the use of this method are highly suspect. To allow the parties more meaningful review of Shell's analysis, the values of alpha that were selected for the individual slug test curve matches should be distributed to the parties.

b. Because calculations of hydraulic conductivities based on the slug test data are questionable, the resultant velocity calculations are also unreliable. The average velocity calculated based on slug test data from Wells 02505 and 02598 is approximately 28 ft/yr (p. 18). Based on the migration of the benzene front over a 6-year period, a velocity of 33 ft/yr was estimated (p. 19). However, because some biodegradation appears to be occurring within the plume, the contaminant front will be retarded in relation to the average velocity of the ground water. Consequently, the velocity calculated from migration of the contaminant front should be less than that calculated from the slug test analyses. Instead, it is greater.

c. Well 01580 appears to be completed in saturated alluvium, while Wells 02505 and 02598 are completed in the unconfined Denver Formation (Figure 5). The hydraulic conductivity of the alluvium should be greater than that of the unconfined Denver; however, Shell's slug test analyses indicate that the average hydraulic conductivity of Well 01580 is lower than that of both wells completed in the Denver (Table 1). This inconsistency further indicates Shell's slug test data cannot be relied upon to determine transmissivities.

Therefore, the State requests additional slug tests be performed using pressure transducers and data loggers.

The State also notes that, although the STFP appears to be currently restricted to the unconfined Denver Formation, flow rates will probably increase when the plume migrates into the alluvium.

Response:

a. Neither the estimated rates of plume migration nor the selection of the monitoring alternative are based on the results of slug tests. Refer to the response to the State's General Comment 3 on the "Draft Final Alternatives Assessment."

b. See response to above.

c. Unfortunately, the hydraulic conductivities listed in Table 1 for Well 01580 were ten times too high. Nevertheless, this error does not affect the conclusions regarding the selected alternative for this IRA, as the conclusions were not based on the slug test results.

The hydraulic conductivity of the alluvium is not necessarily greater than that of the unconfined Denver Formation. For example, alluvial clays would be expected to have hydraulic conductivities much lower than those in Denver Formation sandstone. The hydraulic conductivities estimated from the slug tests

are well within reasonable ranges for the materials in which they were conducted.

Concerning migration rates in the alluvium, refer to the response to Comment 2 of the U.S. Department of Interior.

4. COMMENT:

Figure 5. This figure indicates that Wells 01587 and 01588 are located along flow paths that impact Lower Derby Lake. Well 01588 had a Spring 1990 benzene detection of 40,000 ug/l; Well 01587, just 500 feet from Lower Derby Lake, had a Spring 1990 benzene detection of 2,000 ug/l. The latter well also had a 69 ug/l detection of DCPD which has not been demonstrated by Shell to be undergoing biodegradation. Therefore, the DCPD plume will probably impact the lake before the benzene plume.

This report does not contain any reliable velocity data for these Section 1 flow paths. Data from slug tests conducted in Well 01580, located in the Section 1 saturated alluvium, cannot be used to establish velocity for the reasons explained in specific comment 3. In addition, no slug tests have been conducted in the unconfined Denver Formation in Section 1. Without velocity data, the parties cannot predict when the contaminants present in Wells 01587 and 01588 will reach the lake. Therefore, the State requests that slug tests be conducted in both the unconfined Denver Formation and the saturated alluvium in this area. As previously stated, these tests should be conducted with pressure transducers and data loggers.

Response:

See Response to the State's Comment B on the "Draft Final Alternatives Assessment."

5. COMMENT:

Page 19, Figure 7. Shell's conclusion that the benzene plume has migrated 200 feet in 6 years was premised in part on its assumption that the leading edge of the plume is currently "slightly downgradient of well 02504." However, Well 02504 had a Spring 1989 benzene detection of 1,000 ug/l, and Spring 1990 detections of 300 and 500 ug/l. Therefore, it is probable that the plume has migrated further down gradient than indicated by Shell and is actually within the vicinity of well 02505. In addition, the contaminant front in 1983/84 may have been further upgradient than is indicated in Figure 7. A more conservative extrapolation of the data results in an estimated migration distance between 250 and 350 feet in 6 years. The text and Figures 7 and 10 should be modified accordingly.

Response:

See Response to State's Specific on Comment 10 on the "Draft Final Alternatives Assessment."

6. COMMENT:

Page 12. Shell states that chlorobenzene was detected in a field blank for Well 02504 at 4.1 ug/l, that the source of

the detection is not known, and that the detection is not considered significant in the interpretation of STFP IRA compounds. However, Shell identified chlorobenzene as one of the eight primary STFP contaminants in the STFP Field Report, indicating that distribution and concentration of the contaminant is significant in evaluating the STFP. Additionally, chlorobenzene was detected in Well 02504 at a concentration of 24 ug/l during the 1990 Phase I and Phase II sampling episodes, and is therefore the probable source of the contaminant in the field blank. The text should therefore be modified accordingly.

Response:

The text has been modified to indicate that Well 02504 was the probable source of the detection of chlorobenzene in the field blank. Chlorobenzene is not a constituent of the STFP, therefore, relative to this IRA the detection of chlorobenzene is not significant.

7. COMMENT:

Page 14. This report does not adequately characterize the LNAPL plume. Although the current data are not sufficient to define the boundaries of this plume, they are sufficient to indicate that the plume extends beyond the leading edge identified by Shell in its report of the Investigation of the LNAPL Plume Near Tank 464A, Section 1, RMA, August 1989 (LNAPL Report).

In its comments on Shell's Letter Task Plan, Fall 1989 South Tank Farm Plume Investigation (Letter Task Plan), the State noted that the well screens for Wells 01539, 01540, 01552,

and 01554 were set below the top of the water table, and therefore the absence of LNAPL in samples taken from these wells did not necessarily mean that LNAPLs were not present at those well locations. In the Spring 1990 program, samples from Wells 01539, 01540, 01541, and 01565 did have benzene concentrations of 2,000 mg/l, which exceeds the solubility limits of 1700-1780 mg/l (see, e.g., North Central Study Area Report, Appendix D, P. 3). These concentrations indicate the probable presence of measurable LNAPL in the immediate vicinity of these wells, mixture of the LNAPL in the groundwater that was sampled, and/or migration of the LNAPL into the wells during pumping. Contrary to these data, the LNAPL report lists the former two wells as having no detections of LNAPL (Figure 4 and Tables 2-5 of LNAPL Report). As a result, Shell concluded that:

> [the LNAPL] probably does not exist at measurable thicknesses in the four wells [01539, 01540, 01552, 01554]

(March 1, 1990 Response to State Comment 2.A.3 on Shell's Letter Task Plan.)

This incorrect conclusion has not been revised in the current data report. If, as the State suspects, LNAPLs are present at (or beyond) Well 01541, the downgradient extent of the plume reaches at least 400 feet beyond the leading edge estimated by Shell.

Given these additional data, the State again urges that properly screened wells be constructed to define the extent of the LNAPL plume.

Response:

Shell agrees with the State as to the need for additional characterization of the LNAPL plume. This is to be performed as part of the FS Treatability Study (see response to General Comment 2).

Wells in the vicinity of Tank 464A are appropriately screened for monitoring LNAPL. As the State is aware from its review of the 1989 LNAPL report, Shell installed additional wells in 1989 in the STFP area that are screened above the water table specifically to address this question. Additional wells will be installed, as required, for further investigating the LNAPL plume under the FS Treatability Study.

This report is not intended to characterize the LNAPL plume, therefore, Shell considers this comment to be inappropriate. Actual hydrocarbon volume in porous media is less than the thickness of free product in a monitoring well. Under these conditions even small volumes of LNAPL in the unsaturated media may be manifest by large LNAPL volumes in monitoring wells. Therefore, the conclusions concerning the LNAPL are not necessarily incorrect, but require further study.

8. COMMENT:

Figure 10. Shell has qualified the Spring 1990 data values listed for Wells 01578 and 01579 (200 ug/l and >160 ug/l) with the following statement:

> Data [are] considered invalid due to potential cross-contamination, but not verified during May 1990 resampling and analysis.

Because of the importance of these wells in defining potential flow paths towards Lower Derby Lake, they must either be resampled (as were Wells 01580, 10581, and 01586 when benzene was detected in the 1990 Phase I sampling program), or the values accepted.

Response:

Contaminant concentrations in groundwater samples collected in Wells 01578 and 01579 during Spring 1990 are suspect due to potential cross-contamination. To provide more complete, comprehensive information, Shell has recommended that these wells be sampled as part of the verification monitoring proposed in the "Draft Final Alternatives Assessment for the STFP IRA." The verification monitoring program will provide an integrated overview as opposed to isolated data.

9. COMMENT:

Page 15. Shell states that the highest concentrations of toluene, xylene, BCHPD, and DCPD have been in the vicinity of or downgradient from Tanks 462A, 463B, 463F, 463G, 464A, and 464B. Examination of Spring 1990 data for benzene (Wells 01533, 01534, 01535, 01539, 01540, 05141, 01552, 01554, 01565, see Figure 10); DCPD (Wells 01534, 01565, see Figure 14); toluene (Well 01565, see Figure 11); xylene (Well 01565, see Figure 12); and BCHPD (Well 01565, see Figure 13), indicates that Tanks 462A, 463A, 463B, 463E, 463F, 463G, and 464A are past or current sources of contaminants to groundwater. Well 01565, immediately downgradient of Tank 463F, had a benzene concentration of

2000 mg/l in Spring 1990, indicating the probable presence of measurable product in the well.

Given these distributions of high concentrations of contaminants, it is essential that the sources be identified and characterized as soon as possible so that decisions regarding feasibility and timing of remediation of those sources can proceed on an expedited basis.

Response:

The areal extent of LNAPL contamination in the vicinity of Tank 464A will be determined as part of the proposed FS Treatability Study for the LNAPL plume near that tank. Vadose zone contamination near the LNAPL will be investigated as part of the proposed study. Additional characterization of LNAPL in the STFP area should satisfy the State's request for further source identification for the STFP.

10. COMMENT:

Page 16. What is the specific location within Section 2 from which saturated sediment samples were taken, and on which the biodegradation microcosm studies were performed? As requested in the State's Specific Comment 8 on Shell's initial Draft Alternatives Assessment, please provide the data from the laboratory studies.

Response:

See Response to U.S. Department of Interior Comment 4 on the "Draft Final Alternatives Assessment."

APPENDIX C

REVISED PAGES FOR THE
HYDROGEOLOGIC AND WATER QUALITY CONDITIONS
SOUTH TANK FARM PLUME, IRA
REPORT OF MAY 1990

The tasks conducted to meet the specific objectives of the investigation are outlined below.

1) Sampling and analyses of groundwater for dissolved concentrations of benzene, toluene, xylene, BCHPD, and DCPD.

   Phase 1: 45 wells located throughout the STFP area.

   Phase 2: Verification sampling of 15 wells located adjacent to the lakes to assess cross-contamination and determine the leading edge of the plume.

2) Measurement of dissolved oxygen (DO) in the wells sampled for groundwater quality analyses.

3) Sampling and analysis of groundwater from 10 wells (approximately 25% of the total) for concentrations of selected nutrients significant to the growth of bacteria capable of degrading organic contaminants (i.e., nitrogen and phosphorous). Groundwater samples from the 10 wells were also analyzed for copper and nickel (to evaluate the potential for decomposition of hydrogen peroxide typically used in bioremedial systems) and for iron (to evaluate the potential for clogging caused by precipitation of iron minerals). Samples were obtained from wells located in areas of both low and high concentrations of contaminants.

distribution in Section 2, and determine whether a new IRA should be proposed for the STFP (Shell 1989a). Based on the assumption that the groundwater quality data from 1983/84 and 1989 were comparable, Shell concluded that the benzene plume, first identified in early eighties, was migrating toward Lake Ladora at a sufficient rate that the plume might migrate into Lake Ladora prior to the implementation of the final remedy.

An investigation was conducted by Shell during the summer of 1989 in the South Tank Farm to investigate the extent and composition of a light, non-aqueous phase liquid (LNAPL) previously detected in a well near Tank 464A. This investigation provided a preliminary characterization of the apparent thickness, composition, and lateral extent of a portion of the LNAPL plume which is believed to be a primary source of the dissolved contaminants which comprise the STFP (Shell 1989b).

Another investigation was conducted by Shell during the fall of 1989 to better define both the leading edge and hydrogeologic setting of the STFP in Sections 1 and 2 and to provide limited information on aquifer hydraulic properties for preparing the Draft Final Alternatives Assessment Document for this IRA. The results of the investigation provided additional knowledge of contaminant distribution near Lower Derby Lake and of the hydraulic setting of the STFP. Information obtained during this field investigation is discussed in this report; water quality data, well logs, and hydraulic properties test data are presented in Appendices B, C, and D, respectively.

These previous reports have indicated significant variability in concentrations of benzene particularly in wells which define the boundary of the plume. Comparisons of different sets of data

have resulted in different interpretations of the migration rate and maximum extent of benzene. The March 1990 investigation was undertaken to evaluate the potential causes for this variability and the results of this investigation are presented in the appendices to this report.

3.0 RESULTS AND INTERPRETATION

3.1 GEOLOGY

Two geologic units occur in the STFP study area: an upper alluvial unit underlain by the Denver Formation. The alluvium consists of brown, unconsolidated, silty sand with increasing silt and clay content at depth. It ranges from approximately 5 feet thick near the South Tank Farm to 25 feet thick near Lake Ladora.

The alluvium is underlain by brown to green, weathered and unweathered claystones, mudstones, and siltstones of the Denver Formation. These strata are referred to as the VCE and VC in the South Plants Study Area Report (Ebasco 1989). The uppermost portion of the Denver Formation is weathered and, in places, exhibits narrow joints and fractures. The thickness of the weathered portion averages 4 to 6 feet, but may extend to approximately 20 feet in some locations. The variability of the subsurface lithology near the leading edge of the STFP near Lake Ladora is shown by the geologic cross-section in Figure 4.

3.2 HYDROLOGY

The STFP is located in the uppermost water-bearing zone (WBZ1) as defined in the South Plants Study Area Report (Ebasco 1989). WBZ1 comprises saturated sediments in both the alluvial aquifer and the uppermost Denver Formation. The top of WBZ1 is defined by the water table. The base is defined by the transition between weathered and unweathered sediments in the uppermost Denver Formation; it is identified by a green to brown claystone exhibiting a lesser degree of fracturing and weathering

3.3.1.2 Phase 2

Field QC sample analyses for Phase 2 are also included in Appendix A. The field QC sample analyses indicated that the laboratory provided reproducible data and that sampling collection procedures were adequate. Evaluation of the QC data is provided below.

One sample duplicate was collected from Well 02505. The concentrations detected in the duplicate sample indicate that the laboratory provided reproducible results.

No analytes were detected in the two trip blanks. Chlorobenzene at a concentration of 4.1 ug/L was detected in the field blank from Well 02504. Well 02504 is considered to be the source of chlorobenzene in the field blank, but this detection is not considered significant to the interpretation of STFP IRA compounds.

Since wells containing very high concentrations of contaminants were sampled towards the end of Phase 1, the sampling equipment was decontaminated, plastic tubing was replaced, and a rinse blank was obtained prior to sampling any wells during Phase 2 to evaluate potential cross-contamination. Benzene and chlorobenzene were detected at concentrations of 3.6 and 3.5 ug/L, respectively in the rinse blank (02510R). This indicates that wells sampled during Phase 1, after Well 02561, were probably cross-contaminated with very low concentrations of benzene and chlorobenzene resulting in detections in wells that were previously free of these compounds. However, no contaminants were detected in the first five wells sampled during Phase 2 of the sampling program, indicating that residual contamination on the sampling equipment was removed during

purging of the well and that cross-contamination was not significant during the second phase of sampling. These results also suggest that cross-contamination occurred during the 1988 sampling event since sampling and decontamination procedures were identical, and significant rinse blank contamination was documented. Decontamination procedures are being improved to prevent cross-contamination in future sampling programs.

A second rinse blank was collected after decontaminating sampling equipment used to sample Well 02506. Chlorobenzene was detected at a concentration equal to the CRL (2.7 ug/L). Since chlorobenzene was not detected in Well 02506 or in any of the ten previously sampled wells, the source of chlorobenzene contamination is not known and the detection is considered to be invalid.

3.3.2 Inorganic Groundwater Chemistry

Groundwater pH in the STFP area ranges from 7.0 to 8.4 and averages 7.3. Groundwater temperatures range from 48 to 60°F and average 53°F.

The analytical results for the inorganic constituents are presented in Appendix A. Concentrations of nickel and copper in groundwater samples are generally below the certified reporting limit (CRL). Total copper was detected in three of ten wells sampled at concentrations ranging from 16.0 to 25.2 ug/L. Total nickel was detected in two of the ten sampled wells at concentrations of 13.2 and 19.6 ug/L. Concentrations of total arsenic and mercury are also low, typically at or near the CRL (RMA-PMO database). Total iron was detected at concentrations up to 36 mg/L with a geometric mean of 1.25 mg/L.

TABLE 1: SUMMARY OF INJECTION TEST RESULTS

Well No.	Hydraulic Conductivity (cm/sec)	Hydraulic Gradient (ft/ft)	Saturated Thickness (m)	Flow Velocity (ft/yr)
02505	1.6×10^{-3} to 8.8×10^{-4}		4.9	132-72
02598	4.6×10^{-5} to 4.3×10^{-5}		4.9	3.3-3.1
01580	4.0×10^{-4} to 3.4×10^{-4}		3.3	33-28

08/16/90