EPA/AMD/R07-01/502
2001

EPA Superfund
Record of Decision Amendment:

CORNHUSKER ARMY AMMUNITION PLANT
EPA ID: NE2213820234
OU 01
HALL COUNTY, NE
09/26/2001

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION VII
901 NORTH 5TH STREET
KANSAS CITY, KANSAS 66101

October 2, 2001

U.S. Environmental Protection Agency
Superfund Docket (5202G) Attn: Marty Graves
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Dear Mr. Graves:

Enclosed is a copy of the September 26, 2001, Record of Decision for the Cornhusker Army Ammunition Plant (Operable Unit No. 01), Grand Island, Nebraska. If you have any questions, please contact me at 913/551-7415.

Sincerely,

Lynette Motley
Superfund Division

Enclosure

[redacted]

OU1 ROD AMENDMENT

CORNHUSKER ARMY AMMUNITION PLANT
GRAND ISLAND, NEBRASKA

Prepared for
U.S. Army Corps of Engineers
Omaha District
Omaha, Nebraska

April 2001

URS

101 South 108th Avenue
Omaha, Nebraska 68154
Project No. 45F0000009.00

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Declaration of the Record of Decision Amendment

SITE NAME AND LOCATION

Cornhusker Army Ammunition Plant (CHAAP), Grand Island, Nebraska.

STATEMENT AND BASIS OF PURPOSE

This Record of Decision (ROD) Amendment presents the new proposed remedy for Operable Unit One (OU1) groundwater at CHAAP, Grand Island, Nebraska. The ROD Amendment provides the technical rationale for amending the original ROD (signed September 29, 1994). The remedial alternatives were selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). The information supporting the decisions on the selected remedies is contained in the Administrative Record.

The United States Environmental Protection Agency (USEPA) Region VII and the Nebraska Department of Environmental Quality (NDEQ) concur with the selected remedy.

ASSESSMENT OF THE SITE

The current and realistic future land use for OU1 is industrial and agricultural. The response actions selected in this ROD Amendment for OU1 are necessary to protect the public health and welfare from actual or threatened releases of hazardous substances into the environment. The remedies for OU1 are not driven by ecological risks because the areas that comprise OU1 have no completed exposure pathways for ecoreceptors.

DESCRIPTION OF THE NEW PROPOSED REMEDY

The new Proposed Remedy presents a significant and fundamental change to the original Selected Remedy. The new Proposed Remedy includes the addition of a seventh extraction well to the on-post groundwater extraction system and the implementation of monitored natural attenuation for the off-post distal plume. The monitored natural attenuation alternative replaces off-post extraction and treatment originally planned for the distal plume. The Remedial Action Objectives (RAOs) for OU1 are the same as those listed in the original ROD which were based on the USEPA Health Advisory Levels for explosives.

The new Proposed Remedy also includes institutional controls to prevent residential use for off-post groundwater (in the form of a City Ordinance) and on-post groundwater (in the form of deed restrictions). The U. S. Army will be responsible for implementing and maintaining the effectiveness of institutional controls.

STATUTORY DETERMINATIONS

The new Proposed Remedy will protect human health and the environment, comply with Federal and state requirements that are applicable or relevant to the remedial action, is cost effective, and utilizes permanent solutions. Both the on- post and off- post portions of the plume will be treated until the RAOs for OU1 are achieved.

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in this ROD Amendment. Additional information can be found in the Administrative Record file for this site.

- Chemicals of potential concern (COPCs) (Section 2)
- Baseline risk represented by the COPCs (Section 2)
- Cleanup levels established for COPCs and the basis for these levels (Section 2)
- How source materials constituting principal threats are addressed (Section 4)
- Current and reasonably anticipated future land use assumptions used in the baseline risk assessment and ROD (Sections 2 and 4)
- Potential land use that will be available at the site as a result of the Selected Remedies (Section 4)
- Estimated capital, annual operation and maintenance (O&M), and total present value costs, and the number of years over which the remedy cost estimates are projected (Section 5)
- Key factors that led to selecting the remedies (Section 5)

Larry V. Gulledge
Deputy to Commander
U.S. Army Operations Support Command

7 Sep. 2001
Date

Andrea Jirka for
Michael Sanderson
Director, Superfund Division
U.S. Environmental Protection Agency, Region VII

9/26/01
Date

This Record of Decision (ROD) Amendment for Operable Unit One (OU1) identifies the new Proposed Remedy for remediating groundwater at OU1 of the Cornhusker Army Ammunition Plant (CHAAP), Grand Island, Nebraska (see Figure 1). The ROD Amendment provides the rationale for amending the original ROD (signed on September 29, 1994). This document is issued by the US Army, the owner of the site, with concurrence from the U. S. Environmental Protection Agency Region VII (USEPA) and the Nebraska Department of Environmental Quality (NDEQ).

The US Army is choosing to implement the new Proposed Remedy presented in this ROD Amendment in accordance with Section 117 of the Comprehensive Environmental Response, Compensation, and Liabilities Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), and to the extent practicable, Section 300.435(c)(2)(ii) of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP). This ROD Amendment summarizes information that is presented in greater detail in the original ROD (signed on September 29, 1994), Remedial Investigation/Feasibility Study (ICF Kaiser 1996) and subsequent groundwater monitoring reports (W-C 1997, 1998a, 1999; URSGWFS 1999; URS 2000b). All documents are included in the Administrative Record File for this site (in accordance with Section 300.825(a)(2) of the NCP).

The ROD Amendment will become part of the Administrative Record file. The Administrative Record file, which includes all documents referenced in this ROD Amendment (in accordance with Section 300.825(a)(2) of the NCP), is available for public review at the Grand Island Public Library. USEPA and the NDEQ encourage the public to review these documents to gain a more comprehensive understanding of site remediation activities.

The Administrative Record File, including all referenced documents, for the site is available at:

Grand Island Public Library
211 North Washington Street
Grand Island, Nebraska 68802
(308) 385-5333
Hours of operation:
M-Th 9 a.m. - 9 p.m.
Fr-Sat 9 a.m. - 9 p.m.
Sat 1 p.m. - 5 p.m.

SECTION TWO Site History, Contamination, and Original Selected Remedy

CHAAP is located on a 10,520-acre tract approximately 2 miles west of Grand Island, Nebraska (see Figure 1). CHAAP was constructed and became fully operational in 1942 as a U. S. Government-owned, contractor-operated facility. CHAAP was responsible for the production of artillery shells, mines, bombs, and rockets for World War II and the Korean and Vietnam conflicts. The plant was operated intermittently for 30 years, with the most recent operations ending in 1973. The facility is currently in the process of being excessed in accordance with the Hall County reuse plan.

CHAAP was placed on the Superfund National Priorities List (NPL) in 1987 and is participating in the Installation Restoration Program (IRP), a specially funded program established by the Department of Defense (DoD) in 1978 to identify, investigate, and control migration of hazardous contaminants at DoD facilities. An Interagency Agreement between the USEPA, NDEQ, and the DoD was signed in 1990, under which the US Army has investigated and is cleaning up the site.

2.1 CONTAMINATION

Explosive wastes and residues associated with munitions loading, assembly, and packing operations resulted in a groundwater contamination plume that originated near the CHAAP load lines and extends northeastward towards Grand Island (see Figures 2 and 3).

The explosive compounds have migrated east-northeast with the predominant direction of groundwater flow. The more mobile compounds, RDX and HMX, have migrated the greatest distances. Highly sorbing compounds, such as TNT, have migrated shorter distances.

Evaluation and remediation of explosives contamination has been an ongoing process at CHAAP. The US Army conducted a soil excavation and incineration project from 1987 to 1988 designed to remove the soil sources of explosives contamination. That project reduced the soil contamination source areas; however, high concentrations of dissolved contaminants remained in groundwater.

2.2 SUMMARY OF SITE RISK ASSESSMENT

The Remedial Investigation/Feasibility Study (RI/FS) report (ICF Kaiser 1996) included a risk assessment to estimate current and future risks to human health and the environment from exposures to contaminated groundwater. Although the levels of explosives in on- post groundwater were elevated, there are many uncertainties in predicting the risk estimates, including the assumption that residents would actually consume on-post groundwater on a regular basis.

Estimated risks for carcinogens (potentially cancer- causing chemicals) were compared to the NCP acceptable range (e.g., the target risk range of one in a million to one in ten thousand [$1x10^{-6}$ to $1x10^{-4}$] for human health protection at Superfund sites). Chemicals with completed pathways that exceed a risk of one in one million ($1x10^{-6}$) usually warrant remedial action under Nebraska ARARs.

Noncarcinogen chemical concentrations were compared to a hazard quotient of 1.0. Chemicals that are present in concentrations that exceed a hazard quotient of 1.0 usually warrant remedial action. Estimated risks are summarized as follows.

2.2.1 Estimated On-Post Groundwater Risks

- For ingestion of explosives-contaminated on-post groundwater, the risk estimates indicated excess lifetime cancer risks above the $1x10^{-4}$ risk level. In addition, it was determined that unacceptable levels of adverse noncarcinogenic effects associated with explosives in groundwater may occur. This exposure pathway will be eliminated because CHAAP will implement deed restrictions prohibiting drinking water supply wells on excessed property in the vicinity of the plume.

- Future cancer risk estimates associated with the future ingestion of crops irrigated with on-post groundwater were at the low end of the 1x10-6 to 1x10-4 risk range, and the noncarcinogenic hazard indices were below one. These low risk estimates demonstrate, based on the assumptions made in the risk assessment, that no unacceptable cancer risks and no unacceptable adverse health effects are likely to occur from exposure to explosives in vegetables that have been irrigated with CHAAP groundwater.

- There are no estimated risks to ecological receptors because on- post groundwater is considered inaccessible to ecological receptors at CHAAP.

- Risks associated with all other organic and inorganic chemicals in groundwater were estimated to be at acceptable levels.

2.2.2 Estimated Off-Post Groundwater Risks

- Lifetime groundwater risk estimates for off-post residents were all lower than or at the low end of the 1x10-6 to 1x10-4 risk range and all hazard indices were less than one, except for a child's ingestion of groundwater. The need for groundwater use as a drinking water supply has been eliminated because all residences in the affected areas have been connected to the city water supply.

- There are no estimated risks to ecological receptors because off-post groundwater is considered inaccessible to ecological receptors near CHAAP and in the city.

2.3 REMEDIAL ACTION OBJECTIVES

The Remedial Action Objectives for CHAAP groundwater are:

- Protect human health and the environment

- Clean up groundwater to below health advisory levels

- Contain high concentrations of explosives in groundwater on post

The ROD (USAEC 1994b) established Remedial Action Objectives for explosives in groundwater at CHAAP. The Remedial Action Objectives are included on Table 1 and remain unchanged for the new Proposed Remedy.

2.4 ORIGINAL SELECTED REMEDY

2.4.1 Original Selected Remedy On Post

Under terms of the first ROD, signed on September 29, 1994, the original Selected Remedy in the area identified as the contamination source (e.g., on post) included:

- Extraction of contaminated groundwater;

- Treatment of the extracted groundwater using granular activated carbon (explosives), granular media filtration (suspended solids), chemical precipitation (as needed to meet NPDES limits), and the constructed wetlands (nitrates);

- Discharge of treated effluent to the Platte River through the Wood River Diversion Channel easement.

The on-post portion of the groundwater extraction and treatment system was constructed in summer 1998 under the direction of the US Army Corps of Engineers (USACE). Full-time operation began in December 1998. The original groundwater extraction system included six wells with a total extraction flow rate of about 750 gallons per minute.

In March 2000, an additional extraction well was added to improve the on-post extraction system. The on-post extraction system is designed to prevent the migration off post of the on-post portion of the explosives plume (i.e., highest explosives concentrations). The overall flow rate was maintained at 750 gallons per minute. Groundwater is currently being treated for explosives through granular activated carbon filters and discharged to on-post drainage canals leading to Silver Creek.

2.4.2 Original Selected Remedy Off Post

The original Selected Remedy for the area identified as the distal end/ intermediate area included:

- Extraction of contaminated groundwater at both the distal end and the intermediate area;

- Treatment of the extracted groundwater using granular activated carbon and granular media filtration;

- Discharge of treated effluent to the Platte River through the Wood River Diversion Channel easement.

The off-post portion of the groundwater extraction and piping system (that is, the distal end/intermediate area remedy) was tabled due to difficulties with establishment of permanent easements for the piping and public concern for any additional effluent discharges to Silver Creek.

The technical basis for the ROD Amendment is the Long-Term Monitoring data, the results of the Monitored Natural Attenuation Demonstration, and the model-predicted contaminant fate and transport.

3.1 LONG-TERM MONITORING AND NATURAL ATTENUATION DEMONSTRATION

The primary objective of the LTM program was to monitor and identify explosives plume migration trends in the off- post monitoring well locations. Additional objectives for the LTM included identifying natural attenuation trends for the off-post explosives plume. Five LTM and natural attenuation demonstration sampling events have been completed since 1998. The data from these events supports the use of monitored natural attenuation for remediation of the off-post explosives plume. Complete discussion of the natural attenuation demonstration methodology, water quality parameter results, natural attenuation processes identification, and degradation rate estimates along with supporting tables and figures is included in Appendix B.

3.1.1 Long-Term Monitoring Results

The LTM sampling results support the following conclusions:

Off-Post Plume

- The explosives plume, consisting primarily of RDX, is still present off post, but has not migrated any further downgradient.
- Explosives concentrations within the off- post plume have declined over time from 1994 to 2000.
- TNT breakdown products (e.g., 2-Am-DNT and 4-Am-DNT) have been detected in off-post monitoring well clusters NW020, CA350, and CA380, indicating biodegradation has occurred.
- HMX has not been detected above the health advisory level (i.e., 400 ug/L) during any LTM sampling event.

Reasons for off-post explosives concentrations declining from 1984 (Spalding and Fulton 1988) to 2000 (URS 2000) include natural attenuation processes (e.g., dispersion, biodegradation, and abiotic degradation), contaminant soil source removal and on-post groundwater extraction.

On-Post Source Areas

- RDX and TNT concentrations remain significantly above health advisory levels at LL1, LL2, and LL3.
- On-post RDX and TNT concentrations near extraction wells EW-4, EW-5, and EW-6 have remained low (similar over the past three LTM monitoring events).
- No explosives concentrations were detected above health advisory levels at LL4, LL5, or the nitrate area.
- HMX has not been detected above the health advisory level (i.e., 400 ug/L) during any LTM sampling event.

Complete discussion of the current nature and extent of the explosives plume, along with supporting table and figures, is included in **Appendix B**.

3.1.2 Natural Attenuation Demonstration Results

The natural attenuation demonstration results indicated natural attenuation of explosives in groundwater is occurring at CHAAP. The key elements that support the use of monitored natural attenuation at CHAAP include:

- RDX and TNT concentrations in the off- post plume have decreased steadily over time.
- Significant denitrification is occurring in the feedlot area, which is facilitating explosives degradation as the plume migrates through this area. The feedlot area subsurface zone is functioning as an in-situ anaerobic/reducing treatment cell.
- Other anaerobic degradation processes (e.g., Fe reduction, methanogenesis, and sulfate reduction) are also occurring in the feedlot area, but to a lesser extent.
- Explosives degradation products are present, including RDX degradation products (e.g., MNX, DNX, and TNX [Spalding 1998]) and TNT breakdown products (e.g., 2-Am-DNT and 4-Am-DNT). The degradation products have not been detected at concentrations above 1x10-6 risk levels and will continue to be monitored under the long- term monitoring program.
- Contaminant fate and transport modeling results indicate the off-post explosives plume is degrading at a sufficient rate to achieve cleanup goals within a timeframe that is approximately equal to the expected time frame for remediation to be completed using an off-post pump-and-treat remedy (e.g., 10 to 15 years for distal plume).
- The on-post explosives soil source areas have been removed.
- No further migration of on-post explosives contamination is expected because contaminated groundwater migration from groundwater explosives source areas will be contained by the on-post groundwater extraction system.
- Potential off-post receptors/residences have been provided an alternative drinking water source (i.e., connected to Grand Island city water supply).

3.2 GROUNDWATER FLOW AND CONTAMINANT FATE AND TRANSPORT MODELING

A numerical groundwater contaminant fate and transport model was developed to evaluate the use of natural attenuation for remediation of the off-post explosives. The numerical model simulated baseline contaminant transport and transport under remediation conditions. The baseline contaminant fate and transport simulation and the new Proposed Remedy simulation were used to evaluate natural attenuation of the off-post explosives plume. Complete details of Model-predicted results indicated on-post pumping could contain the existing explosives plume on the facility property while the off-post plume is allowed to naturally attenuate. Model-predicted results indicated the off-post plume would naturally attenuate to below target clean-up goals in about 20 years.

3.2.4 Contaminant Fate and Transport Modeling Conclusions

Contaminant fate and transport modeling of extraction alternatives indicated the optimized on-post extraction with EW-7 and off-post natural attenuation alternative (i.e., the new Proposed Remedy) would remove contamination emanating from LL 1, 2, and 3, contain the on-post contamination, and naturally attenuate the off-post plume. Model-predicted results indicated distal extraction would not decrease the overall clean-up times significantly.

This ROD Amendment presents a significant and fundamental modification to the original Selected Remedy. This modification includes the addition of a seventh extraction well (EW-7) to the on-post groundwater extraction system and the implementation of monitored natural attenuation for the off-post distal plume. The monitored natural attenuation alternative replaces off-post extraction and treatment originally planned for the distal plume.

The full set of remedial alternatives to treat on-and off-post groundwater at CHAAP were presented in the Feasibility Study (WJE 1994), analyzed in the original Proposed Plan (USAEC 1994a), and modified in the Explanation of Significant Differences (USAEC 1996), and will not be restated herein. Instead, this document will focus on the original Selected Remedy compared to the new Proposed Remedy.

4.1 SUMMARY OF REMEDIES

Table 2 summarizes the original Selected Remedy and the new Proposed Remedy. The original Selected Remedy and the new Proposed Remedy are shown on Figures 4 and 5, respectively.

4.1.1 Original Selected Remedy Summary

The original Selected Remedy included the following basic components:

- On-post groundwater extraction
- Off-post groundwater extraction
- Groundwater Treatment
- Disposal of treated water to Silver Creek
- Institutional controls designed to limit public exposure to contaminated groundwater

A portion of the original Selected Remedy is currently in place without the off- post groundwater extraction wells and a change in discharge location.

4.1.2 New Proposed Remedy Summary

The new Proposed Remedy includes the following basic components:

- On-post groundwater extraction and treatment (completed December 1998) using optimized extraction rates and an additional extraction well (completed March 2000)
- Disposal of treated water to Silver Creek
- Monitored natural attenuation of the off-post plume
- Institutional controls designed to limit public exposure to contaminated groundwater on and off post

The new Proposed Remedy has several advantages over the original Selected Remedy. The new Proposed Remedy is expected to reduce capital costs by at least $4.0 million compared to the original Selected Remedy while achieving substantial risk reduction through the permanent treatment of groundwater contaminants using natural processes.

The new Proposed Remedy is also expected to reduce the risk within a time frame similar to that expected with the original Selected Remedy. Based on the information available at this time, the US Army believes the new Proposed Remedy is protective of human health and the environment, complies with Applicable or Relevant and Appropriate Requirements (ARARs), is cost-effective, and utilizes permanent solutions to the maximum extent practicable. Because it would continue to treat the groundwater sources constituting principal threats, the new Proposed Remedy also would meet the statutory preference for the selection of a remedy that involves treatment as a principal element.

4.2 TREATMENT, CONTAINMENT, AND STORAGE COMPONENTS

The treatment, containment, and storage components of the original Selected Remedy and the new Proposed Remedy are outlined on Table 2 and summarized in the following sections.

4.2.1 Original Selected Remedy Treatment, Containment, and Storage Components

The original Selected Remedy included the operation of an on- post groundwater extraction and treatment system comprised of six extraction wells. This system has been modified to include continued operation of the on-post groundwater extraction and treatment system with the addition of a seventh extraction well (installed in March 2000), which has been designated EW-7. EW-7 was constructed along the mid-line of the explosives plume adjacent to the downgradient (i.e., eastern) Post boundary to provide on- post containment of the explosives plume.

Extracted groundwater is piped to a central groundwater treatment facility. Groundwater is pre-treated (for suspended solids removal) using granular media filters, treated for explosives using granular activated carbon, discharged to on-post drainage canals leading to Silver Creek, and ultimately discharged to Silver Creek. There is no storage component to the original Selected Remedy.

In addition, the original Selected Remedy included the operation of an off-post extraction system (and augmented treatment facility) originally planned for the distal end and intermediate area of the plume. The off-post extraction system was originally planned to prevent further migration of explosives by containing the distal end of the plume. Administrative implementability constraints delayed the construction of the off-post extraction system.

4.2.2 New Proposed Remedy Treatment, Containment, and Storage Components

The new Proposed Remedy modifications include the addition of EW-7 to provide containment of the on-post explosives plume combined with the elimination of the off-post extraction wells, conveyance piping, and augmented treatment system. Instead, off-post groundwater will be monitored while the low concentrations of explosives naturally attenuate.

Two distinct lines of evidence support the monitored natural attenuation component of the new Proposed Remedy. Supporting evidence includes demonstrated trends of declining explosive concentrations and total mass over time and predictive computer modeling (documented in the March 2000 LTM report (URS 2000b) and Groundwater Flow and Contaminant Fate and Transport Modeling report [URS 2001]).

Monitored natural attenuation will be implemented in accordance with a Long-Term Monitoring Plan developed for the CHAAP site. The Long-Term Monitoring Plan will include appropriate monitoring well locations, field analyses, laboratory analyses, schedules, and reporting requirements. The Long-Term Monitoring Plan will be based on the original Technical Plan for the Long-Term Monitoring Program (W-C 1997) and the subsequent annual Amendments (W-C 1998, URSGWCFS 1999, and URSGWCFS 2000a). The objective of the long-term monitoring program will be to monitor explosives concentrations and migration trends for the on- post and off-post portions of the plume.

This new Proposed Remedy will ensure that the toxicity, mobility and volume of the contaminants in the on-and off-post groundwater are permanently reduced to acceptable levels (i.e., Remedial Action Objectives). All contaminants will be treated under the new

Proposed Remedy; no hazardous materials or wastes will be contained or stored.

4.3 INSTITUTIONAL CONTROL COMPONENTS

The original Selected Remedy included limited provisions for institutional controls. These institutional controls will be augmented under the new Proposed Remedy. The additional institutional controls are designed to help prevent drinking water exposures to contaminated groundwater until the Remedial Action Objectives (listed in Table 1) have been attained throughout the plume area.

Institutional controls for both the original Selected Remedy and the new Proposed Remedy are listed below.

4.3.1 Institutional Controls/Actions for Original Selected Remedy

The original Selected Remedy included the following institutional controls/actions:

- Off-Post Plume

  - The US Army contracted the City of Grand Island to extend, in 1986 and 1993, the municipal water main to provide water supply to all residences (est. 400) in the vicinity of the plume. Five residences refused the City water hookup at that time. Those five residences are currently outside the interpreted explosives plume boundary (drawn using Health Advisory Levels (USEPA 2000)) presented in the March 2000 Long Term Monitoring Report (URS 2000).

  - The US Army has communicated plume locations, concentrations, and drinking water hazards to the public through Public Meetings and Press Releases in Grand Island Paper.

- On-Post Plume

  - The US Army prohibits water supply (drinking and irrigation) well drilling in the on-post plume area.

4.3.2 Institutional Controls/Actions for New Proposed Remedy

The new Proposed Remedy includes the following institutional controls/ actions:

- Off-Post Plume

  - The US Army will assist the City in establishing a City “Overlay Zone” Ordinance for an institutional control area prohibiting drinking water supply well drilling in the plume area. The City will monitor and enforce the Ordinance by denying plumbing permits to hookup residences to private wells in the “Overlay Zone”.

  - The City of Grand Island will continue to provide water supply to all residences in the plume area.

  - The US Army will continue to communicate plume locations, concentrations, and drinking water hazards to the public through Press Releases in the Grand Island Independent newspaper. The paper will be notified when the annual monitoring report is issued at the conclusion of each annual sampling round.

- On-Post Plume

  - Land use restrictions will be placed on excessed property. The land use restrictions will include: 1) Restrictive covenants or easements prohibiting drinking water supply well drilling in the plume vicinity until groundwater is cleaned up to health advisory levels, and 2) Restrictive covenants or easements prohibiting the use of the property for residential purposes.

- The Hall County Reuse Plan will enforce excessed CHAAP land designation for agricultural and industrial zoning.

- For US Army property, water supply well drilling will continue to be prohibited in the plume area.

The US Army will monitor the effectiveness of the institutional controls. The US Army will include institutional control results in the Annual Long- Term Monitoring Reports for the CHAAP facility.

4.4 KEY APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS)

All ARARs potentially considered are listed in Section 3 of the Focused Feasibility Study (WJE 1994). The requirements determined to be Applicable or Relevant and Appropriate are listed in **Table 2** through **4**, which include chemical-specific, location-specific, and action-specific ARARs. In the absence of chemical-specific ARARs for explosives, USEPA health advisory levels (USEPA 2000) are used for determining the remedial action objectives.

4.5 REMEDIAL ACTION OBJECTIVES

As discussed above, the same Remedial Action Objectives (see Table 1 and Section 2.3) will be used under the new Proposed Remedy as the original Selected Remedy. The Remedial Action Objectives include the USEPA health advisory levels as clean- up goals for explosives in groundwater (USEPA 2000). The time required to achieve the objectives under the new Proposed Remedy is not anticipated to be any longer than under the original Selected Remedy (URS 2000).

4.6 EXPECTED OUTCOMES

Aside from the implementation of additional institutional controls (discussed above), there are no changes to the expected outcomes that will result from this ROD Amendment.

This section discusses the relative performance of the original Selected Remedy versus the new Proposed Remedy. Nine criteria are typically used to evaluate different scenarios and select a remedy. Table 5 provides a comparison of the original Selected Remedy and the new Proposed Remedy using these nine evaluation criteria. The comparison is summarized below.

5.1 OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

Both remedies will provide adequate protection of human health and the environment by eliminating, reducing, or controlling risk. Under the original Selected Remedy, explosives will be treated to Remedial Action Objectives, both on and off post, using extraction and treatment technologies.

Under the new Proposed Remedy, on-post explosives will be treated to Remedial Action Objectives using extraction and treatment technologies. However, the off-post explosives will be treated through natural attenuation mechanisms.

Both demonstrated trends of declining explosives concentrations and total mass, and predictive computer modeling indicate that monitored natural attenuation of the off-post explosives plume would successfully attain Remedial Action Objectives. The USEPA and NDEQ have determined that contingency measures are not warranted as part of the new Proposed Remedy.

The estimated time for monitored natural attenuation to attain Remedial Action Objectives off post is the same as the original Selected Remedy using extraction and treatment technologies.

5.2 COMPLIANCE WITH ARARS

Both groundwater remedial remedies would meet all ARARs with respect to Federal and State laws. ARARs are included in Tables 3 and 4.

5.3 LONG-TERM EFFECTIVENESS AND PERMANENCE

Both groundwater remedies would be effective in the long term by reducing contaminant concentrations in groundwater. The adequacy and reliability of the extraction and treatment technologies have been well proven for explosives. Monitored natural attenuation has some uncertainty associated with the time required to reach the final Remedial Action Objectives, but the predictive modeling results (URS 2001) estimated cleanup times to be similar to the current alternative.

5.4 REDUCTION OF TOXICITY, MOBILITY, OR VOLUME OF CONTAMINANTS THROUGH TREATMENT

The original Selected Remedy uses extraction and treatment with carbon adsorption to reduce toxicity, mobility, and volume of contaminants. Spent carbon units containing explosives residuals are being regenerated prior to thermal destruction and managed in accordance with the Resource Conservation and Recovery Act (RCRA).

The new Proposed Remedy uses natural processes to reduce toxicity, mobility, and volume of contaminants in off-post groundwater.

5.5 SHORT-TERM EFFECTIVENESS

Precautions were taken during construction of the extraction wells under the original Selected Remedy to eliminate all risks to the public associated with construction. Short-term risks to construction workers associated with normal construction hazards and potential contact with contaminated water were eliminated through appropriate controls and adherence to proper health and safety protocols.

The new Proposed Remedy has no new risks associated with implementation, would take little to no time to implement, and is anticipated to be effective in the short- term.

5.6 IMPLEMENTABILITY

Both groundwater remedies are technically implementable without construction difficulties.

The off-post portion of the original Selected Remedy had significant administrative difficulties and has not been implemented. Administrative concerns have included difficulties in gaining access agreements and easements for the 7.5 miles of off-post piping to be installed, and difficulties in gaining public consensus to discharge an additional 750 to 1,500 gallons per minute to Silver Creek. Any increase in discharge that will impact the downstream drainage of Silver Creek will require the US Army to relocate the effluent discharge.

The new Proposed Remedy has few associated administrative difficulties and requires little or no implementation time.

5.7 COST

The estimated capital cost of the new Proposed Remedy is slightly more than that of the original Selected Remedy for the on-post groundwater (due to the construction and operation of a seventh extraction well), but significantly less than that of the original Selected Remedy for the off-post groundwater. The estimated capital cost of the original Selected Remedy is $9.0 million for the on-post groundwater remedy, and $4.0 million for the off-post groundwater remedy. In contrast, the estimated capital cost of the new Proposed Remedy is $9.7 million for the on-post groundwater remedy (including the addition of a seventh extraction well), and $0 for the off- post groundwater remedy.

Both remedies were estimated to take a similar amount of time to achieve cleanup goals. Estimated cost for groundwater monitoring and operation and maintenance (O&M) of the treatment system for the original Selected Remedy is $1.2 million per year, versus $800 thousand per year for the new Proposed Remedy. These annual costs were used to estimate both a present value and a total incremental cost of each remedy. Costs are summarized in the table below.

SUMMARY OF ESTIMATED OU1 REMEDIAL COSTS

Costs	Original Selected Remedy	New Proposed Remedy
On-Post Capital Costs	$9 M	$9.7 M
Off-Post Capital Costs	$4 M	$0
Annual Operation and Maintenance Costs	$1.2 M	$0.8 M
Presents Value (20-years at 7%)	$26 M	$18 M
Total Incremental Costs (20-years)	$36 M	$26 M

5.8 STATE/SUPPORT AGENCY ACCEPTANCE

The USEPA and NDEQ support the new Proposed Remedy and believe the combination of on- post groundwater extraction and off-post monitored natural attenuation will lead to restoration of the aquifer to the proposed health advisory levels in an acceptable time frame. The USEPA and the NDEQ also believe the institutional controls will minimize the threat of human exposure to groundwater contamination before complete aquifer restoration is achieved. The USEPA and the NDEQ will monitor the effectiveness of the proposed remedies to ensure that they remain protective of human health and the environment.

5.9 COMMUNITY ACCEPTANCE

Community acceptance of the new Proposed Remedy will be evaluated after the public comment period ends and will be described in the forthcoming Final CHAAP OU1 ROD Amendment.

This section includes all support agency comments on the ROD Amendment and subsequent US Army responses and resolutions.

6.1 USEPA REGION VII COMMENTS AND US ARMY RESPONSES/RESOLUTIONS

Comments by Robert Koke, USEPA Region VII, dated April 23, 2001:

Comment 1. Page 2-3, Section 2.4.1, paragraph 3. End the first sentence at system. Add the following to the next sentence. The on-post extraction system is design[ed] to prevent the migration off post of the on-post...

Comment 2. Page 3-1, first paragraph. Make this change ... natural attenuation for remediation of the off-post...

Comment 3. Page 3-2, Section 3.1.2, bullet 5. Cleanup goals within a time frame that is approximately equal to the expected time frame for remediation to be completed using an off-post... Bullet 7 ... expected because contaminated groundwater migration from groundwater explosives... contained by the on-post...

Comment 4. Section 3.2. Rewrite the first sentence: A numerical groundwater contaminant fate and transport model was developed to evaluate the use of natural attenuation for remediation of the off-post explosives.

Comment 5. Section 3.2.1, first sentence. Explosive concentrations and plume area interpreted from the March...

Comment 6. Section 3.2.3, first paragraph, last sentence.... extraction rate with the additional well...

Comment 7. Page 4-3, second sentence. Insert a comma after over time. Second paragraph, second sentence. Change frequency to schedules.

Comment 8. Section 4.3.1, first dash. Move in 1986 and 1993 to after the word "extend".

Comment 9. Section 5.1, paragraph 3. Start: Both demonstrated trends... Comma after mass. Eliminate the words between modeling and indicate.

Comment 10. Section 5.3, last sentence.... associated with the amount of time required. Change estimated to estimate.

Comment 11. Section 5.5. Insert new between no risks in last paragraph.

Comment 12. Section 5.6, second paragraph, second sentence. Consensus to discharge of an additional...

Comment 13. Tables 2 and 3 and /Actions after institutional controls. Also providing water supply is not an institutional control. It is a remedial action.

> **US Army Response/Resolution:** Comments noted. Changes will be incorporated into the Final OU1 ROD Amendment.

6.2 NEBRASKA DEPARTMENT OF ENVIRONMENTAL QUALITY COMMENTS AND US ARMY RESPONSES/RESOLUTIONS

Comments by Edward W. Southwick, P. G., NDEQ Remediation Section, Waste Mgmt. Div., dated May 29, 2001:

Comment 1. ISSUE: Type of Record of Decision (ROD). The 1994 ROD was an Interim Action ROD. Since this ROD amends the 1994 ROD, is it still an interim action ROD that should instead be entitled "Interim Action OU1 ROD Amendment?" Or does this amendment, in addition to modifying the 1994 ROD, also finalize it and thereby remove the "Interim Action" label? Please clarify. Also, should not Section 1 also include an explanation?

> **US Army Response/Resolution:** EPA Region VII's position is that the term "Interim ROD" will no longer be used. EPA Region VII recommends that the document be titled "OU1 ROD Amendment".

Comment 2. REFERENCE: Section 2.2, 2nd Paragraph, Last Sentence. This sentence, stating that remedial action is usually required for chemicals exceeding 1x10 (superscript: -4) risk levels, fails to acknowledge that Nebraska ARARs requires cleanup to considerably stricter standards, MCLs or 1x10 (superscript: -6) cumulative excess cancer risk level. NDEQ recommends modifying the last sentence or adding a new one which informs the reader that remedial action to MCLs or 1x10 (superscript: -6) risk levels is required under Nebraska ARARs.

> **US Army Response/Resolution:** We will revise the last sentence in the second paragraph to read ..." Chemicals with completed pathways that exceed a risk of one in one million (1x10 -6) usually warrant remedial action under Nebraska ARARs.

Comment 3. ISSUE: Contaminants of Concern. This ROD proposes remediation of only three chemicals of concern (COCs) - TNT, HMX, and RDX - even though other potential COC's have been found in on- post and off-post groundwater. NDEQ wants to know if correspondence exists that address other COC's, particularly those with estimated exposure pathways exceeding 1x10 (superscript: -6) risk levels (i.e. on-post VOCs). With regard to other explosive compounds (see fourth bullet of Section 3.1.2), NDEQ recommends including a statement that these contaminants (to date) have not been detected above 1x10 (superscript: -6) risk levels and will continue to be monitored under the long-term monitoring program.

> **US Army Response/Resolution:** Currently, there are no on-post VOCS exceeding 1x10-6 or MCLs associated with the OU1 groundwater. There were on-post VOCs associated with OU3 that exceeded MCLs. These have been addressed under the OU3 ROD.

> **US Army Response/Resolution:** A sentence will be added under Section 3.1.2, fourth bullet, that will read..." The degradation products have not been detected at concentrations above 1x10-6 risk levels and will continue to be monitored under the long term monitoring program."

Under Section 121 of CERCLA and the NCP, the lead regulatory agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment to permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element. CERCLA also includes a bias against off-site disposal of untreated wastes. The following sections discuss how the new Proposed Remedy meets these statutory requirements.

7.1 PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

The new Proposed Remedy will protect human health and the environment through the treatment of on-post explosives contamination using extraction and treatment technologies. In addition, off-post contamination will be monitored as it attenuates naturally. Both the on-post and the off-post portions of the plume will be treated until the groundwater Remedial Action Objectives have been attained.

The new Proposed Remedy will reduce the cancer risks from exposure to less than 1x10-6 and the Hazard Index for adverse, noncarcinogenic health effects to less than 1.0. This level falls below USEPA's target risk range of 1x10-6 to 1x10-4 . There are no short- term threats associated with the new Proposed Remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the new Proposed Remedy.

7.2 COMPLIANCE WITH ARARS

The new Proposed Remedy including an on-post extraction and treatment system and monitored natural attenuation off-post complies with all ARARs. The ARARs are presented above in Tables 2 through 4.

7.3 OTHER CRITERIA, ADVISORIES, OR GUIDANCE TO BE CONSIDERED (TBCS) FOR THIS REMEDIAL ACTION

In implementing the new Proposed Remedy, the USEPA and the State have agreed to consider a number of non-binding criteria, also known as TBCs. The Monitored Natural Attenuation Demonstration (URS 2000) and subsequent recommendation of monitored natural attenuation of the off-post explosives plume was completed in accordance with TBC protocols presented in:

- United Stated Environmental Agency. 1997. "Use of Monitored Natural Attenuation at Superfund, RCRA, Corrective Action, and Underground Storage Tank Sites." OSWER Directive 9200.4-17. December 1.
- United States Army Corps of Engineers Waterways Experiment Station. 1999. "Draft Protocol for Evaluating, Selecting, and Implementing Monitored Natural Attenuation at Explosives-Contaminated Sites." Technical Report EL-99. March.

7.4 COST-EFFECTIVENESS

The USEPA believes the new Proposed Remedy is cost-effective and represents a reasonable value for the money to be spent. In making this determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness," (NCP §300.430(f)(1)(ii)(D)). This was accomplished by comparing the costs associated with the original Selected Remedy to the costs associated with the new Proposed Remedy since the "overall effectiveness" of both remedies satisfied the threshold criteria (i.e., both were protective of human health and the environment and ARAR-compliant). Overall effectiveness was determined by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness).

The estimated present worth cost of the new Proposed Remedy is $26 million (based on a 20-year evaluation at a 7-percent discount rate). Although this cost includes a $700,000 capital cost increase to the on-post portion of the remedy (due to the installation and operation of the seventh extraction well), the significant decrease in off-post capital costs ($0 for the new Proposed Remedy, versus $4.0 million for the original Selected Remedy) compensates for this additional initial cost. The total cost savings estimated from the new Proposed Remedy, based on total incremental costs over 20 years, is $11 million. USEPA believes that the new Proposed Remedy will provide an overall level of protection to human health and the environment comparable to the original Selected Remedy at a significantly lower cost.

7.5 UTILIZATION OF PERMANENT SOLUTIONS AND ALTERNATIVE TREATMENT TECHNOLOGIES (OR RESOURCE RECOVERY TECHNOLOGIES) TO THE MAXIMUM EXTENT PRACTICABLE

The USEPA has determined the new Proposed Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site.

The new Proposed Remedy treats the source materials constituting principal threats at the site to achieve significant reductions in explosives concentrations. The new Proposed Remedy also satisfies the criteria for long-term effectiveness by permanently eliminating the explosives contamination through natural means. The new Proposed Remedy does not present short-term risks different from the other treatment alternatives. There are no special implementability issues associated with the new Proposed Remedy.

7.6 PREFERENCE FOR TREATMENT AS A PRINCIPAL ELEMENT

By treating site contamination using extraction and treatment technologies combined with monitored natural attenuation, the new Proposed Remedy addresses principal threats posed by the site through the use of treatment technologies. This satisfies the statutory preference for remedies that employ treatment as a principal element.

7.7 FIVE-YEAR REVIEW REQUIREMENTS

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site until Remedial Action Objectives have been attained, a statutory review will be conducted within five years after initiation of new Proposed Remedy to ensure that the remedy will remain protective of human health and the environment.

The US Army, USEPA, and NDEQ have solicited input from the community on the ROD Amendment for cleanup of the CHAAP site. At this time, there have been no oral or written comments from the public on the Revised Proposed Plan for OU1 ROD Amendment.

Community participation has complied with the following in accordance with the NCP Section 300.515e. The US Army and regulatory agencies:

- Have issued a notice of availability and brief description of the proposed amendment to the ROD in a major local newspaper of general circulation;
- Have made the revised proposed plan for the amendment to the ROD and information supporting the decision available for public comment;
- Have provided a reasonable opportunity, not less than 30 calendar days, for submission of written or oral comments on the revised proposed plan for the amendment to the ROD. Upon timely request, the lead agency will extend the public comment period by a minimum of 30 additional days;
- Have provided the opportunity for a public meeting to be held during the public comment period at or near the facility at issue;
- Have kept a transcript of comments received at the public meeting held during the public comment period;
- Will include in the amended ROD a brief explanation of the amendment and the response to each of the significant comments, criticisms, and new relevant information submitted during the public comment period;
- Will publish a notice of the availability of the amended ROD in a major local newspaper of general circulation; and
- Will make the amended ROD and supporting information available to the public in the administrative record and information repository prior to the commencement of the remedial action affected by the amendment.

The Administrative Record File, including all referenced documents, for the site is available at:

Grand Island Public Library
211 North Washington Street
Grand Island, Nebraska 68802
(308) 385-5333
Hours of operation:
M–Th 9 a.m.–9 p.m.
Fr–Sat 9 a.m.–6 p.m.
Sun 1 p.m.–5 p.m.

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United States Army Environmental Center (USAEC). 1996. Explanation of Significant Differences. Operable Unit One - Groundwater. Cornhusker Army Ammunition Plant.

United States Environmental Protection Agency (USEPA). 1997. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. OSWER Directive 9200.4-17. December 1.

United States Environmental Protection Agency (USEPA). 2000. Drinking Water Regulations and Health Advisories. EPA-822-B-00-001. Summer. http://www.epa.gov/ost/drinking/standards/summary.html.

URS Corporation (URS). 2000a. Technical Plan Addendum for March 2000 Sampling Event for the Long-Term Monitoring Program. Cornhusker Army Ammunition Plant. Prepared for USACE. February.

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URS Greiner Woodward Clyde Federal Services (URSGWCFS). 1999. March 1999 Annual Sampling Event for the Long- Term Monitoring Program. Cornhusker Army Ammunition Plant. Prepared for USACE. October.

Watkins-Johnson Environmental, Inc (WJE). 1994. Focused Feasibility Study for Groundwater - Operable Unit One. Cornhusker Army Ammunition Plant. Prepared for U. S. Army Environmental Center. March.

Woodward-Clyde (W-C). 1997. 1996 Annual Long-Term Monitoring. Final Report. Cornhusker Army Ammunition Plant. Prepared for USAEC. July.

Woodward-Clyde (W-C), 1998a. October 1997 Annual Sampling Event for the Long-Term Monitoring Program. Final Report. Cornhusker Army Ammunition Plant. Prepared for USACE. March

Woodward-Clyde (W-C). 1998b. Draft Technical Plan for Long-Term Monitoring Program. Cornhusker Army Ammunition Plant. Prepared for USACE. April.

Woodward-Clyde (W-C). 1998c. Technical Plan Addendum for June 1998 Groundwater Sampling Event for Long- Term Monitoring Program. Cornhusker Army Ammunition Plant. Prepared for USACE. June 5, 1998.

Woodward-Clyde (W-C). 1999. June 1998 Annual Sampling Event for the Long-Term Monitoring Program. Final Report. Cornhusker Army Ammunition Plant. Prepared for USACE. February.

TABLE 1

REMEDIAL ACTION OBJECTIVES
CORNHUSKER ARMY AMMUNITION PLANT
GRAND ISLAND, NEBRASKA

Explosives Compound	Remedial Action Objective (parts per Billion)
TNT	2
HMX	400
RDX	2

TABLE 2

SUMMARY OF REMEDIES
CORNHUSKER ARMY AMMUNITION PLANT
GRAND ISLAND, NEBRASKA

	Original Selected Remedy	New Proposed Remedy
On-Post Groundwater	***Groundwater Extraction:*** EW-1 at 50 gpm EW-2 at 100 gpm EW-3 at 50 gpm EW-4 at 50 gpm EW-5 at 200 gpm EW-6 at 250 gpm Total at 700 gpm ***Groundwater Treatment:*** – Granular Media Filtration (suspended solids pre-treatment) – Granular Activated Carbon (explosives treatment) – Wetland System (nitrates treatment) ***Effluent Disposal:*** – Discharge to Silver Creek ***Groundwater Monitoring*** ***Institutional Controls:*** – Prohibit water supply well drilling in the impacted area	***Groundwater Extraction:*** EW-1 at 0 gpm EW-2 at 0 gpm EW-3 at 0 gpm EW-4 at 50 gpm EW-5 at 200 gpm EW-6 at 250 gpm EW-7 at 250 gpm Total at 750 gpm ***Groundwater Treatment:*** – Granular Media Filtration (suspended solids pre-treatment) – Granular Activated Carbon (explosives treatment) – Wetland System (nitrates treatment) ***Effluent Disposal:*** – Discharge to Silver Creek ***Groundwater Monitoring*** ***Institutional Controls:*** – Prohibit water supply well drilling in the impacted area – Deed restrict excessed property to prohibit water supply well drilling in the impacted areas and prohibit residential land use – Enforce the Hall County Reuse Plan that designates excessed CHAAP property as agricultural and industrial use only

TABLE 2

SUMMARY OF REMEDIES
CORNHUSKER ARMY AMMUNITION PLANT
GRAND ISLAND, NEBRASKA

	Original Selected Remedy	New Proposed Remedy
Off-Post Groundwater	***Groundwater Extraction:*** Distal-1 at 150 gpm Distal-2 at 700 gpm Distal-3 at 300 gpm Total at 1150 gpm	
	Groundwater Treatment: – Granular Media Filtration (suspended solids pre-treatment) – Granular Activated Carbon (explosives treatment) – Wetland System (nitrates treatment)	Monitored Natural Attenuation
	Effluent Disposal: – Discharge to Silver Creek	
	Groundwater Monitoring	***Groundwater Monitoring***
	Institutional Controls: – Provide municipal water supply to all impacted residences – Public information and education program through Public Meetings and Press Releases	***Institutional Controls:*** – Provide municipal water supply to all impacted residences – Public information and education program through Public Meetings and Press Releases – Establish a City "Overly Zone" Ordinance prohibiting drinking water supply well drilling in the impacted areas

Notes:
Groundwater monitoring for both remedies includes sampling on- and off-post monitoring wells for explosives concentrations and off-post wells for natural attenuation parameters. Annual sampling events and reporting are planned.

TABLE 3

CHEMICAL-SPECIFIC ARARs/TBCs
CORNHUSKER ARMY AMMUNITION PLANT – GRAND ISLAND, NEBRASKA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comment
Federal			
Health Advisory Levels (HALs)	Drinking Water Regulations and Health Advisories	Estimates of acceptable drinking levels for a chemical substance based on health effects information.	HALs are not included in a promulgated regulation. HALs are TBCs used as guidance to establish Remedial Action Objectives for chemicals without established MCLs.
Safe Drinking Water Act	42 USCA Sect. 300		
National Primary Drinking Water Regulations and National Revised Primary Drinking Water Regulations	40 CFR Part 141	Establishes maximum contaminant levels (MCLs), health-based standards for specific contaminants. MCLs are applicable for drinking water as supplied to the end users of public water supplies.	MCLs are relevant and appropriate for contamination of groundwater that is or may be used as drinking water. MCLs that have been published as final but are not yet in effect are TBCs. MCLs are relevant for deriving NPDES dishcarge levels.
National Primary Drinking Water Implementation Regulations	40 CFR Part 142	Establishes procedures for granting variances from MCL requirements. Specifies best technologies for treatment of various pollutants.	Requirements relevant and appropriate for determining cleanup goals for certain contaminants, if the MCL is not used or is available.
National Secondary Drinking Water Standards	40 CFR Part 143	Establishes secondary MCLs which are guidelines for public drinking water systems to protect the aesthetic quality of the water. Secondary MCLs are not Federally enforceable.	TBC if any of these constituents are addressed by a remedial action alternative, or if any treated and discharged groundwater is to be used as a source of drinking water. Relevant for deriving NPDES discharge levels.
Maximum Contaminant Level Goals (MCLGs)	40 CFR Parts 141, 142	Establishes non-enforceable health goals for drinking water quality at a level at which no adverse health effects may arise with an adequate margin of safety.	TBC for determination of groundwater cleanup levels and NPDES discharge levels. The MCL is the controlling ARAR.

TABLE 3

CHEMICAL-SPECIFIC ARARs/TBCs
CORNHUSKER ARMY AMMUNITION PLANT – GRAND ISLAND, NEBRASKA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comment
Water Pollution Control Act, as amended	33 USCA Sect. 1251 et seq.		
Ambient Water Quality Criteria	40 CFR Part 131 Quality Criteria for Water	Requires states to establish ambient water quality criteria for surface water based on use classifications and the criteria stated under Section 304(a) of the Clean Water Act.	Ambient water quality criteria are relevant and appropriate because treated groundwater is discharged to surface water. State ambient water quality criteria are the applicable ARAR.
Guidelines Establishing Test Procedures for the Analysis of Pollutants	40 CFR Sect. 136.1-5 and Appendices A-C	Specific analytical procedures for NPDES applications and reports.	Applicable because treated groundwater is discharged to a surface water.
Pretreatment Standards	40 CFR 403	Applies to discharges of pollutants to publicly-owned treatment works (POTWs). Requires that such pollutants not interfere with operation of the POTW, or pass through the POTW at concentrations which cause a violation of the POTW NPDES permit.	Applicable only if investigation-derived wastewater, treated groundwater, or other wastewater is discharged to a municipal wastewater treatment system. Categorical standards may be relevant and appropriate.
Solid Waste Disposal Act (SWDA), as amended	42 USCA Sect. 6901-6992K		
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines characteristics of hazardous wastes and provides lists of hazardous wastes. Identifies solid wastes which are subject to regulation as hazardous wastes under 40 CFR Parts 124, 262-265, 268, 270, and 271.	Applicable to wastes generated by remedial activities, including investigation-derived wastes, excavated soil, or solid wastes generated by treatment of soil, groundwater, or hazardous wastes.
Releases from Solid Waste Management Units	40 CFR Part 264.94	Subpart F (264.94) gives concentration limits in groundwater for hazardous constituents from a regulated unit.	Applicable if listed hazardous constituents are found in groundwater.

TABLE 3

CHEMICAL-SPECIFIC ARARs/TBCs
CORNHUSKER ARMY AMMUNITION PLANT – GRAND ISLAND, NEBRASKA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comment
<u>State</u>			
Nebraska Environmental Protection Act	Neb. Rev. Stat., Chapter 81	State's policy on environmental control.	
Nebraska Surface Water Quality Standards	Neb. Adm. Rules & Regs., Title 117	Establishes water quality standards and criteria for the surface waters of the state.	Applicable because treated groundwater is discharged to surface waters.
Ground Water Quality Standards and Use Classification	Neb. Adm. Rules & Regs., Title 118	Establishes groundwater quality standards and use classifications for groundwater sources. Used to determine priorities for groundwater remedial actions.	State MCLs are ARARs for contaminated groundwater if the state MCL is more stringent than federal requirements. The antidegradation clause (Chapter 3) provides that if the existing quality of any groundwater is better than the MCLs, that quality will be maintained and protected.
Rules and Regulations Pertaining to the Issuance of Permits under the NPDES, Effluent Guidelines and Standards	Neb. Adm. Rules & Regs., Titles 119 and 121	Establishes effluent limitations and procedures for determining effluent limitations.	Applicable if state standards are more stringent than federal requirements.
Regulations Governing Public Water Supply Systems	Neb. Adm. Rules & Regs., Title 179	Establishes MCLs for public water supply systems.	Relevant and appropriate for contaminated groundwater if the state MCL is more stringent than federal requirements.
	Neb. Adm. Rules & Regs., Title 129, Chapter 32	Prohibits visible emissions of fugitive particulate matter beyond the premises where it originates.	Applicable if remedial activities, such as soil excavation or grading, generate fugitive dust.

[1] Nebraska's Air Quality Regulations were last amended May 29, 1995.

TABLE 4

LOCATION-SPECIFIC ARARs
CORNHUSKER ARMY AMMUNITION PLANT – GRAND ISLAND, NEBRASKA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments
Federal			
Floodplain Management	Executive Order 11988 40 CFR Part 6, Appendix A and 40 CFR Part 6.302	Limits activities in a floodplain, which is defined as "the lowland and relatively flat areas adjoining inland and coastal waters including at a minimum that area subject to a 1 percent or greater chance of flooding in any given year" (the 100-year floodplain)	Applicable if remedial actions occur in the 100-year floodplain.
100-Year Floodplain Management	40 CFR 264.18(b)	RCRA treatment, storage, or disposal facility must be designed, constructed, operated, and maintained to avoid washout within 100-year floodplain.	Applicable if remedial actions occur in the 100-year floodplain.
Protection of Wetlands	Executive Order 11990 40 CFR Part 6, Appendix A	Addresses possible impacts of construction of facilties or management of property in wetlands; must avoid adverse effects, minimize potential harm, and preserve and enhance wetlands, to the extent possible.	Applicable if wetlands occur at proposed remedial action locations.
Water Pollution Control Act, as amended	33 USCA Sect. 1251 et seq. (CWA Section 404) 40 CFR Part 230 33 CFR Parts 320-330	Prohibits discharge of dredged or fill material into wetlands (as defined in U.S. Army Corps of Engineers regulations) without permit.	Applicable if dredged or fill material will be placed into a wetland during remedial actions.
Solid Waste Disposal Act (SWDA), as amended	42 USCA Sect. 6901-6992K		
Floodplains	40 CFR Part 264.18(b)	RCRA treatment, storage, or disposal facility must be designed, constructed, operated, and maintained to avoid washout within 100-year floodplain.	Applicable if remedial actions occur in the 100-year floodplain.

TABLE 4

LOCATION-SPECIFIC ARARs
CORNHUSKER ARMY AMMUNITION PLANT – GRAND ISLAND, NEBRASKA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments
Farmland Protection Policy Act	7 USC 420 et seq.	Establishes requirement for federal agencies for acquiring, managing and disposing of lands and facilities; or provide criteria that identify and take into account the adverse effects of actions on the preservation of farmland.	Relevant and appropriate if treatment facility location and project related activities affect farmland.
Fish and Wildlife Coordination Act	16 USCA Sect. 661 et seq. 33 CFR Parts 320-330 40 CFR Part 6.302	Establishes requirements for action taken to prevent, mitigate, or compensate for project-related damages or losses to fish and wildlife resources.	Applicable to effluent structures in or near a stream or river.
Archaeological and Historic Preservation Act of 1974	16 USCA Sect. 469; 36 CFR Part 65	Must recover and preserve artifacts in area where alteration of terrain threatens significant scientific, prehistorical, or archaeological data.	Applicable if artifacts are found during remedial activities.
National Historic Preservation Act of 1966, as amended	16 USCA Sect. 470 et seq. 36 CFR Part 800 40 CFR Sect. 6.301	Must preserve property in or eligible for National Register of Historic Places; actions should minimize harm to National Historic Landmarks.	Applicable if eligible property are potentially impacted during remedial activities.
Native American Graves Protection and Repatriation Act	PL 101-601	Requires that if Native American remains or cultural items are found on federal lands, the appropriate tribe must be notified, and all activity in the area of discovery must cease for at least 30 days.	Applicable if Native American remains or cultural items are found during remedial activities.
Antiquities Act of 1906	16 USCA 431-433 43 CFR Part 3	Provides for protection of historic and prehistoric ruins and objects on Federal lands.	Applicable if historical ruins or objects are found during remedial activities.
<u>State</u>			
Nebraska Human Burial Sites Act	Neb. Rev. Stat., Article 12, Sections 12-1201 to 1212.	Provides protection for unmarked human burial sites on private and public lands.	Applicable if human burial sites are discovered during remedial activities.

TABLE 4

LOCATION-SPECIFIC ARARs
CORNHUSKER ARMY AMMUNITION PLANT – GRAND ISLAND, NEBRASKA

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comments
Floodplains	Neb. Rev. Stat., Chapter 31, Article 10, Neb. Adm. Rules & Regs., Title 455, Chapters 1 through 7.	Regulates, and requires permits for, certain activities proposed to take place in a floodplain.	Applicable if remedial activities occur in the 100-year floodplain.

TABLE 5

ACTION-SPECIFIC ARARs/TBCs
CORNHUSKER ARMY AMMUNITION PLANT

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comment
Safe Drinking Water Act	42 USCA Sect. 300(f) et seq.		
Standards for Owners and Operators of Public Water Supply System	40 CFR Part 141	Establishes primary drinking water regulations, including treatment (water quality) requirements for public water supply systems.	Remedial action will not involve designing a public water supply treatment system; however, primary levels (MCLs) may be applicable to treatment of groundwater.
Clean Water Act	33 USCA Sect. 1251-1376		
National Pollutant Discharge Elimination System	40 CFR Parts 122, 125	Requires permits for the discharge of pollutants from any point source into waters of the United States.	Substantive requirements applicable for remedial actions that involve point source discharges to surface waters. May be applicable to treatment system discharges.
	40 CFR Sect. 122.26(b)(14)(x)	Requires that storm water runoff be monitored and controlled on construction sites greater than five acres.	Applicable if the remediation site is greater than five acres, relevant and appropriate for smaller sites.
Wetland Protection	CWA 404 40 CFR 230.3 (1) 33 CFR 328 (b)	Established requirements to avoid degradation of wetland due to construction activities	Applicable to construction activities near wetlands which may be present along pipeline or well locations.
Hazardous Materials Transportation Act	40 USCA Sect. 1801-1813		
Hazardous Materials Transportation Regulations	49 CFR Parts 107, 171-177	Regulates transportation of hazardous materials.	Applicable for remedial actions that involve off-site transportation of hazardous materials. (e.g., spent carbon or sludge disposal)

TABLE 5

ACTION-SPECIFIC ARARs/TBCs
CORNHUSKER ARMY AMMUNITION PLANT

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comment
Occupational Safety and Health Act of 1970	PL 91-596 29 USCA Sect. 651-678		
Occupational Safety and Health Standards	29 CFR Part 1910	Establishes safety and health requirements for personnel working with hazardous materials and hazardous waste.	Applicable to on-site remedial activities and long term operation and maintenance of treatment system.
Safety and Health Regulations for Construction	20 CFR Part 1926	Establishes protection standards (e.g., hazard communication, excavation and trenching requirements) for workers involved in hazardous waste operations.	Applicable to on-site remedial activities.
<u>**State**</u>			
Nebraska Environmental Protection Act	Neb. Rev. Stat., Chapter 81 Article 15		
Nebraska Surface Water Quality Standards	Neb. Adm. Rules & Regs., Title 117	Establishes water quality standards and criteria for the surface waters of the state.	Applicable because contaminated water is treated and discharged into surface waters.
Ground Water Quality Standards and Use Classification	Neb. Adm. Rules & Regs., Title 118	Provides groundwater remedial actions protocol for point source groundwater pollution; defines Remedial Action Classes (RACs) with basic requirements for remedial action.	Relevant and appropriate for remedial actions addressing groundwater pollution at this site.
Rules and Regulations Pertaining to the Issuance of Permits under the NPDES	Nebr. Adm. Rules & Regs., Title 119	Requires permit for discharging pollutants from a point source into the waters of the State.	Substantive requirements are applicable to point source discharges to surface water.
Effluent Guidelines and Standards	Neb. Adm. Rules & Regs., Title 121	Establishes point source effluent standards and secondary treatment standards for industries.	Applicable to point source discharges to surface water.

TABLE 5

ACTION-SPECIFIC ARARs/TBCs
CORNHUSKER ARMY AMMUNITION PLANT

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comment
Design, Operation, and Maintenance of Wastewater Treatment Facilities	Neb. Adm. Rules & Regs., Title 123	Establishes procedures for the design, operation, and maintenance of wastewater treatment works, including the submittal of plans, receipt of construction permits, and construction and testing requirements.	Applicable for on-site treatment of extracted groundwater.
Rules and Regulations Pertaining to the Management of Wastes	Neb. Adm. Rules & Regs., Title 126	Requires permits for licenses for various waste management activities and establishes policy for releases of oil or hazardous substances and remediation of such releases.	Substantive requirements for spills/releases and remediation of spills/releases are given in Title 118 and Title 128.
Rules and Regulations Governing Hazardous Waste Management in Nebraska	Neb. Adm. Rules & Regs., Title 128	Establishes procedures for notification of hazardous waste activity, identification and listing of hazardous wastes, generators, and operators of treatment, storage, and disposal facilities.	Substantive requirements that are the same or more stringent than 40 CFR 261, 262, 263, 264, 268, 270 are applicable.
Air Pollution Control Rules and Regulations[1]	Neb. Adm. Rules & Regs., Title 129, Chapter 2	Defines "major source" of hazardous air pollutants and major stationary sources of other pollutants, including fugitive dust and other particulate emissions.	Applicable to remedial activities generating fugitive dust, and potentially applicable to remedial alternatives involving volatilization or incineration.
	Neb. Adm. Rules & Regs., Title 129, Chapter 20	Prohibits visible dust beyond the limits of the property line where handling, transportation, or construction is taking place.	Applicable to remedial activities generating fugitive dust.
	Neb. Adm. Rules & Regs., Title 129, Chapter 39	Limits visible emissions from diesel-powered vehicles on public streets or highways.	Applicable only when diesel-powered vehicles used during remedial activities are on public streets or highways.

TABLE 5

ACTION-SPECIFIC ARARs/TBCs
CORNHUSKER ARMY AMMUNITION PLANT

Standard, Requirement, Criteria, or Limitation	Citation	Description	Comment
Regulations Governing Licensure of Water Well and Pump Installation Contractors and Certification of Water Well Drilling, Pump Installation, and Water Well Monitoring Supervisors	Neb. Adm. Rules & Regs., Title 178, Chapter 10	Contains rules governing the qualifications of contractors installing water wells.	Applicable for installation of monitoring wells, extraction of recovery wells, and the installation of pumps.
Regulations Governing Water Well Construction, Pump Installation, and Water Well Abandonment Standards	Neb. Adm. Rules & Regs., Title 178, Chapter 12	Contains rules governing water well construction and abandonment and pump installation.	Applicable for installation of monitoring wells, extraction or recovery wells, and the installation of pumps.

[1] Nebraska's air quality regs were last amended May 29, 1995.

TABLE 6

DETAILED ANALYSIS OF REMEDIES
CORNHUSKER ARMY AMMUNITION PLANT
GRAND ISLAND, NEBRASKA

Evaluation Criterion	Original Selected Remedy	New Proposed Remedy
Overall Protection of Human Health and the Environment		
Human Health Protection	Protection of human health in the short-term through installation of a public water supply system. Possible human health risk not mitigated through institutional actions includes installation of new water supply wells, or continued use of impacted supply wells.	Protection of human health in the short-term through installation of a public water supply system. Increased protection of human health through additional institutional controls (e.g., City Ordinance).
Environmental Protection	Protects groundwater downgradient of source areas from further contamination. Also protects further aquifer degradation at the distal end of the plume.	Protects groundwater downgradient of source areas and CHAAP property boundary from further contamination. No engineered control of distal plume migration, but MNA would degradation track and provide early exposure and migration warnings.
Compliance with ARARs		
Compliance with ARARs	Meets ARARs.	Meets ARARs.
Appropriateness of Waivers	None required.	None required.
Long-Term Effectiveness and Permanence		
Magnitude of Residual Risk	Residual risks include potential continued use of the impacted aquifer for water supply.	Residual risks mitigated through increased institutional actions.
Adequacy and Reliability of Controls	Groundwater extraction and treatment are proven technologies. Institutional controls do not eliminate residual risk to human exposure.	Groundwater extraction and treatment are proven technologies. Institutional actions are expected to be reliable at eliminating residual risks to human exposure. MNA demonstrated to be adequate and reliable.
Need for 5-Year Review	Review would be required to ensure adequate protection of human health and the environment is maintained.	Review would be required to ensure adequate protection of human health and the environment is maintained.
Reduction of Toxicity, Mobility, and Volume		
Treatment Processes Used	Groundwater extraction and treatment using conventional groundwater extraction wells, pre-treatment using granular media filtration, and treatment in granular activated carbon vessels.	Groundwater extraction and treatment using conventional groundwater extraction wells, pre-treatment using granular media filtration, and treatment in granular activated carbon vessels. MNA uses natural process of biodegradation, abiotic oxidation, hydrolysis, sorption, and dispersion.
Amount destroyed or treated	Ultimately the entire dissolved-phase groundwater plume would be treated.	Ultimately the entire dissolved-phase groundwater plume would be treated.
Reduction of TMV	Toxicity reduced by transfer to GAC. Mobility enhanced upgradient of groundwater extraction wells, but eliminated downgradient of the distal wells. Volume of contaminated groundwater reduced by extraction.	Toxicity on-post reduced by transfer to GAC. Toxicity off-post reduced by natural attenuation mechanisms. Mobility enhanced upgradient of groundwater extraction wells, but eliminated downgradient of the facility boundary. Volume of contaminated groundwater reduced by extraction on-post and MNA off-post.
Irreversible treatment	Adsorption to GAC reversible.	Adsorption to GAC reversible. Biodegradation is irreversible.
Type and quantity of residuals remaining after treatment	Residuals remaining from treatment process include spent GAC and sludge.	Residuals remaining from treatment process include spent GAC and sludge.

TABLE 6

DETAILED ANALYSIS OF REMEDIES
CORNHUSKER ARMY AMMUNITION PLANT
GRAND ISLAND, NEBRASKA

Evaluation Criterion	Original Selected Remedy	New Proposed Remedy
Short-Term Effectiveness		
Time Required to Achieve Remedial Action Objectives[1]	Estimated between 40 and 50 years on-post and between 10 to 20 years off-post.	Estimated between 40 and 50 years on-post and between 10 to 20 years off-post.
Protection of Community During Remedial Action	On-post work should not effect community. Off-post work can be done safely with adequate traffic signage and construction control.	On-post work should not effect community. Off-post work can be done safely with adequate traffic signage and construction control.
Protection of Workers During Remedial Action	Workers can be protected through proper health and safety training and PPE.	Workers can be protected through proper health and safety training and PPE.
Environmental Impacts During Remedial Action	Potential need for considerable dewatering during construction of conveyance piping from extraction wells to the treatment facility. This water would require temporary storage, treatment, and disposal. Dewatering concerns are heightened off-post due to public health and safety concerns.	Potential need for considerable dewatering during construction of conveyance piping from extraction wells to the treatment facility. This water would require temporary storage, treatment, and disposal.
Implementability		
Ability to Construct and Operate	On-post portion constructed and operable. Off-post distal wells and conveyance piping were tabled due to extreme administrative implementability problems. Real estate transfers, permanent easements, and use of public right-of-ways caused off-post construction to be delayed. Long-term monitoring requires continued support and permission from private land owners.	On-post portion constructed and operable. No off-post constuction required. Long-term monitoring requires continued support and permission from private land owners.
Ease of doing more remedial action, if needed	Simple to expand or augment on-post systems. Off-post expansion limited by real estate constraints.	Simple to expand or augment on-post systems. Off-post expansion limited by real estate constraints.
Ability to monitor effectiveness	LTM will prove effectiveness of source area control/removal and containment/removal of the off-post plume.	LTM will prove effectiveness of source area control/removal and degradation via natural attenuation off-post.
Ability to obtain approvals and coordination with other agencies	Difficult to gain approval from local agencies and property owners. Difficulty related to real estate access.	Approval and coordination with other agencies not expected to be a concern.
Availability of services and equipment	Commercially available.	Commercially available.
Technical Feasibility	Technologies are available and equipment is easily obtained.	Technologies are available and equipment is easily obtained.

TABLE 6

DETAILED ANALYSIS OF REMEDIES
CORNHUSKER ARMY AMMUNITION PLANT
GRAND ISLAND, NEBRASKA

Evaluation Criterion	Original Selected Remedy	New Proposed Remedy
State/Support Agency Acceptance	Selected Remedy previously approved by the USEPA and NDEQ in the ROD (USAEC 1994)	The USEPA and NDEQ support the new Proposed Remedy.
Community Acceptance	The community formally expressed concerns about the Original Selected Remedy which was subsequently selectively implemented. Public comments included concerns about: effluent discharge to infiltration basins and Silver Creek creating flooding or a rise in the regional groundwater table, distal well pumping increasing levels of contamination within Grand Island City Limits due to increased groundwater flow velocities, and real estate concerns regarding the construction of the distal well system conveyance piping.	Community acceptance of the New Proposed Remedy will be evaluation and incorporated into the final ROD amendment.
Estimated Relative Costs		
Capital Costs	$13,000,000	$9,700,000
Annual OM&M	$1,200,000	$800,000
Present Worth	$37,000,000	$26,000,000

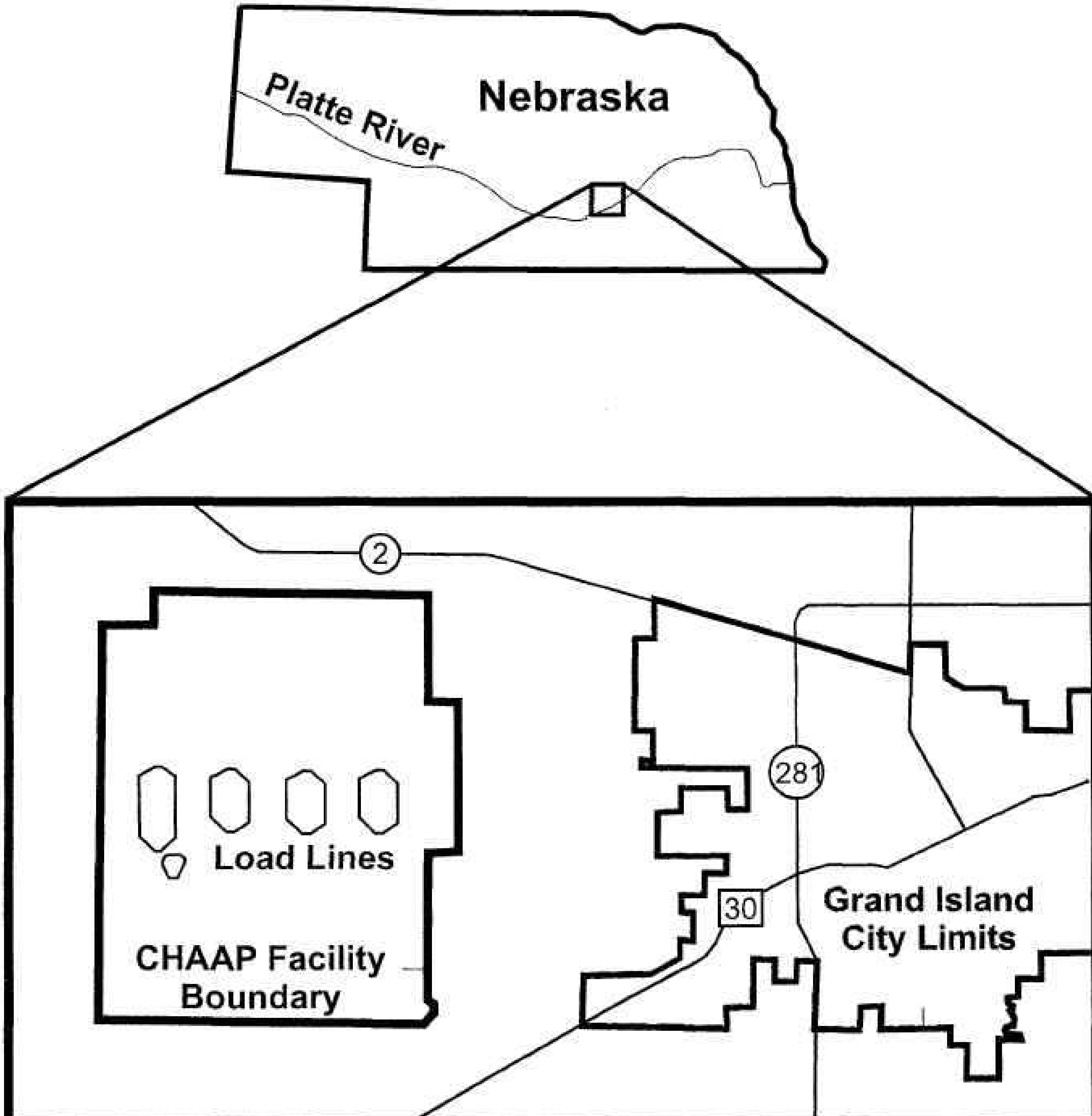
Notes:

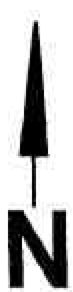
MNA - Monitored Natural Attenuation.

LTM - Long-term Monitoring

[1] - Estimated remedial time periods from Groundwater Flow and Contaminant Fate and Transport Modeling Report (URS 2000)

[2] - Present worth calculated at seven percent discout rate for twenty years of operation and maintenance.

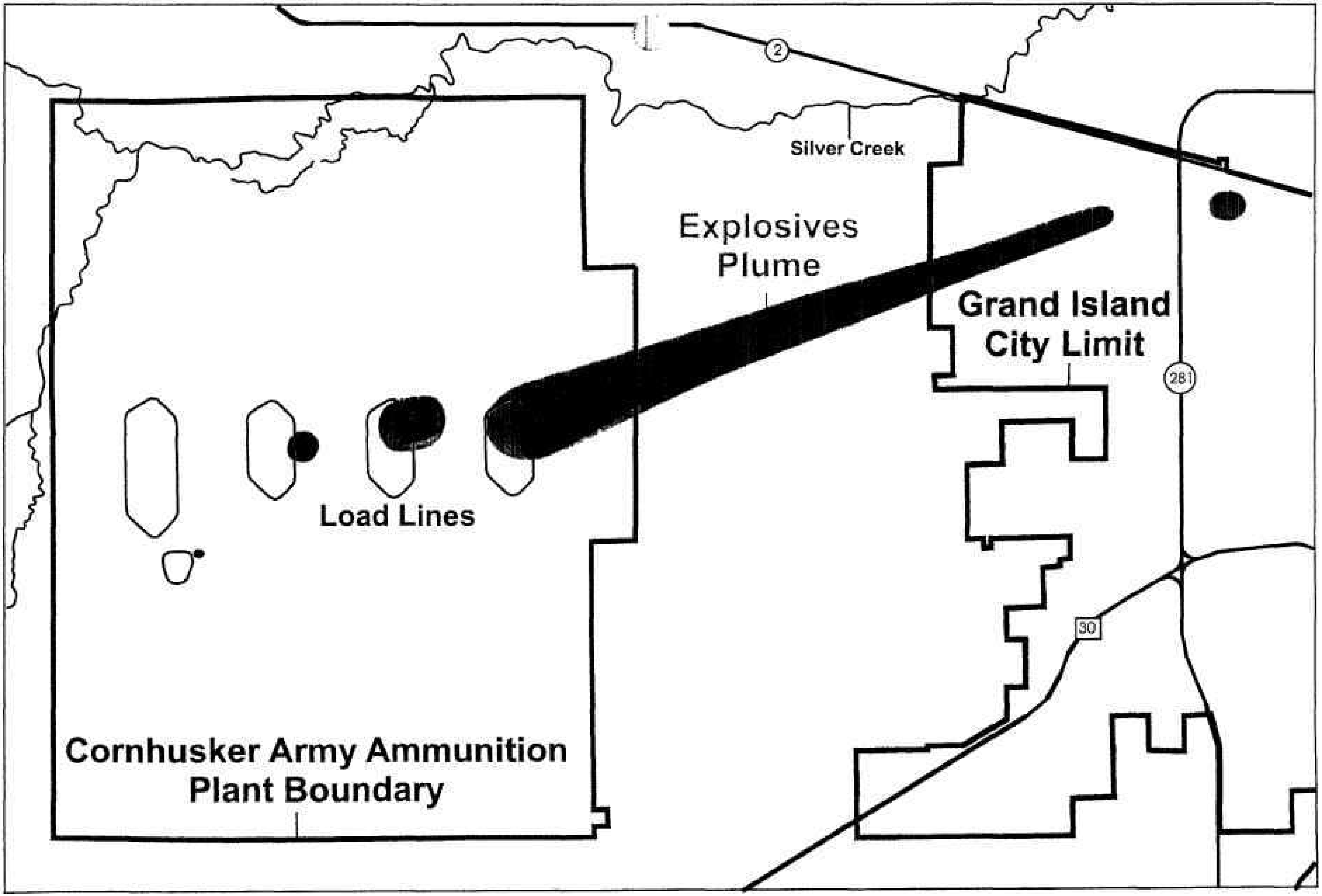




URS

Facility Location Map

DRN BY: JBH	DATE: 01/26/01	PROJECT NUMBER	FIG. NO.
CHK'D BY:	REVISION: 0	49-F0000009.00	1



LEGEND:

Interpreted horizontal extent of total explosives > 2 μg/L

Interpreted horizontal extent of total explosives > 200 μg/L

6,000 0 6,000

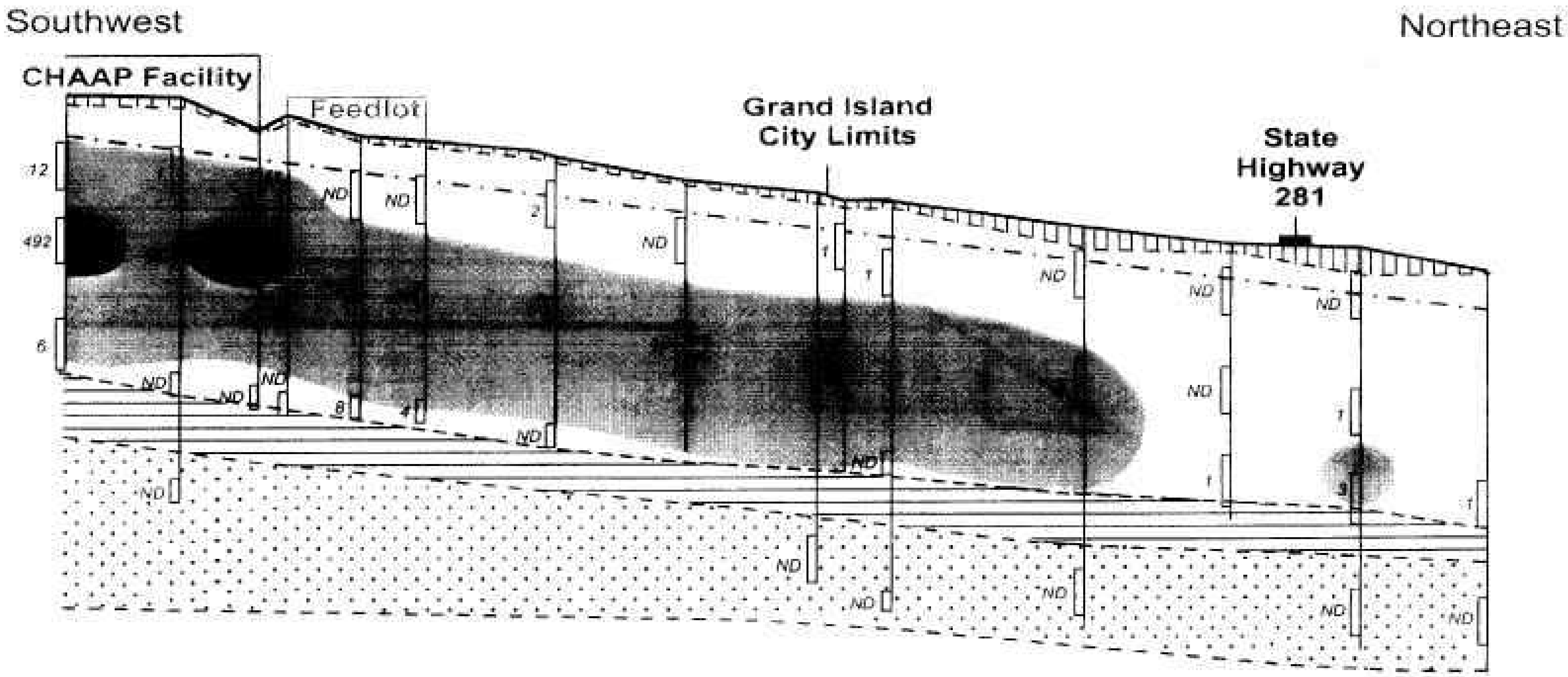
Scale: 1":6,000'

N

URS

Explosives Plume, CHAAP, and Vicinity

DRN BY: JBH	DATE: 01/26/01	PROJECT NUMBER 49-F0000009.00	FIG. NO. 2
CHK'D BY:	REVISION: 0		



LEGEND:

17 — Monitoring Well Location with March 2000 Total Explosives Concentrations in µg/L (ND = Non-detect)

Water Table - March 2000

Interpreted Vertical and Horizontal Extent of Total Explosives > 2 µg/L

Interpreted Vertical and Horizontal Extent of Total Explosives > 200 µg/L

Topsoil - Clay and Silt

Grand Island Formation (Alluvial Sand Aquifer)

Fullerton Formation (Blue Clay Aquitard)

Holdredge Formation (Gravel Aquifer)

4,000 0 4,000

Horizontal Scale: 1":4,000'

40 0 40

Vertical Scale: 1":40'

Vertical Exaggeration is 100:1

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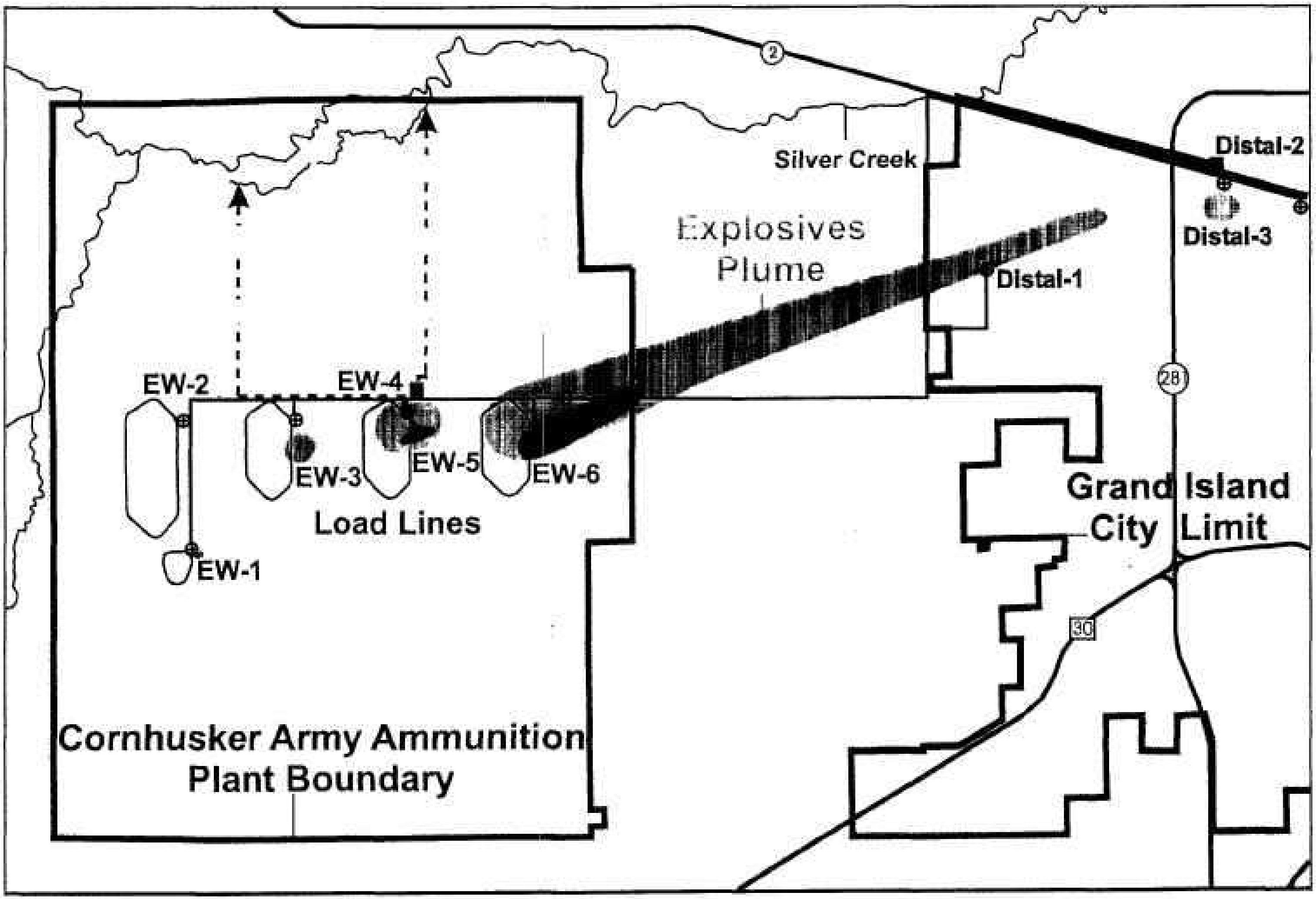
Cross-Sectional View of The Off-Post Explosives Plume

DRN BY: JBH	DATE: 01/26/01	PROJECT NUMBER	FIG NO
CHK'D BY:	REVISION: 0	49-F0000009.00	3



LEGEND:

- Interpreted horizontal extent of total explosives > 2 µg/L
- Interpreted horizontal extent of total explosives > 200 µg/L
- Groundwater Extraction Well
- Surface Discharge and Infiltration Basin
- Groundwater Piping
- Groundwater Treatment Facility

N

6,000 0 6,000

Scale: 1":6,000'

URS

Original Selected Remedy

DRN BY: JBH	DATE: 01/26/01	PROJECT NUMBER 49-F0000009.00	FIG. NO. 4
CHK'D BY:	REVISION: 0		

Administrative Record File – A compilation of documents that record the US Army's decision-making process regarding the selection of a response action to be taken at a site.

Applicable or Relevant and Appropriate Requirements (ARARs) – The Federal and State environmental laws that a selected remedy will meet. These requirements may vary among sites and alternatives.

Biodegradation – The use of microorganisms to transform or alter, through metabolic or enzymatic action, hazardous organic contaminants into nonhazardous substances.

Capital Costs – Up-front costs associated with remediation system construction and start-up, administration, legal, engineering, and design.

Carcinogens – Potential cancer-causing chemicals. RDX and TNT are considered "possible" carcinogens, meaning there is data indicating carcinogenicity in animals but no data for humans.

Comprehensive Environmental Response Compensation, and Liability Act (CERCLA) – The federal law that addresses problems resulting from releases of hazardous substances to the environment, primarily at inactive sites.

HMX (Cyclotetramethylenetetranitramine) – Common military explosive; not classified as a human carcinogen, but at high concentrations may cause other adverse health effects.

Distal End – The far end of the plume of affected groundwater in the off- post area.

Effluent – Process water leaving a treatment unit.

Groundwater Extraction – The process in which groundwater is pumped from an aquifer to the ground's surface for treatment.

Feasibility Study (FS) – This CERCLA document develops and evaluates options for remedial action. The FS emphasizes data analysis and is generally performed concurrently in an interactive fashion with the Remedial Investigation (RI), using data gathered during the RI.

Granular Activated Carbon (GAC) – A water treatment method which uses fine-grained carbon to adsorb organic chemicals such as explosives from the water.

Hazard Quotient (HQ) – A numerical ratio used in risk assessments to describe the potential for non-carcinogenic adverse health effects to occur for a specific chemical and exposure pathway. If the HQ is greater than 1.0, then a hazard may exist and remedial action is usually warranted.

The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) – These CERCLA regulations provide the federal government the authority to respond to the problems of abandoned or uncontrolled hazardous waste disposal sites as well as to certain incidents involving hazardous waste (e.g., spills).

National Priorities List (NPL) – USEPA's list of uncontrolled or abandoned waste sites which present the greatest potential threat to human health or the environment.

Natural Attenuation – Natural processes such as biodegradation and other chemical reactions that reduce contaminant concentrations to acceptable levels.

Operable Unit – A portion of a site separately considered for remedial or corrective action. For example, Operable Unit One at CHAAP addresses the explosives groundwater plume.

Operations and Maintenance (O & M) – Measures required to operate and maintain remedial systems to ensure the effectiveness of the response action.

Preferred Remedial Alternative – The remedial alternative selected by the US Army, USEPA and NDEQ based on a comparison of various remedial alternatives using specific evaluation criteria.

Present Value – A value representing the entire lifetime cost of an alternative converted into an equivalent present cost using an assumed discount rate.

Revised Proposed Plan – CERCLA document that summarizes evidence to support the selection of a revised preferred alternative at a CERCLA site. The document is intended for public distribution to solicit comments on the proposed action(s).

Record of Decision (ROD) – The document that presents the final remedy selected by the concerned agencies for cleanup.

Remedial Investigation (RI) – A process under CERCLA to determine the nature and extent of the problem presented by a release. The RI includes sampling, monitoring, and gathering of sufficient information to determine the necessity for remedial action.

Resource Conservation and Recovery Act (RCRA) – The Federal act that established a regulatory system to track hazardous wastes from the time they are generated to final disposal.

Royal Demolition Explosive (RDX) – Hexahydro-1,3,5-trinitro-1,3,5-triazine – A common military munitions explosive; considered to be a possible human carcinogen.

Superfund Amendments and Reauthorization Act (SARA) – 1986 revision to CERCLA added provisions and clarified much of what was unclear in the original act.

Target Risk Range – A range of probabilities of carcinogenic risks to human health of 1x10-4 to 1x10-6 that is considered to be the risk range for health protection at Superfund sites. If calculated risks fall within the risk range, risk managers must determine whether remedial action is warranted to reduce the risk. If the risks are smaller than 1x10-6 (less than 1 in 1 million), no remedial action is required. If the risks are greater than 1x10-4 (1 in 10 thousand), remedial action is generally required.

Total Incremental Cost – The entire lifetime cost of an alternative assuming payments in the future are based on current costs.

2,4,6-Trinitrotoluene (TNT) – Common military explosive; considered to be a possible human carcinogen and at higher concentrations may cause adverse health effects.

USEPA Health Advisory Levels – Contaminant concentration levels set by USEPA to be protective of human health.

The primary objective of the LTM program is to monitor and identify explosives plume migration trends in the off-post monitoring well locations. Additional objectives for the LTM included identifying natural attenuation trends for the off-post explosives plume. Five LTM and natural attenuation demonstration sampling events have been completed since 1996. The data from these events supports the use of monitored natural attenuation of the off- post explosives plume.

This appendix includes selected text and figures from the LTM events and Monitored Natural Attenuation Demonstration as published in the March 2000 Annual Sampling Event for the Long-Term Monitoring Program Draft Report (URS 2000). The entire report can be found in the administrative record at the Grand Island Public Library. All section numbers, text, tables, and figures remain unchanged from the original report.

The following sections are reproduced from the March 2000 Annual Sampling Event for the Long-Term Monitoring Program Draft Report (URS 2000b).

1.5 SCOPE OF WORK

The March 2000 annual sampling event was the fifth in a series of planned LTM sampling events. During the March 2000 sampling event, URS collected groundwater samples from 82 off-post wells, 42 on-post wells, and 14 on-post piezometers. The samples were analyzed for nitroaromatics and nitroamines using USEPA Method 8330. Groundwater samples were also analyzed for natural attenuation parameters, including alkalinity, ammonia, nitrate/ nitrite, sulfate, total Kjeldahl nitrogen, dissolved organic carbon, and methane. All analyses were completed by EMAX Laboratories, Inc., Torrance, California. Water level readings and water quality parameters were also measured during well purging.

URS resampled 14 wells for explosives reanalysis on June 14 and 15, 2000. The original samples were analyzed outside of holding times for 10 of the 14 wells and were rejected. The four remaining wells were resampled to check the accuracy and precision of the original sample results. The use of the resampled well data is discussed in Section 4.0.

Prior to the March 2000 sampling event, 6 new monitoring wells were installed in December 1999.

1.6 OBJECTIVE

The primary objective of the LTM program is to monitor and identify explosives plume migration trends in the off-post monitoring well locations. Additional objectives for the March 2000 annual sampling event included measuring current explosives concentrations at selected on-post monitoring well locations and identifying natural attenuation trends for the off-post explosives plume.

SECTION FIVE Nature and Extent of Contamination

This section provides a description of the nature and extent of explosives detected in groundwater during the March 2000 sampling event at CHAAP. RDX, HMX, and TNT were selected for this discussion because of their frequency of occurrence, magnitude of detected concentrations, and potential adverse health effects.

Health advisory concentration levels for explosives were established for CHAAP in the ROD. This nature and extent discussion generally focuses on contaminant concentrations above the health advisory levels. These levels are:

- 2 ug/L for RDX and TNT
- 400 ug/L for HMX

5.1 HORIZONTAL EXTENT OF GROUNDWATER PLUME

Horizontal extent of total explosives, RDX, and TNT detected during the March 2000 sampling event are shown on **Figures 5-1a, 5-1b, 5-2, and 5-8**, respectively. The off-post explosives plume originates on the northeast edge of the CHAAP Facility (near LL1) and extends over 21,000 feet northeast into the surrounding rural and urban areas.

5.1.1 Off-Post Plume Extent

The off-post explosives groundwater plume consists primarily of RDX and HMX. TNT was only detected at two off-post well clusters (NW020 and CA350). Maximum concentrations detected off post during the March 2000 sampling event included 16 ug/L RDX (CA351), 7 ug/L HMX (CA351), and 25 ug/L TNT (NW020) **(Figure 5-1b)**. TNT breakdown products (e.g., 2-Am-DNT and 4-Am-DNT) were also detected in the NW020, CA350 and CA380 well clusters. HMX has not been detected above health advisory levels off post or on post during any of the LTM events.

The axis of the off-post explosives plume trends from southwest to northeast **(Figure 5-1b)**. The highest explosives concentrations were located near the facility boundary. Explosives concentrations declined to the northeast, dissipating near well cluster CA290. Low explosives concentrations were also detected in wells CA311 and CA312 (1.1 and 3.0 ug/L RDX, respectively) and CA342 (1.3 ug/L RDX).

March, 2000, March 1999, June 1998, October 1997, December 1996, and July 1994 RDX plume maps are shown on **Figures 5-2, 5-3, 5-4, 5-5, 5-6, and 5-7**, respectively. In general, RDX concentrations have declined from 1994 to 2000 at many of the off- post monitoring well clusters. For example, RDX concentrations (1994 and 2000 concentrations) have decreased at the well locations listed below; **Figure 5-11** presents these declining concentration trends.

- NW020 (from 26 to 12 ug/L)
- NW081 (from 17 to 5.4 ug/L)
- CA251 (from 28 to 5.6 ug/L)
- CA272 (from 15 to 4.3 ug/L)
- CA292 (from 5.85 ug/L to 0.59)

Table 5-1 summarizes the highest historical off-post explosives concentrations detected from 1984 to 2000. Data indicates RDX has declined over time from 1984 (> 100 ug/L) and 1994 (28 ug/L) to the present (12 ug/L). TNT concentrations declined significantly from 1984 (> 350 ug/L) to 1994 (23 ug/L). Since then, TNT concentrations have remained similar, ranging from 22.3 ug/L to 25 ug/L at NW020 (**Table 5-1** and **Figures 5-8 and 5-9**). This may be indicative of a residual source of TNT at LL1. The USACE has overseen the installation of an additional extraction well (EW-7) at the post boundary (see **Figure 1-1**) to contain on-post explosives contamination.

5.1.2 On-Post Plume Extent

The on-post explosives groundwater plumes (at Loadlines [LL] 1, 2, and 3) consist primarily of TNT, RDX, TNB, and HMX. Maximum concentrations detected during the March 2000 sampling event included 2500 ug/L TNT (PZ013 at LL2), 130 ug/L, RDX (PZ013 at LL2), 550 ug/L TNB (PZ012 at LL2), and 27 ug/L HMX (PZ013 at LL2). Explosive breakdown products including 2-Am-DNT, and 4-Am-DNT were also detected in 19 wells and piezometers sampled on post.

The on-post contamination was located mostly on the east sides of LL1, LL2, and LL3 (near the suspected source areas). Highest explosive concentrations were located at LL1 and LL2. No explosive concentrations were detected above the health advisory levels at LL4, LL5 or the nitrate area.

5.2 VERTICAL EXTENT OF GROUNDWATER PLUME

Interpreted vertical extent of the off-post explosives plume is shown on geologic cross-section A-A' **(Figure 5-12)**. Although overall explosives concentrations have generally declined from December 1996 (W-C 1997a) to March 2000, the vertical extent and cross-sectional interpretation of the plume (to 2 ug/L) have remained similar. Contrasts in hydraulic properties between the Grand Island Formation (alluvial sand aquifer) and Fullerton Formation (alluvial clay aquitard) have continued to restrict the occurrence of groundwater contamination to the Grand Island Formation. Explosives were not detected in the deep aquifer (Holdrege Formation). The Fullerton Formation appears to act as a natural barrier, retarding the vertical migration of explosives to the underlying Holdrege Formation (gravel-paleovalley fill aquifer).

The plume was detected at depths of 7 to 57 feet bgs (i.e., from the water table to 50 feet below the water table). There appears to be a clean zone near the water table in the distal edges of the off-post plume, possibly due to infiltrating surface recharge.

5.3 NATURE AND EXTENT SUMMARY

In summary, the March 2000 sampling results indicated the following:

Off-Post Plume

- The explosives plume, consisting primarily of RDX, is still present off post but is not migrating any further downgradient.

- Explosives concentrations within the off-post plume are declining over time.

- TNT breakdown products (e.g., 2-Am-DNT and 4-Am-DNT) have been detected in off-post monitoring well clusters NW020, CA350, and CA380.

- HMX has not been detected above the health advisory level (i.e., 400 ug/L) during any LTM sampling event.

Possible reasons for off-post explosives concentrations declining from 1984 (Spalding and Fulton 1988) to 2000 include natural attenuation processes (e.g., dispersion, biodegradation, and abiotic degradation), contaminant soil source removal and on-post groundwater extraction.

On-Post Source Areas

- RDX and TNT concentrations were significantly above health advisory levels at Loadlines 1, 2, and 3.

- On-post RDX and TNT concentrations near extraction wells EW-4, EW-5, and EW-6 have remained low. (Similar over the past three LTM monitoring events.)

- No explosives concentrations were detected above health advisory levels at LL4, LL5 and the nitrate area.

- HMX has not been detected above the health advisory level (i.e., 400 ug/L) during any LTM sampling event.

SECTION SIX Natural Attenuation Evaluation

This section presents a preliminary evaluation of natural attenuation of the off-post explosives plume at CHAAP. The evaluation was completed using laboratory analyses of water quality parameter data and field water quality parameter data measured during the last three LTM events (i.e., June 1998, March 1999, and March 2000), and explosives data from 1984 to 2000.

6.1 Natural Attenuation Evaluation Methodology

Natural attenuation can be an effective remedial option for contaminants in groundwater at CHAAP if it can be demonstrated that sufficient attenuation processes are occurring at a rate sufficient to protect human health and the environment. These in-situ processes include biodegradation, abiotic transformation, dispersion, organic carbon adsorption, and irreversible soil binding. The natural attenuation demonstration at CHAAP is being implemented in accordance with the protocols presented in the OSWER Directive "Use of Monitored Natural Attenuation at Superfund, RCRA, Corrective Action, and Underground Storage Tank Sites" (USEPA 1997), and "Draft Protocol for Evaluating, Selecting, and Implementing Monitored Natural Attenuation at Explosives-Contaminated Sites" (USACE WES 1999). The natural attenuation demonstration at CHAAP includes:

- Completing long-term groundwater monitoring in support of natural attenuation by monitoring key natural attenuation water quality parameters and explosives concentrations over time

- Identifying the significant natural attenuation processes occurring at the site, especially the processes which may be facilitating anaerobic degradation of the off-post explosives plume

- Determining the rate at which the natural attenuation processes are reducing contaminant concentrations

6.2 NATURAL ATTENUATION WATER QUALITY PARAMETER RESULTS

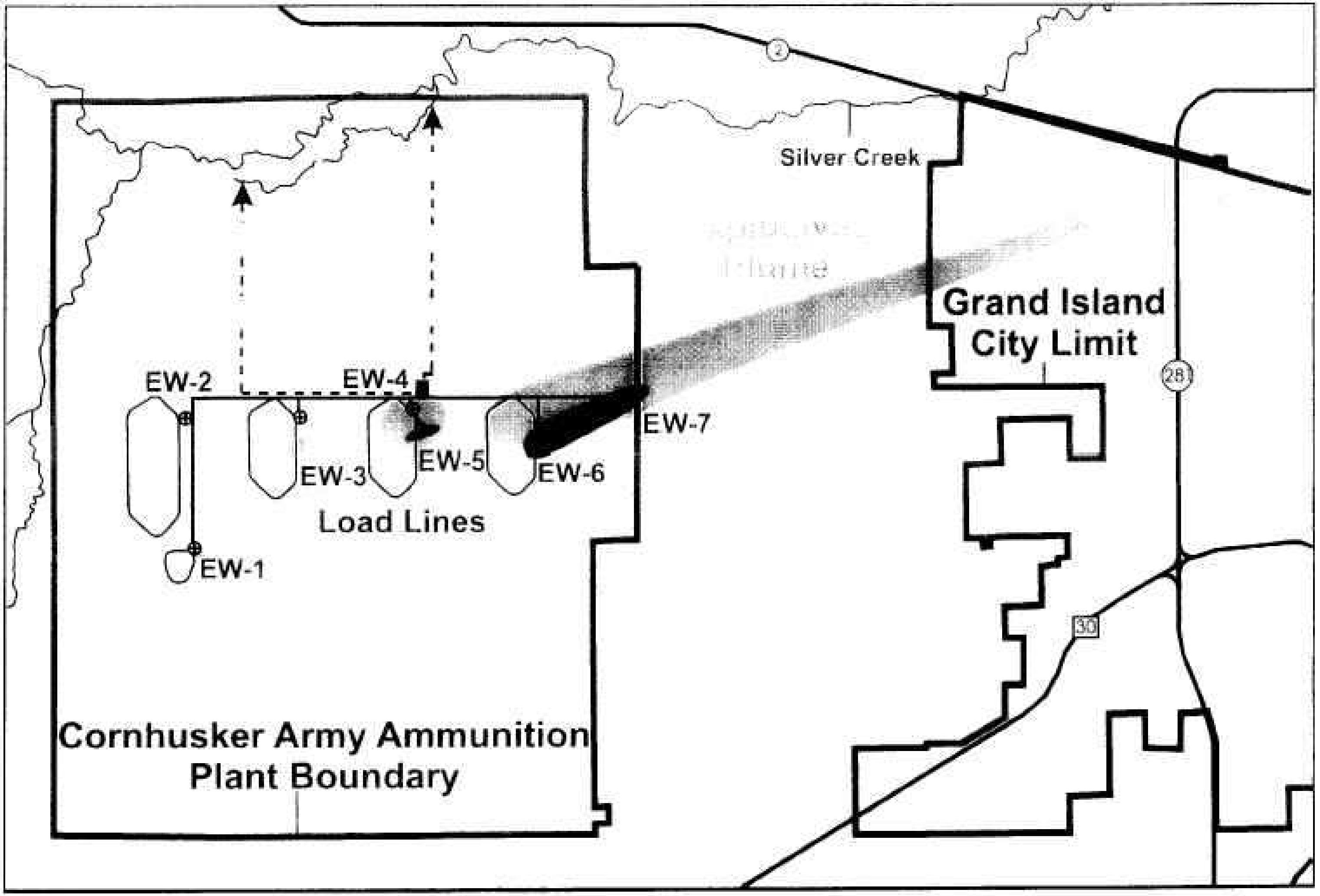
Tables 6-1 and 6-2 present key water quality parameter data, including laboratory parameters (i.e., nitrate+ nitrite, ammonia, TKN, dissolved organic carbon, CO_2, alkalinity, sulfate, and sulfide) and field parameters (i.e., redox, dissolved oxygen, Fe^{2+} , pH, and conductivity). The natural attenuation water quality parameter results are also shown on **Figures 6-1a through 6-1d**. These parameters are reported by Weidemeier et.al. (1996) and USACE WES (1999) to help identify anaerobic degradation processes commonly occurring at groundwater contamination sites. Explosives have been demonstrated to biodegrade under anaerobic/reducing conditions (USACE WES 1997, 1998).

Figures 6-2a through 6-4a present interpreted isoconcentrations of average redox potential, DO, and NO_3+ NO_2 in shallow groundwater. **Figures 6-2b through 6-4b** present the same parameters plotted along a cross section down the center of the off-post explosives plume.

For purposes of comparison, the data has been evaluated and separated into three basic groups: general sitewide data (including background), off-post plume/on-post source area data, and feedlot area data.

6.2.1 General Sitewide Trends

General sitewide and background data trends include:



LEGEND:

- Interpreted horizontal extent of total explosives > 2 μg/L
- Interpreted horizontal extent of total explosives > 200 μg/L
- Groundwater Extraction Well
- Surface Discharge and Infiltration Basin
- Groundwater Piping
- Groundwater Treatment Facility

N

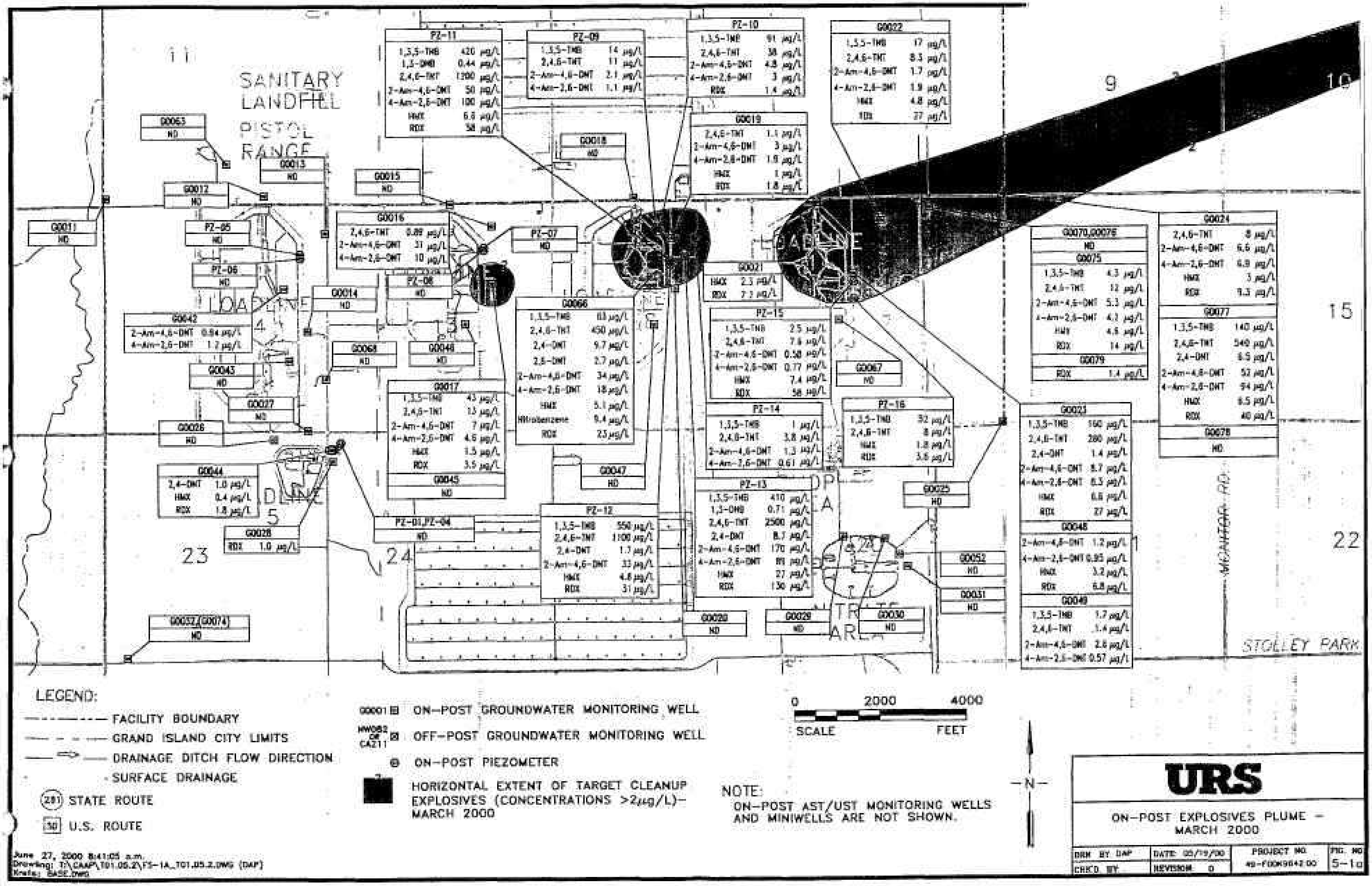
6,000 0 6,000

Scale: 1":6,000'

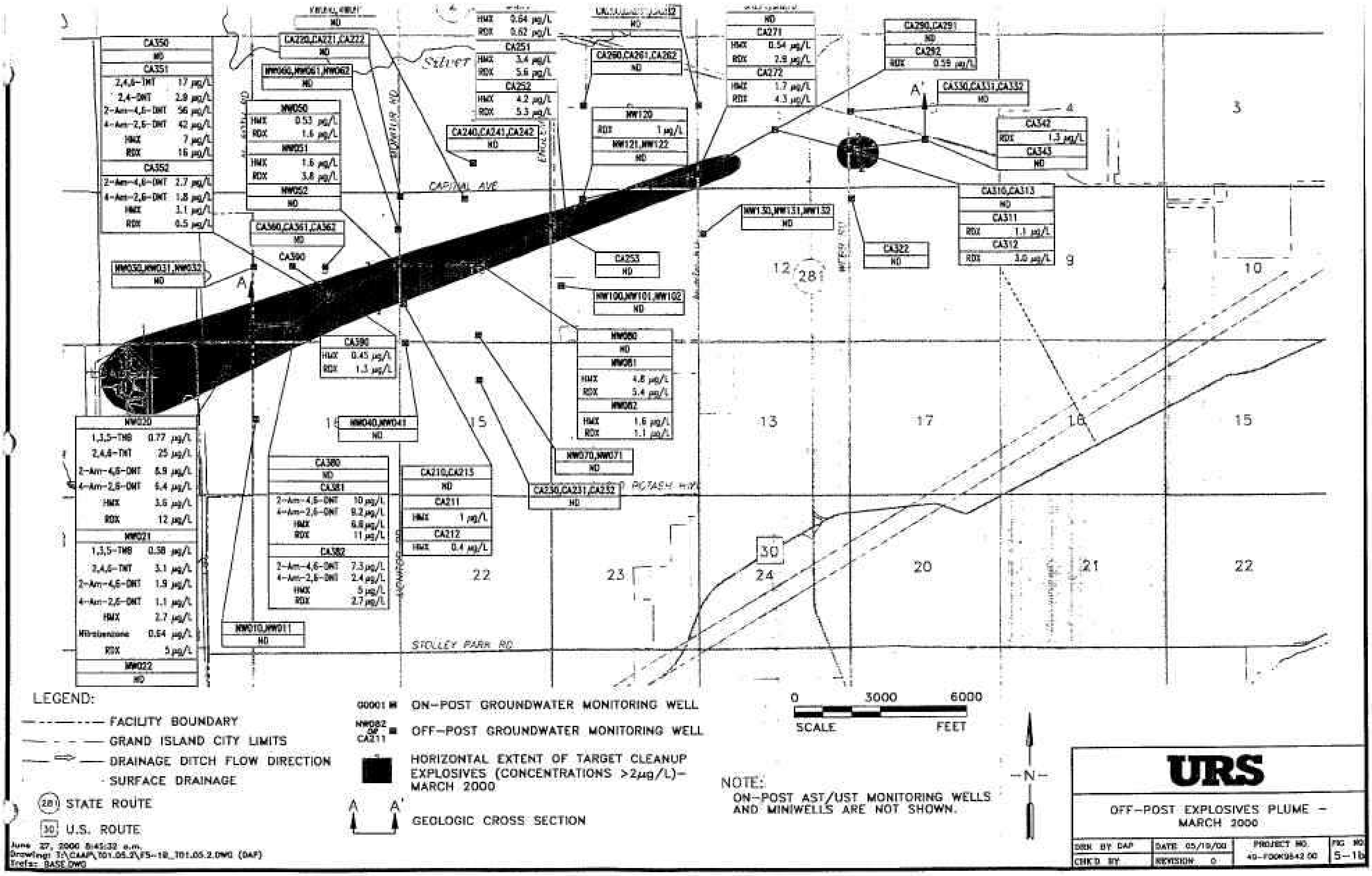
URS

New Proposed Remedy

DRN BY: JBH	DATE: 01/26/01	PROJECT NUMBER 49-F0000009.00	FIG NO. 5
CHK'D BY:	REVISION: 0		



11
SANITARY LANDFILL
PISTOL RANGE
G0063 ND
G0013 ND
G0012 ND
G0011 ND
G0015 ND
PZ-05 ND
PZ-06 ND
G0016 2,4,6-TNT 0.89 µg/L 2-Am-4,6-DNT 31 µg/L 4-Am-2,6-DNT 10 µg/L
PZ-07 ND
PZ-08 ND
G0014 ND
G0042 2-Am-4,6-DNT 0.94 µg/L 4-Am-2,6-DNT 1.2 µg/L
G0068 ND
G0046 ND
G0043 ND
G0027 ND
G0026 ND
G0017 1,3,5-TNB 43 µg/L 2,4,6-TNT 13 µg/L 2-Am-4,6-DNT 7 µg/L 4-Am-2,6-DNT 4.6 µg/L HMX 1.5 µg/L RDX 3.5 µg/L
G0045 ND
G0044 2,4-DNT 1.0 µg/L HMX 0.4 µg/L RDX 1.8 µg/L
G0028 RDX 1.0 µg/L
PZ-01,PZ-04 ND
G0032,(G0074) ND
23
24
PZ-11 1,3,5-TNB 420 µg/L 1,3-DNB 0.44 µg/L 2,4,6-TNT 1200 µg/L 2-Am-4,6-DNT 50 µg/L 4-Am-2,6-DNT 100 µg/L HMX 6.6 µg/L RDX 58 µg/L
PZ-09 1,3,5-TNB 14 µg/L 2,4,6-TNT 11 µg/L 2-Am-4,6-DNT 2.1 µg/L 4-Am-2,6-DNT 1.1 µg/L
G0018 ND
PZ-10 1,3,5-TNB 91 µg/L 2,4,6-TNT 38 µg/L 2-Am-4,6-DNT 4.8 µg/L 4-Am-2,6-DNT 3 µg/L RDX 1.4 µg/L
G0019 2,4,6-TNT 1.1 µg/L 2-Am-4,6-DNT 3 µg/L 4-Am-2,6-DNT 1.9 µg/L HMX 1 µg/L RDX 1.8 µg/L
G0022 1,3,5-TNB 17 µg/L 2,4,6-TNT 8.5 µg/L 2-Am-4,6-DNT 1.7 µg/L 4-Am-2,6-DNT 1.9 µg/L HMX 4.8 µg/L RDX 27 µg/L
9
10
15
22
G0066 1,3,5-TNB 83 µg/L 2,4,6-TNT 450 µg/L 2,4-DNT 9.7 µg/L 2,6-DNT 2.7 µg/L 2-Am-4,6-DNT 34 µg/L 4-Am-2,6-DNT 18 µg/L HMX 5.1 µg/L Nitrobenzene 9.4 µg/L RDX 23 µg/L
G0021 HMX 2.3 µg/L RDX 7.3 µg/L
PZ-15 1,3,5-TNB 2.5 µg/L 2,4,6-TNT 7.6 µg/L 2-Am-4,6-DNT 0.58 µg/L 4-Am-2,6-DNT 0.77 µg/L HMX 7.4 µg/L RDX 58 µg/L
G0067 ND
PZ-14 1,3,5-TNB 1 µg/L 2,4,6-TNT 3.8 µg/L 2-Am-4,6-DNT 1.3 µg/L 4-Am-2,6-DNT 0.61 µg/L
PZ-16 1,3,5-TNB 32 µg/L 2,4,6-TNT 8 µg/L HMX 1.8 µg/L RDX 3.6 µg/L
G0047 ND
PZ-12 1,3,5-TNB 550 µg/L 2,4,6-TNT 1100 µg/L 2,4-DNT 1.7 µg/L 2-Am-4,6-DNT 33 µg/L HMX 4.8 µg/L RDX 31 µg/L
PZ-13 1,3,5-TNB 410 µg/L 1,3-DNB 0.71 µg/L 2,4,6-TNT 2500 µg/L 2,4-DNT 8.7 µg/L 2-Am-4,6-DNT 170 µg/L 4-Am-2,6-DNT 89 µg/L HMX 27 µg/L RDX 130 µg/L
G0025 ND
G0052 ND
G0031 ND
G0020 ND
G0029 ND
G0030 ND
G0070,G0076 ND
G0075 1,3,5-TNB 4.3 µg/L 2,4,6-TNT 12 µg/L 2-Am-4,6-DNT 5.3 µg/L 4-Am-2,6-DNT 4.3 µg/L HMX 4.6 µg/L RDX 14 µg/L
G0079 RDX 1.4 µg/L
G0024 2,4,6-TNT 8 µg/L 2-Am-4,6-DNT 6.6 µg/L 4-Am-2,6-DNT 6.9 µg/L HMX 3 µg/L RDX 9.3 µg/L
G0077 1,3,5-TNB 140 µg/L 2,4,6-TNT 540 µg/L 2,4-DNT 6.5 µg/L 2-Am-4,6-DNT 52 µg/L 4-Am-2,6-DNT 94 µg/L HMX 6.5 µg/L RDX 40 µg/L
G0078 ND
G0023 1,3,5-TNB 160 µg/L 2,4,6-TNT 280 µg/L 2,4-DNT 1.4 µg/L 2-Am-4,6-DNT 8.7 µg/L 4-Am-2,6-DNT 8.3 µg/L HMX 6.6 µg/L RDX 27 µg/L
G0048 2-Am-4,6-DNT 1.2 µg/L 4-Am-2,6-DNT 0.95 µg/L HMX 3.2 µg/L RDX 6.8 µg/L
G0049 1,3,5-TNB 1.7 µg/L 2,4,6-TNT 1.4 µg/L 2-Am-4,6-DNT 2.6 µg/L 4-Am-2,6-DNT 0.57 µg/L
MONITOR RD.
STOLLEY PARK
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
281 STATE ROUTE
30 U.S. ROUTE
G0001 ON-POST GROUNDWATER MONITORING WELL
HW082 OR CA211 OFF-POST GROUNDWATER MONITORING WELL
ON-POST PIEZOMETER
HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (CONCENTRATIONS >2µg/L)–MARCH 2000
0 2000 4000
SCALE FEET
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
N
URS
ON-POST EXPLOSIVES PLUME – MARCH 2000
DRN BY DAP
CHKD BY
DATE 05/19/00
REVISION 0
PROJECT NO. 49-F00K9642.00
FIG. NO 5-1a
June 27, 2000 8:41:05 a.m.
Drawing: T:\CAAP\T01.05.2\FS-1A_T01.05.2.DWG (DAP)
Xrefs: BASE.DWG



CA350
ND
CA351
2,4,6-TNT 17 µg/L
2,4-DNT 2.8 µg/L
2-Am-4,6-DNT 56 µg/L
4-Am-2,6-DNT 42 µg/L
HMX 7 µg/L
RDX 16 µg/L
CA352
2-Am-4,6-DNT 2.7 µg/L
4-Am-2,6-DNT 1.8 µg/L
HMX 3.1 µg/L
RDX 0.5 µg/L
CA220,CA221,CA222
ND
NW060,NW061,NW062
ND
NW050
HMX 0.53 µg/L
RDX 1.6 µg/L
NW051
HMX 1.6 µg/L
RDX 3.8 µg/L
NW052
ND
HMX 0.64 µg/L
RDX 0.62 µg/L
CA251
HMX 3.4 µg/L
RDX 5.6 µg/L
CA252
HMX 4.2 µg/L
RDX 5.3 µg/L
CA240,CA241,CA242
ND
CA260,CA261,CA262
ND
NW120
RDX 1 µg/L
NW121,NW122
ND
CA271
HMX 0.54 µg/L
RDX 2.8 µg/L
CA272
HMX 1.7 µg/L
RDX 4.3 µg/L
CA290,CA291
ND
CA292
RDX 0.59 µg/L
CA330,CA331,CA332
ND
CA342
RDX 1.3 µg/L
CA343
ND
CA310,CA313
ND
CA311
RDX 1.1 µg/L
CA312
RDX 3.0 µg/L
CA360,CA361,CA362
ND
CA390
NW030,NW031,NW032
ND
NW130,NW131,NW132
ND
CA322
ND
CA253
ND
NW100,NW101,NW102
ND
CA390
HMX 0.45 µg/L
RDX 1.3 µg/L
NW080
ND
NW081
HMX 4.8 µg/L
RDX 5.4 µg/L
NW082
HMX 1.6 µg/L
RDX 1.1 µg/L
NW020
1,3,5-TNB 0.77 µg/L
2,4,6-TNT 25 µg/L
2-Am-4,6-DNT 6.9 µg/L
4-Am-2,6-DNT 6.4 µg/L
HMX 3.6 µg/L
RDX 12 µg/L
NW021
1,3,5-TNB 0.38 µg/L
2,4,6-TNT 3.1 µg/L
2-Am-4,6-DNT 1.9 µg/L
4-Am-2,6-DNT 1.1 µg/L
HMX 2.7 µg/L
Nitrobenzene 0.64 µg/L
RDX 5 µg/L
NW022
ND
NW040,NW041
ND
CA380
ND
CA381
2-Am-4,6-DNT 10 µg/L
4-Am-2,6-DNT 9.2 µg/L
HMX 6.6 µg/L
RDX 11 µg/L
CA382
2-Am-4,6-DNT 7.3 µg/L
4-Am-2,6-DNT 2.4 µg/L
HMX 5 µg/L
RDX 2.7 µg/L
CA210,CA215
ND
CA211
HMX 1 µg/L
CA212
HMX 0.4 µg/L
NW070,NW071
ND
CA230,CA231,CA232
ND
NW010,NW011
ND
Silver
CAPITAL AVE
POTASH HWY
STOLLEY PARK RD
A
A'
28
30
3
4
9
10
12
13
15
17
16
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22
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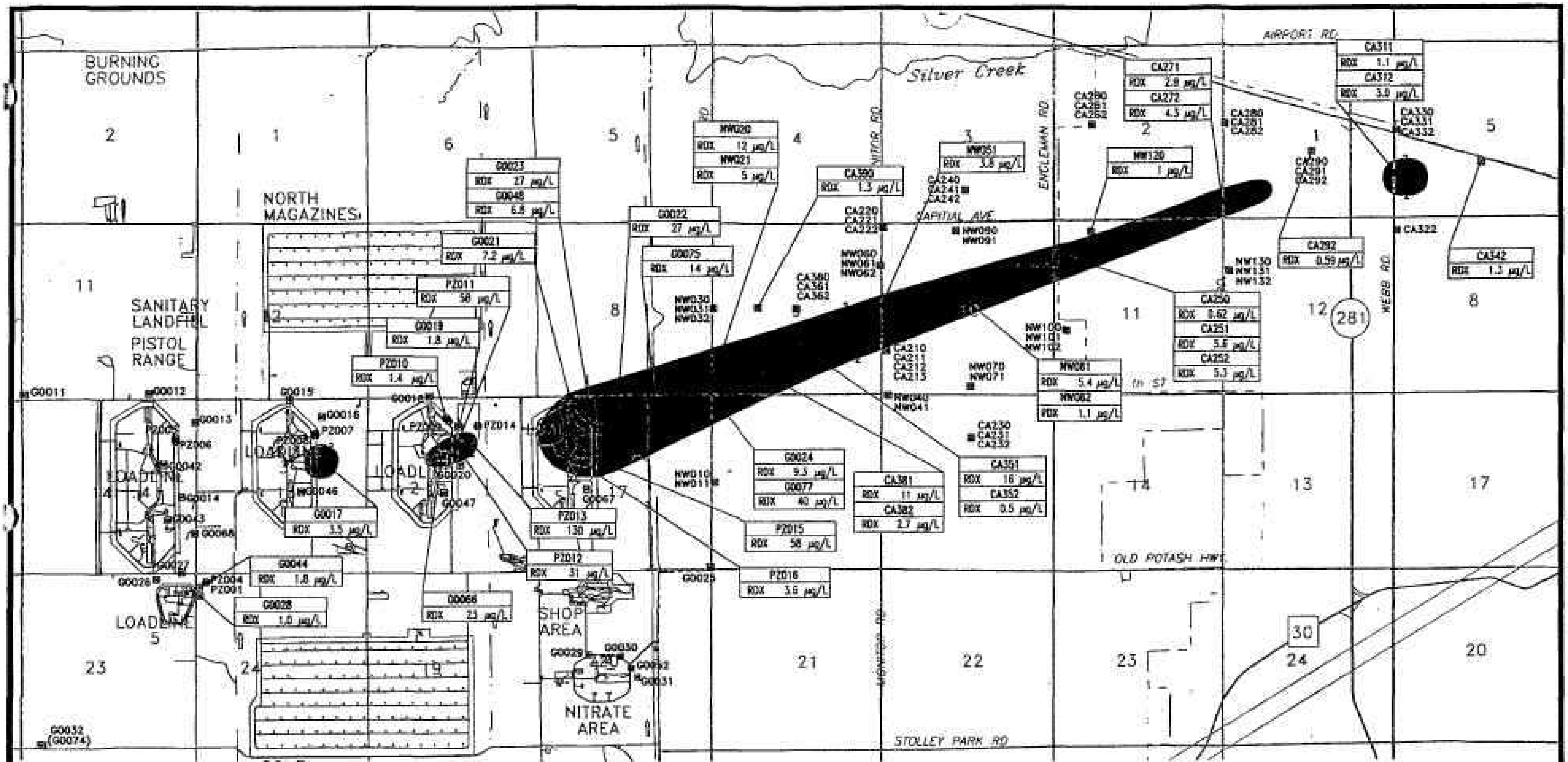
21
22
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
STATE ROUTE
U.S. ROUTE
G0001 ON-POST GROUNDWATER MONITORING WELL
NW082 or CA211 OFF-POST GROUNDWATER MONITORING WELL
HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (CONCENTRATIONS >2µg/L)-MARCH 2000
GEOLOGIC CROSS SECTION
0 3000 6000
SCALE FEET
N
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
URS
OFF-POST EXPLOSIVES PLUME - MARCH 2000
DSN BY DAP
CHK'D BY
DATE 05/10/00
REVISION 0
PROJECT NO.
FIG NO.
5-1b
June 27, 2000 8:45:32 a.m.
Drawing: T:\CAAP\T01.05.2\F5-1B_T01.05.2.DWG (DAF)
Xrefs: BASE.DWG



LEGEND:

- FACILITY BOUNDARY
- GRAND ISLAND CITY LIMITS
- DRAINAGE DITCH FLOW DIRECTION
- SURFACE DRAINAGE
- (281) STATE ROUTE
- [30] U.S. ROUTE
- ON-POST GROUNDWATER MONITORING WELL
- NW062 or CA211 OFF-POST GROUNDWATER MONITORING WELL
- ON-POST PIEZOMETER
- HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2µg/L)-MARCH 2000

NOTE:

1. ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
2. ALL OFF-POST MONITORING WELLS WERE SAMPLED AND ANALYZED FOR RDX. DETECTED RDX CONCENTRATIONS ARE SHOWN. ALL OTHER OFF-POST WELLS WERE "NON-DETECT" FOR RDX.

-N-

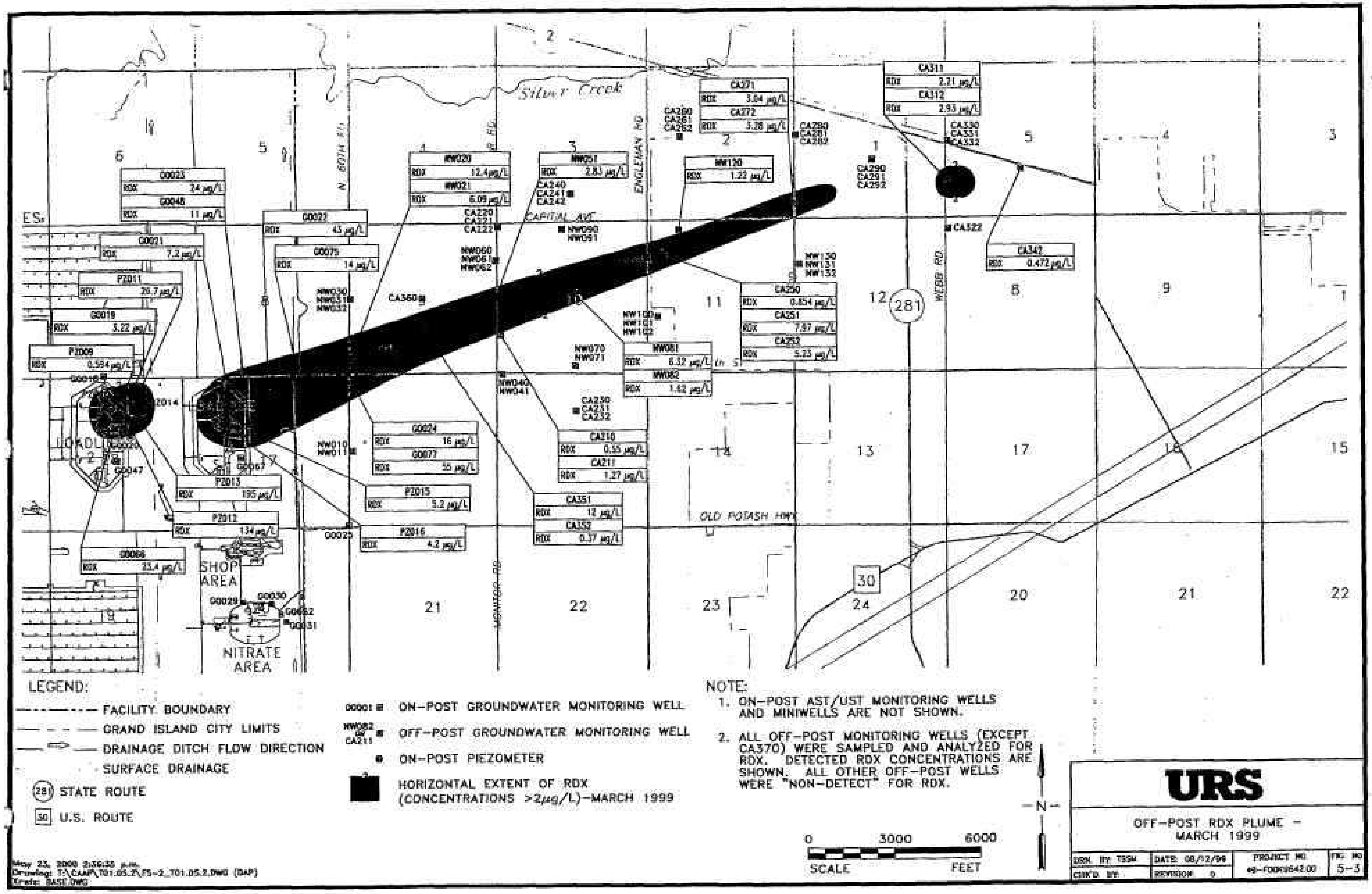
SCALE 0 3000 6000 FEET

URS

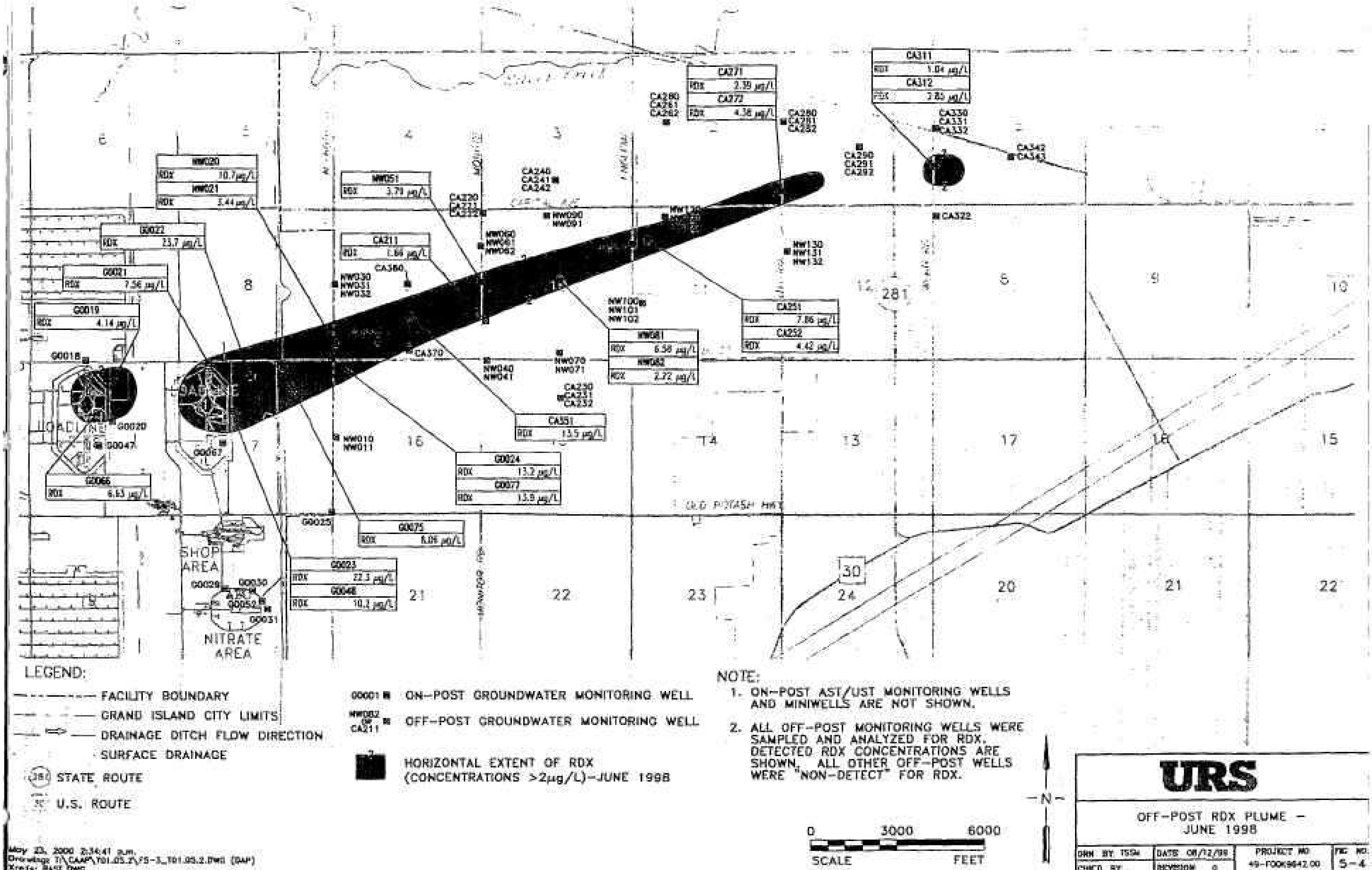
RDX PLUME - MARCH 2000

DRN. BY DAP	DATE 05/19/00	PROJECT NO. 49-F00K9642.00	FIG. NO. 5-2
CHK'D. BY	REVISION 0		

June 27, 2000 8:55:37 a.m.
Drawing: T:\CAAP\T01.05.2\F5-2_T01.DWG (DAP)
Xrefs: BASE.DWG



Silver Creek
CAPITAL AVE
OLD POTASH HWY
N. 80TH RD
ENGLEMAN RD
WEBB RD
MONITOR RD
SHOP AREA
NITRATE AREA
G0023 RDX 24 µg/L
G0048 RDX 11 µg/L
G0021 RDX 7.2 µg/L
PZ011 RDX 20.7 µg/L
G0019 RDX 3.22 µg/L
PZ009 RDX 0.584 µg/L
G0022 RDX 43 µg/L
G0075 RDX 14 µg/L
NW020 RDX 12.4 µg/L
NW021 RDX 6.09 µg/L
NW251 RDX 2.83 µg/L
CA271 RDX 3.04 µg/L
CA272 RDX 3.28 µg/L
NW120 RDX 1.22 µg/L
CA311 RDX 2.21 µg/L
CA312 RDX 2.93 µg/L
CA342 RDX 0.472 µg/L
CA250 RDX 0.854 µg/L
CA251 RDX 7.97 µg/L
CA252 RDX 5.23 µg/L
NW081 RDX 6.32 µg/L
NW082 RDX 1.62 µg/L
G0024 RDX 16 µg/L
G0077 RDX 55 µg/L
CA210 RDX 0.55 µg/L
CA211 RDX 1.27 µg/L
PZ013 RDX 195 µg/L
PZ015 RDX 5.2 µg/L
PZ012 RDX 134 µg/L
CA351 RDX 12 µg/L
CA352 RDX 0.37 µg/L
PZ016 RDX 4.2 µg/L
G0066 RDX 23.4 µg/L
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
STATE ROUTE
U.S. ROUTE
ON-POST GROUNDWATER MONITORING WELL
OFF-POST GROUNDWATER MONITORING WELL
ON-POST PIEZOMETER
HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2µg/L)—MARCH 1999
NOTE:
1. ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
2. ALL OFF-POST MONITORING WELLS (EXCEPT CA370) WERE SAMPLED AND ANALYZED FOR RDX. DETECTED RDX CONCENTRATIONS ARE SHOWN. ALL OTHER OFF-POST WELLS WERE "NON-DETECT" FOR RDX.
0 3000 6000
SCALE FEET
N
URS
OFF-POST RDX PLUME — MARCH 1999
DATE: 08/12/99
REVISION 0
5-3



CA311
RDX 1.04 µg/L
CA312
RDX 2.85 µg/L
CA271
RDX 2.39 µg/L
CA272
RDX 4.38 µg/L
CA260
CA261
CA262
CA280
CA281
CA282
CA330
CA331
CA332
CA342
CA343
CA290
CA291
CA292
CA322
NW020
RDX 10.7 µg/L
NW021
RDX 3.44 µg/L
NW051
RDX 3.79 µg/L
CA240
CA241
CA242
CA220
CA221
CA222
NW090
NW091
NW060
NW061
NW062
G0022
RDX 23.7 µg/L
CA211
RDX 1.66 µg/L
CA360
NW030
NW031
NW032
G0021
RDX 7.56 µg/L
G0019
RDX 4.14 µg/L
G0018
NW130
NW131
NW132
281
CA251
RDX 7.86 µg/L
CA252
RDX 4.42 µg/L
NW100
NW101
NW102
NW081
RDX 6.56 µg/L
NW082
RDX 2.72 µg/L
CA370
NW040
NW041
NW070
NW071
CA230
CA231
CA232
CA351
RDX 13.5 µg/L
G0020
G0047
G0067
NW010
NW011
G0024
RDX 13.2 µg/L
G0077
RDX 13.9 µg/L
G0066
RDX 6.63 µg/L
OLD POTASH HWY
G0025
G0075
RDX 8.06 µg/L
SHOP AREA
G0023
RDX 22.3 µg/L
G0048
RDX 10.2 µg/L
G0029
G0030
G0052
G0031
NITRATE AREA
30
6
5
4
3
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12
6
9
10
16
14
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17
18
15
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22
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24
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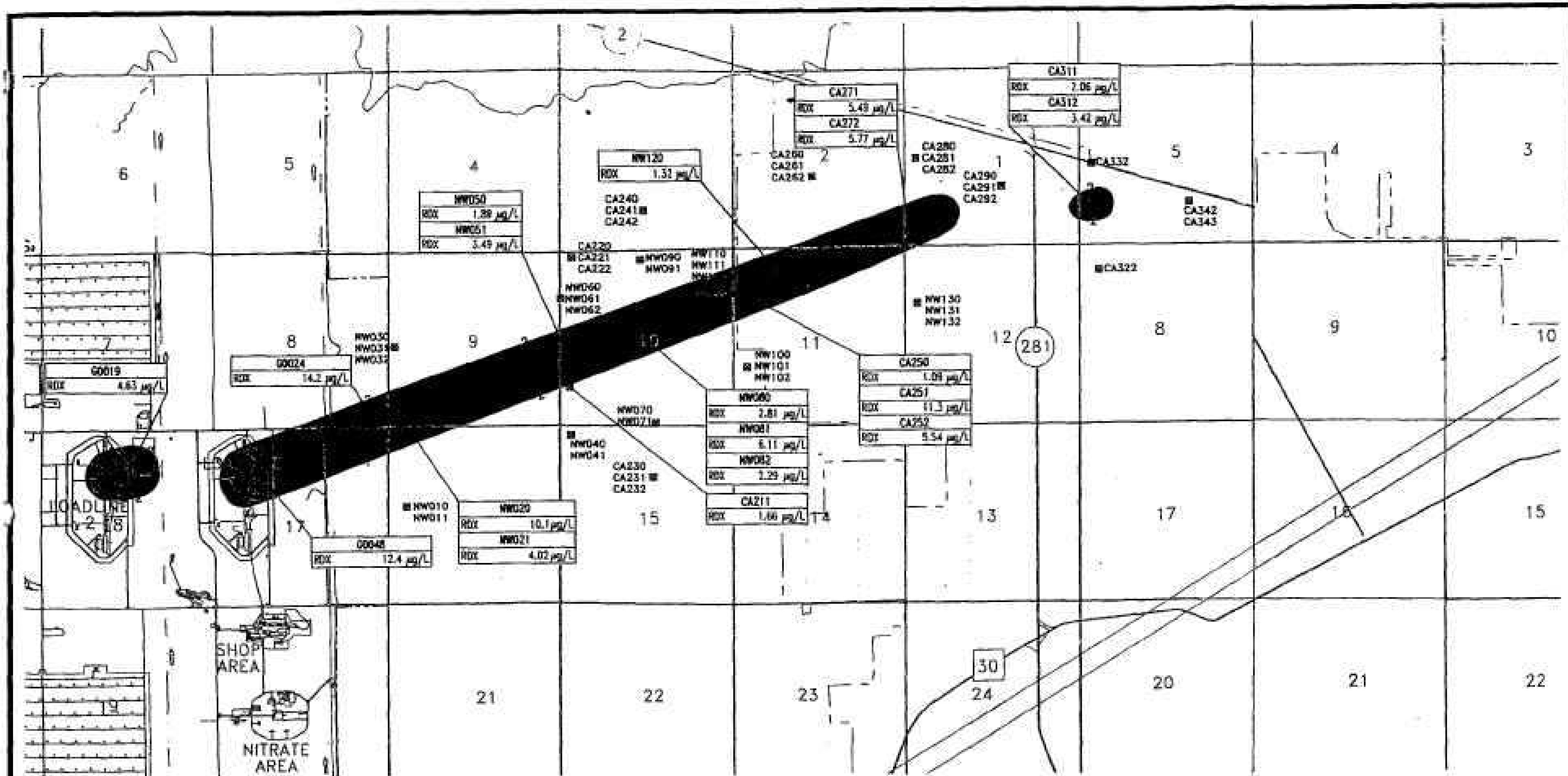
21
22
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
STATE ROUTE
U.S. ROUTE
G0001 ON-POST GROUNDWATER MONITORING WELL
NW082 OR CA211 OFF-POST GROUNDWATER MONITORING WELL
HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2µg/L)-JUNE 1998
NOTE:
1. ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
2. ALL OFF-POST MONITORING WELLS WERE SAMPLED AND ANALYZED FOR RDX. DETECTED RDX CONCENTRATIONS ARE SHOWN. ALL OTHER OFF-POST WELLS WERE "NON-DETECT" FOR RDX.
0 3000 6000
SCALE FEET
N
URS
OFF-POST RDX PLUME - JUNE 1998
DRN BY TSSH
DATE 08/12/99
PROJECT NO 49-FOOK9642.00
FIG NO. 5-4
CHK'D BY
REVISION 0



LEGEND:

- FACILITY BOUNDARY
- GRAND ISLAND CITY LIMITS
- DRAINAGE DITCH FLOW DIRECTION
- SURFACE DRAINAGE
- (281) STATE ROUTE
- [30] U.S. ROUTE
- G0001 ON-POST GROUNDWATER MONITORING WELL
- NW082 or CA211 OFF-POST GROUNDWATER MONITORING WELL
- HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2µg/L)-OCTOBER 1997

NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.

0 3000 6000
SCALE FEET

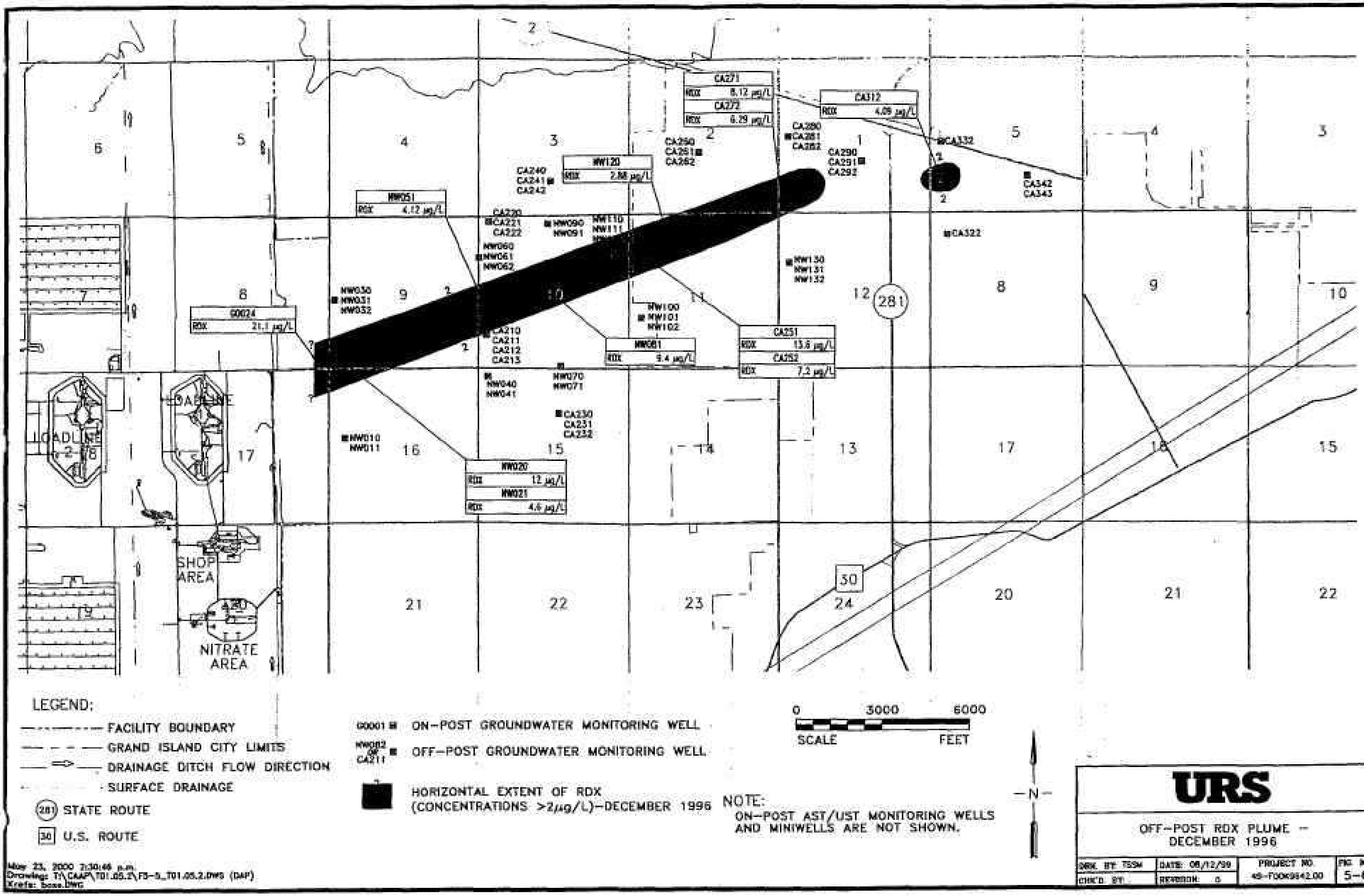
N

URS

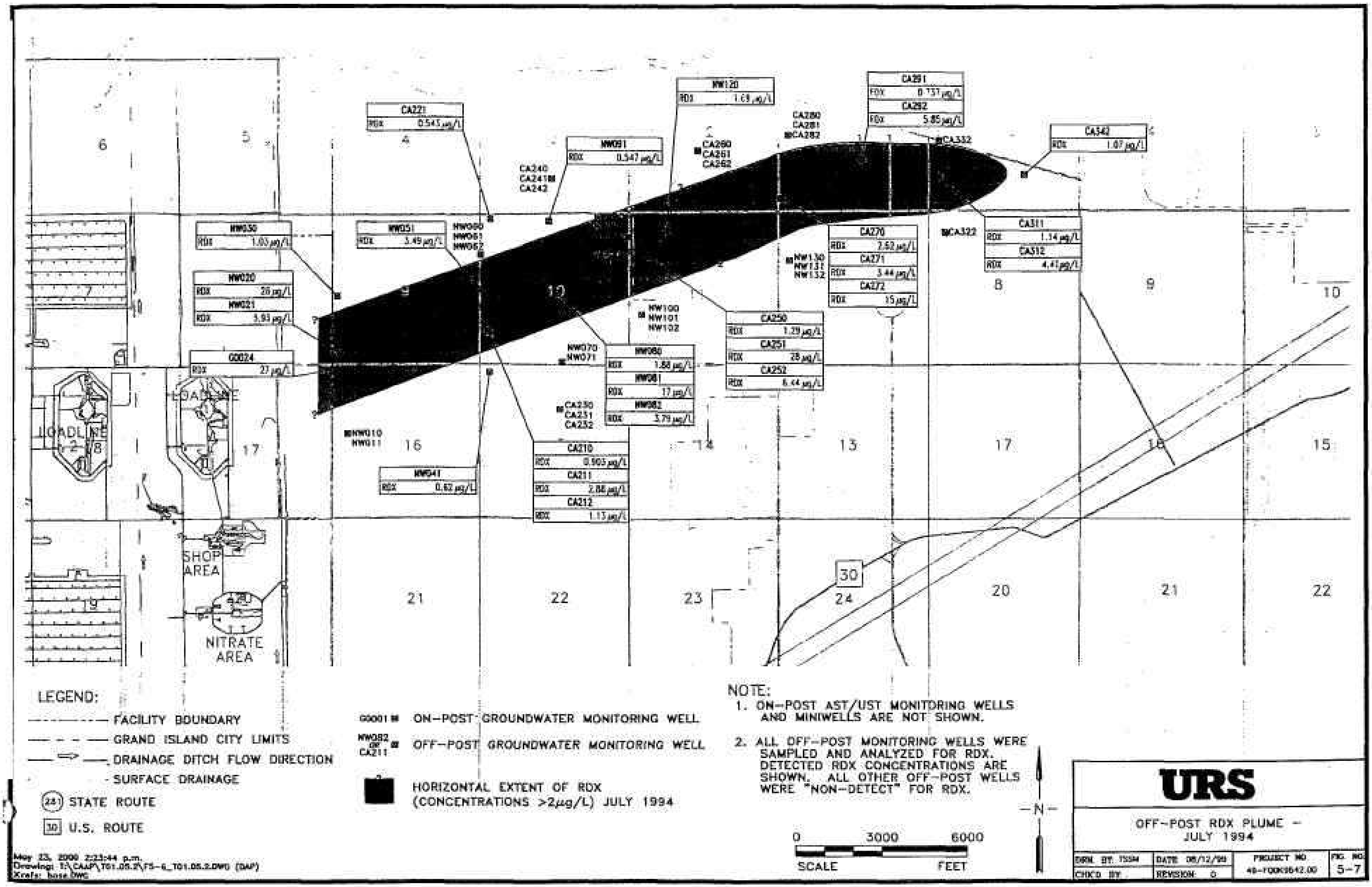
OFF-POST RDX PLUME - OCTOBER 1997

DRN. BY: TSW	DATE: 06/12/00	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	40-F0009642.00	5-5

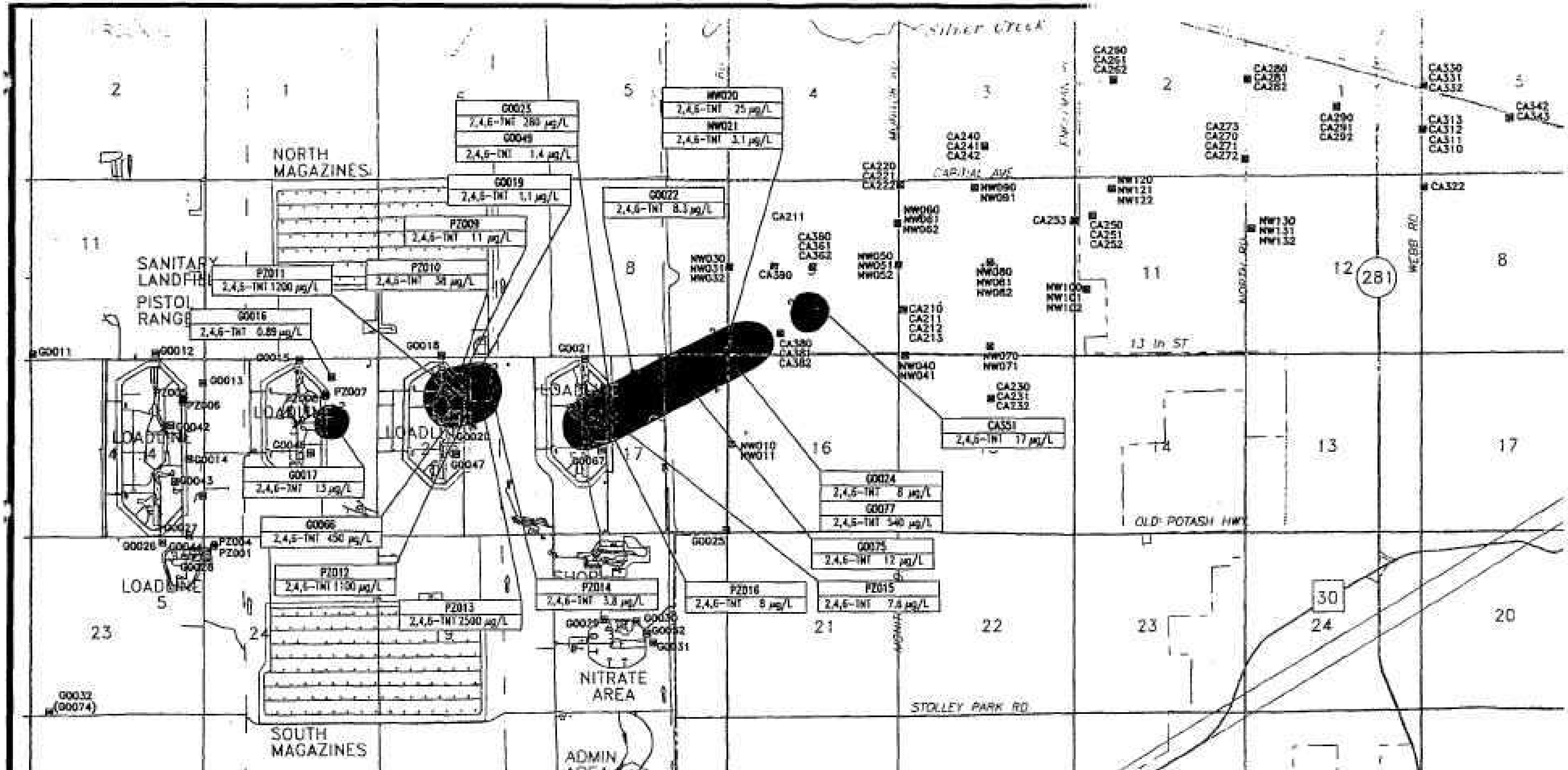
May 23, 2000 2:32:56 p.m.
Drawing: T:\CAAP\T01.05.2\F5-4_T01.05.2.DWG (DAP)
Xrefs: base.DWG



CA271
RDX 8.12 µg/L
CA272
RDX 6.29 µg/L
CA312
RDX 4.09 µg/L
NW120
RDX 2.88 µg/L
NW051
RDX 4.12 µg/L
G0024
RDX 21.1 µg/L
NW081
RDX 9.4 µg/L
CA251
RDX 13.6 µg/L
CA252
RDX 7.2 µg/L
NW020
RDX 12 µg/L
NW021
RDX 4.6 µg/L
CA280
CA281
CA282
CA290
CA291
CA292
CA260
CA261
CA262
CA240
CA241
CA242
CA332
CA342
CA343
CA322
CA220
CA221
CA222
NW090
NW091
NW110
NW111
NW060
NW061
NW062
NW130
NW131
NW132
NW030
NW031
NW032
NW100
NW101
NW102
CA210
CA211
CA212
CA213
NW040
NW041
NW070
NW071
CA230
CA231
CA232
NW010
NW011
LOADLINE
LOADLINE 2-8
SHOP AREA
NITRATE AREA
281
30
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
281 STATE ROUTE
30 U.S. ROUTE
G0001 ON-POST GROUNDWATER MONITORING WELL
NW082 OR CA211 OFF-POST GROUNDWATER MONITORING WELL
HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2µg/L)-DECEMBER 1996
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
0 3000 6000
SCALE FEET
N
URS
OFF-POST RDX PLUME - DECEMBER 1996
DRN. BY: TSSM
DATE: 08/12/99
PROJECT NO. 49-F00K9842.00
FIG. NO. 5-6
CHK'D. BY:
REVISION: 0
May 23, 2000 2:30:46 p.m.
Drawing: T:\CAAP\T01.05.2\F5-5_T01.05.2.DWG (DAP)
Xrefs: base.DWG



CA221 RDX 0.543 µg/L
NW120 RDX 1.69 µg/L
CA291 RDX 0.737 µg/L
CA292 RDX 5.85 µg/L
CA342 RDX 1.07 µg/L
NW091 RDX 0.547 µg/L
NW050 RDX 1.03 µg/L
NW051 RDX 3.49 µg/L
NW020 RDX 26 µg/L
NW021 RDX 3.93 µg/L
G0024 RDX 27 µg/L
CA270 RDX 7.62 µg/L
CA271 RDX 3.44 µg/L
CA272 RDX 15 µg/L
CA311 RDX 1.14 µg/L
CA312 RDX 4.41 µg/L
CA250 RDX 1.29 µg/L
CA251 RDX 28 µg/L
CA252 RDX 6.44 µg/L
NW080 RDX 1.88 µg/L
NW081 RDX 17 µg/L
NW082 RDX 3.79 µg/L
CA210 RDX 0.905 µg/L
CA211 RDX 2.88 µg/L
CA212 RDX 1.13 µg/L
NW041 RDX 0.62 µg/L
CA240 CA241 CA242
CA260 CA261 CA262
CA280 CA281 CA282
CA332
CA322
NW060 NW061 NW062
NW130 NW131 NW132
NW100 NW101 NW102
NW070 NW071
CA230 CA231 CA232
NW010 NW011
LOADLINE
LOADLINE 2 8
SHOP AREA
NITRATE AREA
30
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
281 STATE ROUTE
30 U.S. ROUTE
G0001 ON-POST GROUNDWATER MONITORING WELL
NW082 or CA211 OFF-POST GROUNDWATER MONITORING WELL
HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2µg/L) JULY 1994
NOTE:
1. ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
2. ALL OFF-POST MONITORING WELLS WERE SAMPLED AND ANALYZED FOR RDX. DETECTED RDX CONCENTRATIONS ARE SHOWN. ALL OTHER OFF-POST WELLS WERE "NON-DETECT" FOR RDX.
0 3000 6000
SCALE FEET
N
URS
OFF-POST RDX PLUME - JULY 1994
DATE 06/12/99
REVISION 0
FIG. NO. 5-7
May 23, 2000 2:23:44 p.m.



LEGEND:

- FACILITY BOUNDARY
- GRAND ISLAND CITY LIMITS
- DRAINAGE DITCH FLOW DIRECTION
- SURFACE DRAINAGE
- (281) STATE ROUTE
- [30] U.S. ROUTE
- G0001 ■ ON-POST GROUNDWATER MONITORING WELL
- NW082 OR CA211 ■ OFF-POST GROUNDWATER MONITORING WELL
- ● ON-POST PIEZOMETER
- ■ HORIZONTAL EXTENT OF TNT (CONCENTRATIONS >2µg/L)–MARCH 2000

NOTE:

1. ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
2. ALL OFF-POST MONITORING WELLS WERE SAMPLED AND ANALYZED FOR TNT. DETECTED TNT CONCENTRATIONS ARE SHOWN. ALL OTHER OFF-POST WELLS WERE "NON-DETECT" FOR TNT.

0 3000 6000
SCALE FEET

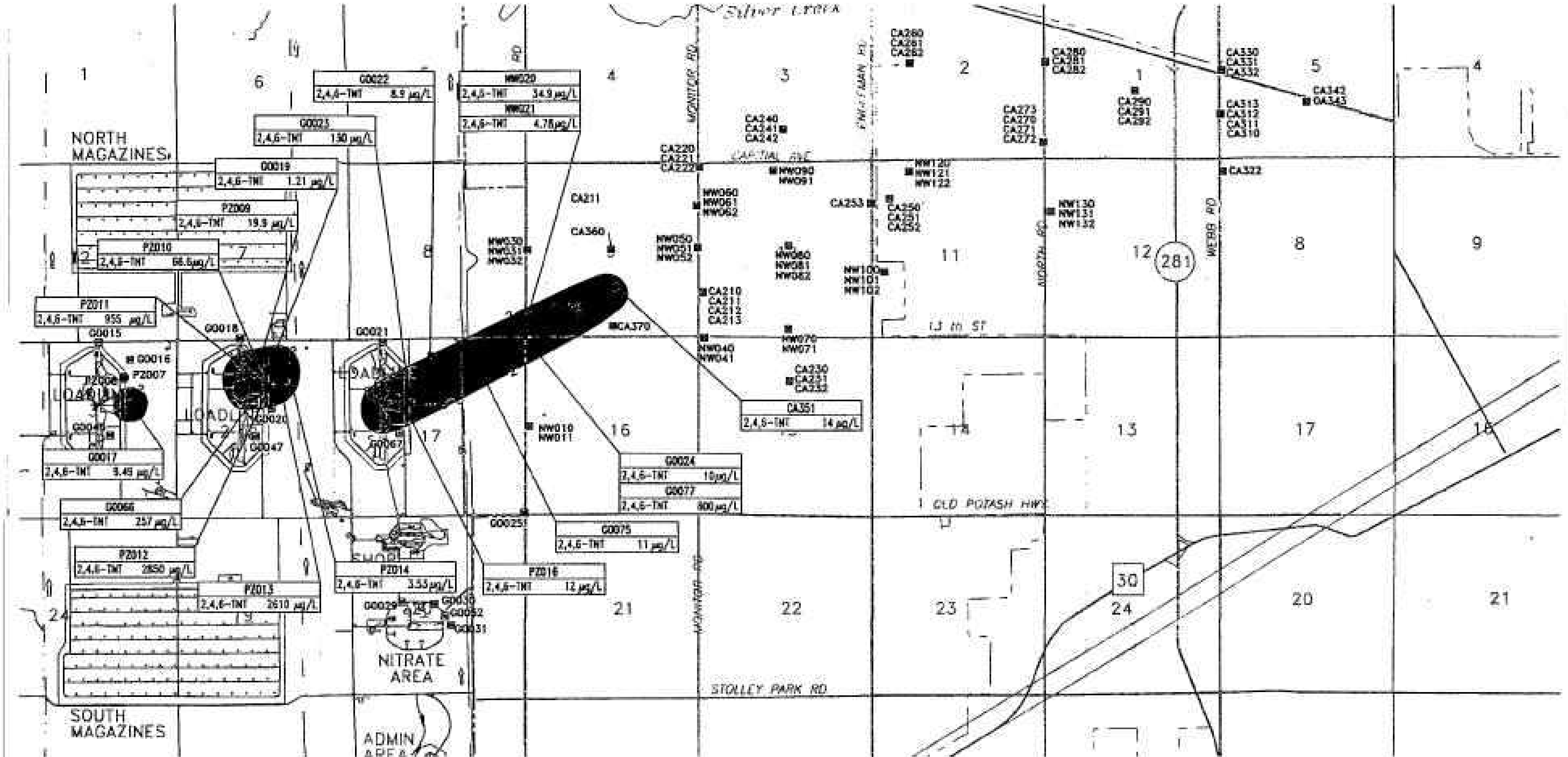
N

URS

TNT PLUME – MARCH 2000

DRN. BY: DAP	DATE: 05/19/00	PROJECT NO. 46-F00K9642.00	FIG. NO. 5-8
CHK'D. BY:	REVISION: 0		

June 27, 2000 8:57:24 a.m.
Drawing: T:\CAAP\T01.05.2\F5-7_T01.DWG (DAP)
Xrefs: BASE.DWG



LEGEND:

- FACILITY BOUNDARY
- GRAND ISLAND CITY LIMITS
- DRAINAGE DITCH FLOW DIRECTION
- SURFACE DRAINAGE
- (281) STATE ROUTE
- [30] U.S. ROUTE
- G0001 ■ ON-POST GROUNDWATER MONITORING WELL
- NW082 OR CA211 ■ OFF-POST GROUNDWATER MONITORING WELL
- ● ON-POST PIEZOMETER
- ■ HORIZONTAL EXTENT OF TNT (CONCENTRATIONS >2µg/L)–MARCH 1999

NOTE:

1. ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
2. ALL OFF-POST MONITORING WELLS WERE SAMPLED AND ANALYZED FOR TNT. DETECTED TNT CONCENTRATIONS ARE SHOWN. ALL OTHER OFF-POST WELLS WERE "NON-DETECT" FOR TNT.

SCALE 0 3000 6000 FEET

N

URS

TNT PLUME – MARCH 1999

DSN. BY: TSSM	DATE: 08/12/99	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	49-F00K0642.00	5-9

June 07, 2000 5:10:10 p.m.
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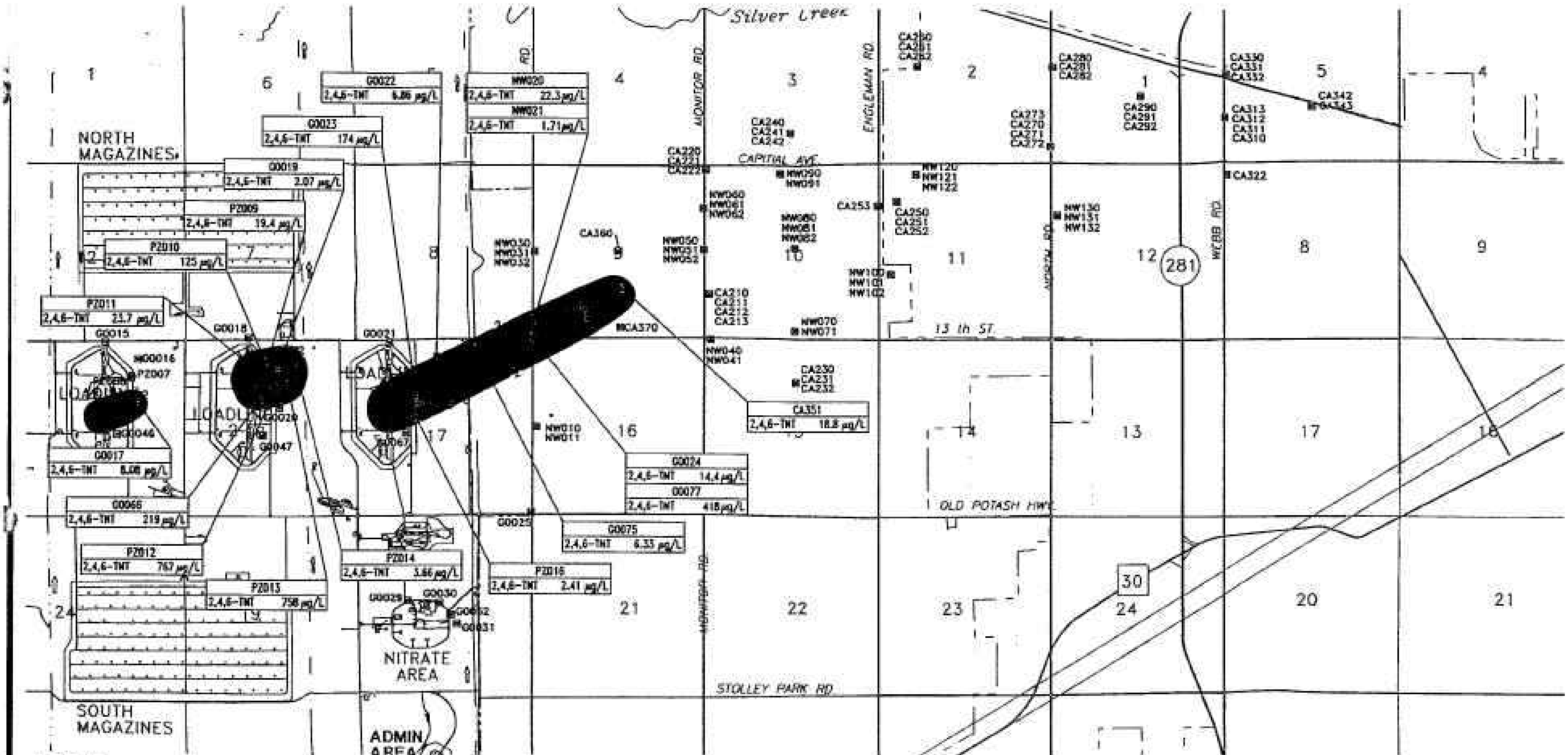
Xrefs: BASE.DWG



LEGEND:

- FACILITY BOUNDARY
- GRAND ISLAND CITY LIMITS
- DRAINAGE DITCH FLOW DIRECTION
- SURFACE DRAINAGE
- (281) STATE ROUTE
- [30] U.S. ROUTE
- G0001 ON-POST GROUNDWATER MONITORING WELL
- NW082 or CA211 OFF-POST GROUNDWATER MONITORING WELL
- ON-POST PIEZOMETER
- HORIZONTAL EXTENT OF TNT (CONCENTRATIONS >2µg/L)-JUNE 1998

NOTE:

1. ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
2. ALL OFF-POST MONITORING WELLS WERE SAMPLED AND ANALYZED FOR TNT. DETECTED TNT CONCENTRATIONS ARE SHOWN. ALL OTHER OFF-POST WELLS WERE "NON-DETECT" FOR TNT.

0 3000 6000
SCALE FEET

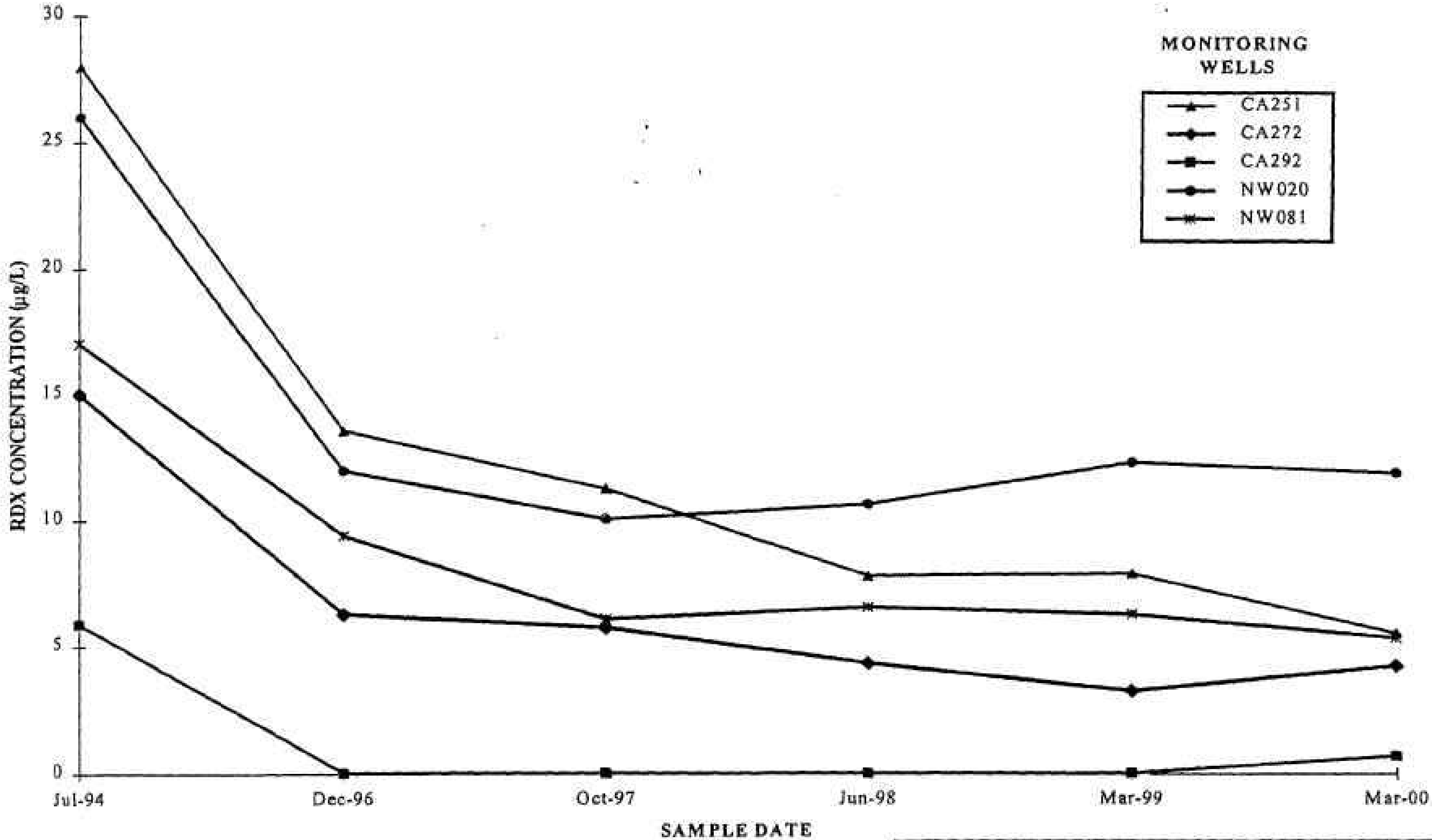
N

URS

TNT PLUME – JUNE 1998

DRN. BY: TSSM	DATE: 06/12/99	PROJECT NO.	FIG. NO.
CHK'D BY:	REVISION: 0	49-F00K0642.00	5-10

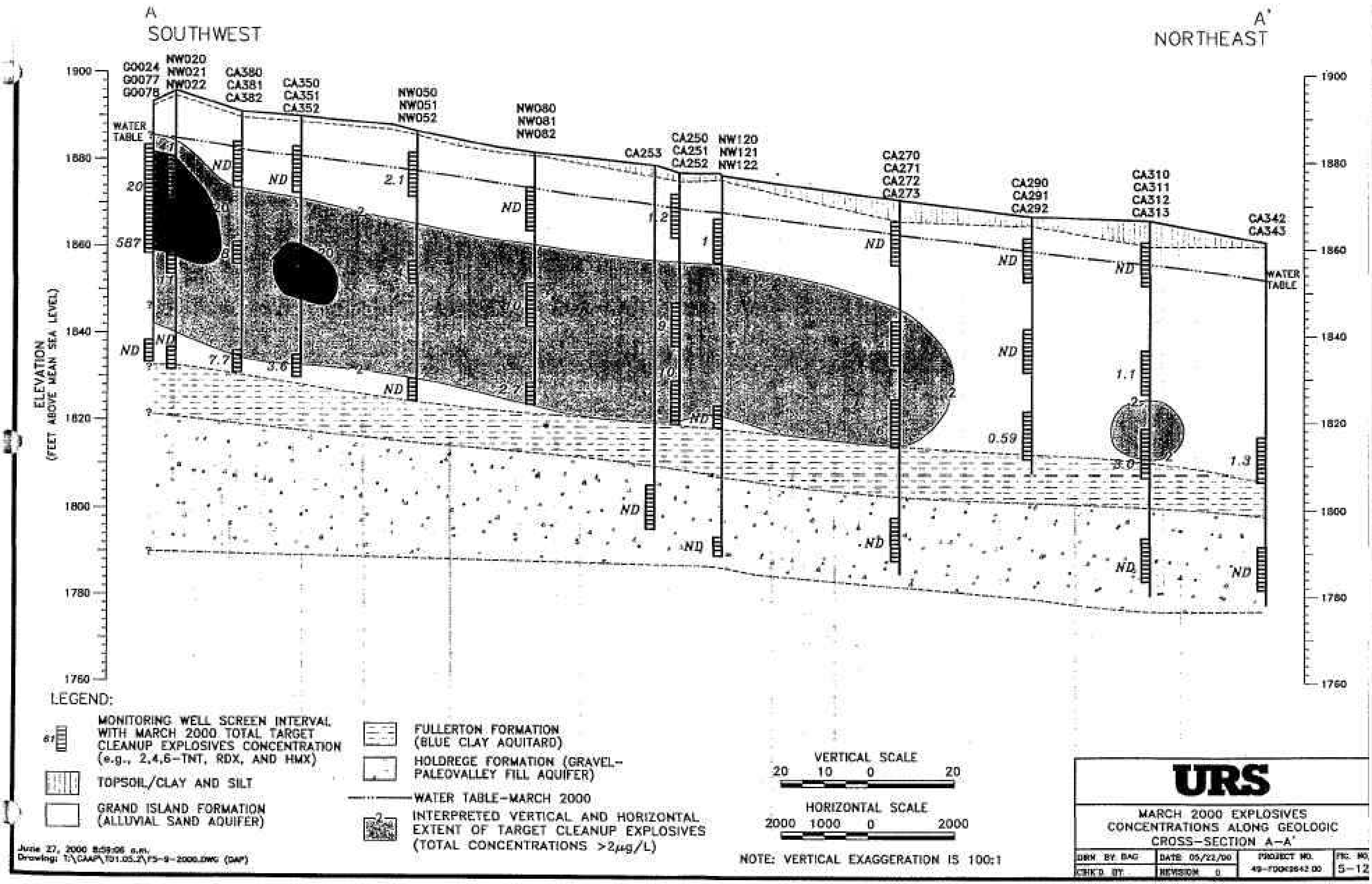
June 07, 2000 5:14:11 p.m.
Drawing: T:\CAAP\T01.05.2\F5-8_T01.05.2.DWG (BAG)
Xrefs: BASE.DWG



URS

RDX CONCENTRATION TRENDS IN SELECTED OFF-POST MONITORING WELLS

DRN BY: CA	DATE: 6/29/00	PROJECT NO.	FIG NO.
CHK'D BY:	DATE:	49F00K9642	5-11



A
SOUTHWEST
A'
NORTHEAST
G0024
G0077
G0078
NW020
NW021
NW022
CA380
CA381
CA382
CA350
CA351
CA352
NW050
NW051
NW052
NW080
NW081
NW082
CA253
CA250
CA251
CA252
NW120
NW121
NW122
CA270
CA271
CA272
CA273
CA290
CA291
CA292
CA310
CA311
CA312
CA313
CA342
CA343
WATER TABLE
ELEVATION (FEET ABOVE MEAN SEA LEVEL)
1900
1880
1860
1840
1820
1800
1780
1760
20
587
ND
2.1
1.2
1
0.59
1.1
3.0
1.3
7.7
3.6
2.7
LEGEND:
MONITORING WELL SCREEN INTERVAL WITH MARCH 2000 TOTAL TARGET CLEANUP EXPLOSIVES CONCENTRATION (e.g., 2,4,6-TNT, RDX, AND HMX)
TOPSOIL/CLAY AND SILT
GRAND ISLAND FORMATION (ALLUVIAL SAND AQUIFER)
FULLERTON FORMATION (BLUE CLAY AQUITARD)
HOLDREGE FORMATION (GRAVEL-PALEOVALLEY FILL AQUIFER)
WATER TABLE-MARCH 2000
INTERPRETED VERTICAL AND HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (TOTAL CONCENTRATIONS >2µg/L)
VERTICAL SCALE
20 10 0 20
HORIZONTAL SCALE
2000 1000 0 2000
NOTE: VERTICAL EXAGGERATION IS 100:1
URS
MARCH 2000 EXPLOSIVES CONCENTRATIONS ALONG GEOLOGIC CROSS-SECTION A-A'
DRN BY BAG
DATE 05/22/00
PROJECT NO. 49-FD0K3642.00
FIG. NO. 5-12
CHK'D BY
REVISION 0
June 27, 2000 8:59:06 a.m.
Drawing: T:\CAAP\T01.05.2\F5-9-2000.DWG (DAP)

TABLE 5-1

HIGHEST HISTORICAL OFF-POST PLUME EXPLOSIVES CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

	Highest Off-Post Concentrations[1]					
Compound Detected (μg/L)	**March 2000**	**March 1999**	**June 1998**	**Oct 1997**	**Dec 1996**	**July 1994**
Cyclonite (RDX)	12 (16)[2]	12.4 (12.0)[2]	10.7 (13.5)[2]	11.3	13.6	28
2,4,6-Trinitrotoluene (TNT)	25 (17)[2]	34.9	22.3	22.8	30	23
Cyclotetramethylenetetranitramine (HMX)	4.8 (6.6)[2]	3.8 (5.9)[2]	4.3 (14.8)[2]	4.07	4.9	9.54
1,3,5-Trinitrobenzene (TNB)	0.77	0.793	ND	1.24	1.2	1.54
2,4-Dinitrotoluene (2,4-DNT)	ND (2.8)[2]	ND (2.4)[2]	3.78	0.753	0.78	0.311
2-Amino-4,6-Dinitrotoluene (2-Am-DNT)	8.9 (56)[2]	9.15 (42)[2]	8.0 (53.4)[2]	10.4	13	12
4-Amino-2,6-Dinitrotoluene (4-Am-DNT)	6.4 (42)[2]	6.26 (33)[2]	5.9 (49.4)[2]	7.15	10.8	NA

[1] Includes off-post plume wells only.
[2] Concentrations measured in new feed lot well clusters (installed May 1998 and December 1999) were often higher than other off-post locations, and are shown in parentheses.

- Redox potentials within the Grand Island Formation aquifer off post were lower at the base of the aquifer than the water table and shallow-intermediate depths. Shallow wells averaged 170 mV, shallow-intermediate wells averaged 156 mV, and intermediate wells averaged 111 mV (**Table 6-1**).

- DO concentrations within the Grand Island Formation aquifer off post were generally lower at depth than at the water table surface. Shallow wells averaged about 3.8 mg/L, shallow-intermediate wells averaged 2.3 mg/L, and intermediate wells averaged 1.1 mg/L (**Table 6-1**).

- Fe2+ concentrations within the Grand Island Formation aquifer off post were negligible. Average values were 0.10 mg/L (shallow), 0.06 mg/L (shallow-intermediate), and 0.26 mg/L (intermediate) (**Table 6-1**).

- Within the deeper Holdrege Formation aquifer, redox potentials were low (average of -40 mV), DO values were low (average of 0.59 mg/L), and Fe2+ was consistently detected at low levels (average 0.53 mg/L).

- Many of the on-post natural attenuation parameter results (both field and laboratory) were inconclusive. The sporadic nature of the contaminant occurrences (isolated sources) make interpretation of the natural attenuation parameter results somewhat problematic.

6.2.2 Off-Post Plume/On-Post Source Area Trends

Most parameters were similar to the sitewide parameters, except in areas of higher contamination levels (mostly on-post at LL1 and LL2 and the feedlot area). The trends included:

- Redox potentials near the LL2 source were generally lower (averaging less than 100 mV) than background areas (greater than 100 mV) (see **Figure 6-2a**).

- DO concentrations near LL2 source area and within the off-post plume were generally lower (most below 2 mg/L) than background areas (greater than 2 mg/L) (see **Figure 6-3a**). There was an area of anomalously high DO concentrations within the LL1 source area. The increase in DO concentrations may be the result of the soil removal action completed in this area.

- On-post NO3+ NO2 concentrations were generally lower (less than 10 mg/L) in areas with significant explosives concentrations (e.g., near LL2) than in background areas (mostly greater than 10 mg/L) (see **Figure 6-4a**).

- Excluding the feedlot area, the interpretation of off-post plume area trends is currently inconclusive. Off-post explosives concentrations in the low ug/L levels may not be high enough to significantly alter the overall water chemistry of the aquifer, especially when the natural attenuation parameters are typically measured at mg/L levels.

6.2.3 Feedlot Area Trends

Most parameter results indicated the groundwater underlying and just downgradient of the feedlot area was significantly different than background areas and other off- post plume areas (see **Tables 6-1 and 6-2 and Figures 6-1 through 6-4**). The data indicates that the feedlot area has highly reducing conditions which appear to have facilitated anaerobic degradation processes. Significant trends were as follows:

- Redox potentials within the Grand Island Formation aquifer underlying and downgradient of the feedlot area were much lower than other areas. Shallow wells averaged -89 mV, shallow-intermediate wells averaged 3 mV, and intermediate wells averaged -58 mV (**Table 6-1**). **Figures 6-2a and 6-2b** indicate a zone of reducing conditions that extends from the water table surface to the base of the aquifer underneath the feedlot area.

- DO concentrations beneath the feedlot area were generally less than other areas (see **Figure 6-3a and 6-3b**). Shallow wells averaged about 0.81 mg/L, shallow-intermediate wells averaged 0.29 mg/L, and intermediate wells averaged 0.27 mg/L (**Table 6-1**).

- NO3+ NO2 concentrations were significantly lower in the feedlot area (generally less than 1.0 mg/L) than other areas (mostly greater than 10 mg/L) (see **Figure 6-4a**). **Figure 6-4b** indicates NO3+ NO2 concentrations lower than background throughout the water column in the feedlot area. Additionally, TKN and ammonia concentrations in the shallow feedlot wells (average values of 45.7 and 39.5 mg/L, respectively) were significantly elevated above other areas (average values of 0.14 mg/L and 0.10 mg/L, respectively). These differences indicate significant denitrification is occurring in the feedlot area.

- Fe2+ concentrations in the shallow feedlot wells (average 15.7 mg/L) were significantly higher than shallow wells in other areas (average 0.1 mg/L), indicating Fe3+ reduction is occurring in the feedlot area.

- Methane concentrations in the shallow feedlot wells (average 1,757 ug/L) are elevated above shallow wells in other areas (average 14.6 ug/L), indicating methanogenesis is occurring in the feedlot area.

- Alkalinity, CO2, DOC, and conductivity values in the shallow feedlot wells (average 560 mg/L, 246 mg/L, 77.0 mg/L, and 1,924 mS/cm, respectively) were elevated above other areas (average 159 mg/L, 69.4 mg/L, 8.4 mg/L, and 700 mS/cm, respectively).

6.3 ANAEROBIC DEGRADATION PROCESSES IDENTIFICATION

The data indicates groundwater chemical conditions are favorable for anaerobic degradation to occur within the explosives plumes, especially in the feedlot area and near LL2. TNT degradation products (e.g., 2-Am-DNT-and 4-Am-DNT) were present in samples collected in the on-post source areas and the off-post feedlot area. RDX degradation products (e.g., MNX, DNX, and TNX) were detected by Spalding (1998) in the feedlot area. Spalding's (1998) report was included as Appendix F to the March 1999 Annual Report (URSGWCFS 1999).

Anaerobic degradation processes proceed in an order of preference based on the amount of energy yielded by the reaction. The order of preference is denitrification, Fe3+ reduction, sulfate reduction, and then methanogenesis (Stumm and Morgan 1981, Bouwer 1994). The data indicates that denitrification is the main anaerobic degradation process occurring in the feedlot area and near LL2. The other anaerobic degradation processes (e.g., Fe3+ reduction, sulfate reduction, and methanogenesis) are also occurring in the feedlot area, but to a lesser extent.

The conditions favoring denitrification at CHAAP include:

- Abundant supply of nitrate in the aquifer from fertilizer applications sitewide and urea at the feedlot

- High organic carbon content in the aquifer underlying the feedlot

- Anaerobic/reducing conditions in groundwater underlying the feedlot. Denitrification will occur at redox values as high as 740 mV (Bouwer 1994).

- Probable presence of denitrifying bacteria in the feedlot and potentially sitewide

6.4 DEGRADATION RATE ESTIMATION

As part of the natural attenuation evaluation at CHAAP, URS completed Groundwater Contaminate Fate and Transport Modeling (URSGWCFS 2000b). For the modeling evaluations, first-order decay rates were estimated for RDX, TNT, and HMX. Decay rate constants represent loss of contaminant mass due to biotic decay processes (e.g., biodegradation) and abiotic decay processes (e.g., hydrolysis and evaporation). The decay rates were estimated using the following three methods:

- Graves (1995) using single well estimates and concentrations over time
- Graves (1995) using multiple well estimates and concentrations along the groundwater flow path
- Buscheck and Alcantar (1995) using multiple well estimates and concentrations along the groundwater flow path

Decay rate constants were converted into degradation half-lives. **Table 6-3** presents the estimated degradation half-lives used to complete the fate and transport modeling. Methodology, data, and calculations used to estimate degradation half- lives are included in the modeling report (URSGWCFS 2000b). Half- lives were estimated for three separate geographic areas based on the spatial relationship to the explosives plume and the feedlot. Estimated average half-lives were as follows:

- LL 1 (source area): RDX – 5.7 years, TNT – 5.7 years, and HMX – 7.2 years
- Feedlot (off post): RDX – 4.3 years, TNT – 2.5 years, and HMX – 0.6 years
- Distal off-post plume: RDX – 8.9 years, and HMX – 8.0 years

Generally, the modeling results indicated, if continuing on-post sources are contained, the current contaminant concentrations in the off-post plume (feedlot and distal plume areas) may be degraded to below the target cleanup goals in less than 20 years without distal. well pumping. This is a similar timeframe to that expected using the off-post pump-and-treat remedial action proposed in the ROD (e.g., 20 to 30 years). The half-live estimates for CHAAP are within the range of published literature values for explosives (USACE WES 1997, 1998, 1999).

6.5 NATURAL ATTENUATION SUMMARY

The preliminary evaluation indicates natural attenuation of explosives in groundwater may be occurring at CHAAP. The key elements that support the use of natural attenuation at CHAAP include:

- RDX and TNT concentrations in the off-post plume have decreased steadily over time.
- Significant denitrification is occurring in the feedlot area which is facilitating explosives degradation as the plume migrates through this area. The feedlot area subsurface zone is functioning as an in-situ anaerobic/reducing treatment cell.
- Explosives degradation products are present, including RDX degradation products (e.g., MNX, DNX, and TNX from Spalding [1998]) and TNT breakdown products (e.g., 2-Am-DNT and 4-Am-DNT).
- The fate and transport modeling results indicate off-post explosives plume is degrading at a sufficient rate to achieve cleanup goals within the timeframe expected using an off-post pump-and-treat remedial action.

- Other anaerobic degradation processes (e.g., Fe reduction, methanogenesis, and sulfate reduction) are also occurring in the feedlot area, but to a lesser extent.

- The on-post explosives soil source areas have been removed.

- No further migration of on-post explosives contamination is expected because groundwater explosives source areas will be contained with the on- post groundwater extraction system.

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	Redox (mV)				DO (mg/L)				NO_3+NO_2 (mg/L)				Ammonia (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells																
NW010	205	179	139	**174**	1.91	2.80	4.22	**2.98**	7.7	6.9	5.5	**6.7**	ND	ND	ND	**ND**
NW020	99	89	110	**99**	3.22	1.63	2.62	**2.49**	21.7	10.7	18.0	**16.8**	ND	ND	ND	**ND**
NW030	145	150	105	**133**	0.41	2.54	2.38	**1.78**	9.8	12.3	12.7	**11.6**	1.3	ND	ND	**0.4**
NW040	150	143	176	**156**	0.58	0.60	1.91	**1.03**	8.7	20.3	38.1	**22.4**	0.039	ND	ND	**0.01**
NW050	129	131	125	**128**	1.89	2.99	2.17	**2.35**	98.2	94.5	70.4	**87.7**	ND	ND	ND	**ND**
NW060	96	241	138	**158**	5.97	8.09	9.67	**7.91**	25.5	14.2	20.5	**20.1**	ND	ND	ND	**ND**
NW070	-4	240	47	**94**	0.29	1.35	0.17	**0.60**	ND	7.2	ND	**2.4**	0.072	ND	ND	**0.02**
NW080	185	295	204	**228**	6.77	6.64	8.00	**7.14**	45.5	35.7	35.6	**38.9**	ND	ND	ND	**ND**
NW090	128	219	129	**159**	2.66	0.94	1.72	**1.77**	25.8	26.8	12.1	**21.6**	0.11	ND	ND	**0.04**
NW100	249	302	184	**245**	4.16	4.69	4.98	**4.61**	80.7	72.2	89.1	**80.7**	0.033	ND	ND	**0.01**
NW120	40	105	110	**85**	0.57	0.44	0.35	**0.45**	6.5	7.1	8.9	**7.5**	1.48	2.05	1.29	**1.61**
NW130	166	302	145	**204**	5.97	5.66	7.60	**6.41**	10.1	6.6	8.3	**8.3**	ND	ND	ND	**ND**
CA210	151	261	168	**193**	1.85	2.52	1.55	**1.97**	67.0	60.4	47.6	**58.3**	0.024	ND	ND	**0.01**
CA220	175	175	106	**152**	1.03	2.59	3.13	**2.25**	7.8	6.9	7.5	**7.4**	0.026	ND	ND	**0.01**
CA230	142	225	149	**172**	3.67	6.25	5.69	**5.20**	21.9	24.1	12.2	**19.4**	0.053	ND	ND	**0.02**
CA240	224	312	161	**232**	6.21	8.01	9.89	**8.04**	71.9	48.0	40.4	**53.4**	0.052	ND	ND	**0.02**
CA250	194	317	155	**222**	6.26	4.75	6.40	**5.80**	15.2	18.5	16.2	**16.6**	ND	ND	ND	**ND**
CA260	172	319	152	**214**	3.68	5.18	5.89	**4.92**	23.9	15.0	12.1	**17.0**	0.071	ND	ND	**0.02**
CA270	181	231	149	**187**	2.59	1.83	2.88	**2.43**	6.8	4.4	5.6	**5.6**	ND	ND	ND	**ND**
CA280	132	221	163	**172**	5.41	7.34	8.12	**6.96**	7.2	1.9	2.4	**3.8**	ND	ND	ND	**ND**
CA290	206	300	159	**222**	4.25	3.57	5.14	**4.32**	30.1	26.6	36.9	**31.2**	0.19	ND	ND	**0.06**
CA310	-22	216	113	**102**	1.78	2.31	3.60	**2.56**	4.9	9.8	NS	**7.4**	0.045	ND	NS	**0.02**
CA330	111	289	124	**175**	2.11	4.80	6.14	**4.32**	5.7	5.8	4.9	**5.5**	ND	ND	ND	**ND**
Ave	**141**	**229**	**140**	**170**	**3.18**	**3.81**	**4.53**	**3.84**	**26.2**	**23.2**	**22.9**	**23.9**	**0.15**	**0.09**	**0.06**	**0.10**
Shallow Feedlot Wells																
CA350	-72	-66	-68	**-69**	1.06	0.30	0.37	**0.58**	0.2	ND	1.5	**0.6**	0.245	0.177	0.431	**0.28**
CA360	-169	-164	-161	**-165**	3.47	0.22	0.29	**1.33**	ND	ND	ND	**ND**	88.3	93.4	72.2	**84.6**
CA370	-148	NS	NS	**-148**	0.98	NS	NS	**0.98**	ND	NS	NS	**ND**	29.5	NS	NS	**29.5**
CA380	-147	-150	-143	**-147**	2.01	0.25	0.27	**0.84**	ND	ND	ND	**ND**	66.8	94.5	86.8	**82.7**
CA390	NS	NS	85	**85**	NS	NS	0.32	**0.32**	ND	NS	7.6	**7.6**	NS	NS	0.531	**0.53**
Ave	**-134**	**-127**	**-72**	**-89**	**1.88**	**0.26**	**0.31**	**0.81**	**0.1**	**ND**	**2.3**	**1.6**	**46.2**	**62.7**	**40.0**	**39.5**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well	Redox (mV)				DO (mg/L)				NO_3+NO_2 (mg/L)				Ammonia (mg/L)			
Number	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow-Int Wells																
NW011	81	281	122	**161**	0.30	2.79	1.20	**1.43**	3.0	3.2	5.6	**3.9**	ND	ND	ND	**ND**
NW021	41	220	76	**112**	4.97	0.72	0.27	**1.99**	2.5	1.4	0.6	**1.5**	ND	ND	ND	**ND**
NW031	-35	46	-28	**-6**	0.13	0.40	0.25	**0.26**	0.2	ND	ND	**0.1**	ND	ND	ND	**ND**
NW041	193	200	116	**170**	0.28	0.69	0.40	**0.46**	6.2	12.8	5.8	**8.2**	ND	ND	ND	**ND**
NW051	182	209	42	**144**	0.51	0.30	0.29	**0.37**	30.5	28.8	32.2	**30.5**	0.035	ND	ND	**0.01**
NW061	116	85	60	**87**	0.19	0.47	0.17	**0.28**	ND	ND	ND	**ND**	0.16	0.251	ND	**0.14**
NW071	146	197	134	**159**	1.69	1.19	1.79	**1.56**	11.9	13.4	12.9	**12.7**	ND	ND	ND	**ND**
NW081	172	225	206	**201**	1.90	2.43	3.12	**2.48**	35.5	34.7	44.6	**38.3**	ND	ND	ND	**ND**
NW091	58	139	87	**95**	0.18	0.34	0.48	**0.33**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
NW101	171	220	168	**186**	0.13	0.38	0.12	**0.21**	41.2	58.1	45.9	**48.4**	0.093	ND	ND	**0.03**
NW131	181	240	157	**193**	3.36	3.56	3.46	**3.46**	20.9	19.5	21.7	**20.7**	ND	ND	ND	**ND**
CA211	109	107	141	**119**	0.43	0.43	0.39	**0.42**	30.5	31.4	37.6	**33.2**	ND	ND	ND	**ND**
CA221	174	179	77	**143**	0.19	0.35	0.22	**0.25**	1.5	2.4	2.0	**1.9**	ND	ND	ND	**ND**
CA231	198	226	139	**188**	3.13	3.70	5.10	**3.98**	26.1	23.3	19.3	**22.9**	0.053	ND	ND	**0.02**
CA241	181	155	150	**162**	3.24	5.15	6.47	**4.95**	24.0	23.0	26.7	**24.6**	ND	ND	ND	**ND**
CA251	193	218	164	**192**	5.42	5.30	5.87	**5.53**	21.2	20.4	20.8	**20.8**	ND	ND	ND	**ND**
CA261	227	211	155	**198**	4.01	5.70	5.61	**5.11**	57.1	26.7	31.0	**38.3**	ND	ND	ND	**ND**
CA271	192	250	154	**199**	3.41	3.43	4.47	**3.77**	10.9	9.2	12.0	**10.7**	ND	ND	ND	**ND**
CA281	175	291	164	**210**	2.39	2.44	4.57	**3.13**	11.7	11.5	12.5	**11.9**	ND	ND	ND	**ND**
CA291	125	227	167	**173**	2.97	4.47	6.30	**4.58**	19.4	27.6	24.7	**23.9**	0.026	ND	ND	**0.01**
CA311	85	255	127	**156**	4.27	1.89	2.85	**3.00**	13.6	12.5	14.6	**13.6**	ND	ND	ND	**ND**
CA331	154	265	131	**183**	3.07	3.47	4.56	**3.70**	13.0	12.4	14.0	**13.1**	0.032	ND	ND	**0.01**
Ave	**142**	**202**	**123**	**156**	**2.10**	**2.25**	**2.63**	**2.33**	**17.3**	**16.9**	**17.5**	**17.2**	**0.02**	**0.01**	**ND**	**0.01**
Shallow-Int Feedlot Wells																
CA351	69	76	79	**75**	0.75	0.17	0.32	**0.41**	2.7	1.9	1.5	**2.0**	0.05	ND	ND	**0.02**
CA361	NS	NS	-163	**-54**	NS	NS	0.25	**0.25**	NS	NS	ND	**ND**	NS	NS	59.2	**59.2**
CA381	NS	NS	-36	**-12**	NS	NS	0.21	**0.21**	NS	NS	ND	**ND**	NS	NS	4.48	**4.48**
Ave	**69**	**76**	**-40**	**3**	**0.75**	**0.17**	**0.26**	**0.29**	**2.7**	**1.9**	**0.5**	**0.7**	**0.1**	**ND**	**21.2**	**21.2**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	Redox (mV)				DO (mg/L)				NO_3+NO_2 (mg/L)				Ammonia (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Intermediate Wells																
NW022	-108	-59	-63	**-77**	0.33	0.36	0.35	**0.35**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
NW032	-103	-54	-98	**-85**	0.67	0.50	0.33	**0.50**	ND	ND	ND	**ND**	0.052	ND	ND	**0.02**
NW052	-132	-112	-83	**-109**	0.20	0.27	0.25	**0.24**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
NW062	204	-100	-84	**7**	0.42	0.29	0.26	**0.32**	ND	ND	ND	**ND**	ND	0.365	0.201	**0.19**
NW082	209	235	118	**187**	0.59	0.80	0.34	**0.58**	28.0	27.2	40.0	**31.7**	ND	ND	ND	**ND**
NW102	156	240	158	**185**	0.94	1.34	1.38	**1.22**	34.4	34.1	31.6	**33.4**	ND	ND	ND	**ND**
NW121	-63	76	65	**26**	0.64	0.36	0.25	**0.42**	1.1	ND	ND	**0.4**	ND	ND	ND	**ND**
NW132	187	231	147	**188**	0.82	0.53	1.29	**0.88**	25.4	25.8	35.7	**29.0**	ND	ND	ND	**ND**
CA212	74	227	85	**129**	0.63	0.28	0.20	**0.37**	13.0	8.9	13.3	**11.7**	ND	ND	ND	**ND**
CA222	-41	-13	-43	**-32**	0.09	0.50	0.23	**0.27**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
CA232	115	256	128	**166**	2.65	3.96	3.92	**3.51**	8.6	8.3	9.1	**8.7**	ND	ND	ND	**ND**
CA242	161	262	128	**184**	0.51	0.40	0.50	**0.47**	1.2	2.1	2.4	**1.9**	ND	ND	ND	**ND**
CA252	252	295	154	**234**	0.89	0.61	0.77	**0.76**	21.3	19.2	20.1	**20.2**	ND	ND	ND	**ND**
CA262	162	248	137	**182**	0.87	1.98	2.02	**1.62**	9.1	12.8	10.5	**10.8**	0.032	ND	ND	**0.01**
CA272	191	212	100	**168**	0.40	0.49	1.12	**0.67**	6.6	6.3	8.8	**7.2**	ND	ND	ND	**ND**
CA282	93	215	149	**152**	1.59	2.41	3.41	**2.47**	16.9	14.9	12.5	**14.8**	ND	ND	ND	**ND**
CA292	115	247	157	**173**	0.42	0.31	1.16	**0.63**	7.4	6.3	6.2	**6.7**	ND	ND	ND	**ND**
CA312	149	216	109	**158**	0.83	1.25	2.30	**1.46**	12.0	11.1	12.5	**11.9**	ND	ND	ND	**ND**
CA322	162	269	141	**191**	1.92	2.14	2.51	**2.19**	15.4	15.1	15.5	**15.3**	0.078	ND	ND	**0.03**
CA332	107	238	123	**156**	2.31	1.80	1.57	**1.89**	10.7	9.3	9.5	**9.8**	ND	ND	ND	**ND**
CA342	104	211	110	**142**	2.31	1.69	2.29	**2.10**	14.7	15.4	14.1	**14.7**	ND	ND	ND	**ND**
Ave	**95**	**159**	**78**	**111**	**0.95**	**1.06**	**1.26**	**1.09**	**10.7**	**10.3**	**11.5**	**10.9**	**0.01**	**0.02**	**0.01**	**0.01**
Int Feedlot Wells																
CA352	-64	-80	-46	**-63**	0.59	0.24	0.28	**0.37**	ND	ND	ND	**ND**	0.03	ND	ND	**0.01**
CA362	NS	NS	-140	**-140**	NS	NS	0.20	**0.20**	NS	NS	ND	**ND**	NS	NS	5.5	**5.5**
CA382	NS	NS	28	**28**	NS	NS	0.24	**0.24**	NS	NS	ND	**ND**	NS	NS	ND	**ND**
Ave	**-64**	**-80**	**-53**	**-58**	**0.59**	**0.24**	**0.24**	**0.27**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**ND**	**1.8**	**1.8**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	Redox (mV)				DO (mg/L)				NO_3+NO_2 (mg/L)				Ammonia (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Deep Wells																
NW122	-111	-71	-101	**-94**	0.58	0.30	0.29	**0.39**	1.0	ND	ND	**0.3**	0.85	ND	ND	**0.28**
CA213	-129	-79	-82	**-97**	0.15	0.35	0.19	**0.23**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
CA253	-79	-53	-82	**-71**	0.07	0.23	0.24	**0.18**	ND	ND	ND	**ND**	0.11	ND	ND	**0.04**
CA273	-83	-58	-121	**-87**	0.17	1.38	0.21	**0.59**	ND	ND	ND	**ND**	0.071	ND	ND	**0.02**
CA313	-42	-31	-94	**-56**	0.51	0.73	0.25	**0.50**	ND	ND	ND	**ND**	0.026	0.112	0.232	**0.12**
CA343	97	267	128	**164**	1.32	2.27	1.30	**1.63**	11.1	11.5	11.7	**11.4**	ND	ND	ND	**ND**
Ave	**-58**	**-4**	**-59**	**-40**	**0.47**	**0.88**	**0.41**	**0.59**	**2.0**	**1.9**	**2.0**	**2.0**	**0.18**	**0.02**	**0.04**	**0.08**

Notes:

DO - Dissolved Oxygen

TKN - Total Kjeldahl Nitrogen

NO2+NO3 - Nitrate plus Nitrite

CO2 - Carbon Dioxide

DOC - Dissolved Organic Carbon

NS - Not Sampled

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	TKN (mg/L)				DOC (mg/L)				CO_2 (mg/L)				Methane (ug/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells																
NW010	ND	ND	0.160	**0.05**	12.6	7.2	ND	**6.6**	54.6	52.8	44.4	**50.6**	ND	ND	ND	**ND**
NW020	ND	ND	ND	**ND**	8.4	9.0	7.5	**8.3**	99.0	124	127	**116.7**	ND	ND	ND	**ND**
NW030	1.24	ND	0.112	**0.45**	9.5	ND	ND	**3.2**	50.6	71.3	67.8	**63.2**	274	ND	ND	**91**
NW040	ND	ND	0.278	**0.09**	5.6	11.6	6.8	**8.0**	14.1	15.4	17.7	**15.7**	1.23	ND	ND	**0.41**
NW050	ND	ND	0.159	**0.05**	8.7	12.2	5.2	**8.7**	60.3	62.5	71.3	**64.7**	ND	ND	ND	**ND**
NW060	0.042	ND	ND	**0.01**	6.9	12.1	ND	**6.3**	17.5	19.8	19.9	**19.1**	1.43	127	ND	**42.81**
NW070	0.89	ND	2.67	**1.19**	15.6	19.8	7.8	**14.4**	43.8	75.2	73.5	**64.2**	133	157	210	**167**
NW080	ND	ND	ND	**ND**	8.3	14.7	ND	**7.7**	34.6	42.2	37.8	**38.2**	ND	ND	ND	**ND**
NW090	ND	ND	0.214	**0.07**	16.5	13.0	6.2	**11.9**	79.6	71.7	84.5	**78.6**	41.2	33.8	16	**30.3**
NW100	ND	ND	ND	**ND**	7.1	8.1	ND	**5.1**	18.3	11.0	11.1	**13.5**	ND	ND	ND	**ND**
NW120	ND	1.07	1.36	**0.81**	8.8	6.5	13.5	**9.6**	52.8	65.6	66.7	**61.7**	ND	ND	ND	**ND**
NW130	ND	ND	0.132	**0.04**	12.4	15.8	ND	**9.4**	56.3	62.5	85.4	**68.1**	ND	ND	ND	**ND**
CA210	ND	ND	ND	**ND**	13.9	9.9	15.2	**13.0**	70.4	94.2	102	**88.9**	ND	ND	ND	**ND**
CA220	0.036	ND	ND	**0.01**	6.5	12.0	ND	**6.2**	169	208	91.5	**156.2**	3.6	2.91	ND	**2.17**
CA230	ND	ND	0.155	**0.05**	13.8	15.1	6.4	**11.8**	42.9	28.6	40.0	**37.2**	ND	ND	ND	**ND**
CA240	ND	ND	ND	**ND**	7.0	9.5	ND	**5.5**	13.3	29.0	37.8	**26.7**	ND	ND	ND	**ND**
CA250	ND	ND	0.113	**0.04**	7.6	ND	ND	**2.5**	55.0	68.6	71.3	**65.0**	ND	ND	ND	**ND**
CA260	ND	ND	ND	**ND**	5.1	16.4	ND	**7.2**	27.5	44.4	61.2	**44.4**	1.03	ND	ND	**0.34**
CA270	ND	ND	0.221	**0.07**	7.5	12.3	6.2	**8.7**	78.3	58.1	65.6	**67.3**	ND	ND	ND	**ND**
CA280	ND	ND	0.235	**0.08**	6.4	14.7	ND	**7.0**	22.2	22.4	17.8	**20.8**	ND	ND	ND	**ND**
CA290	ND	ND	0.118	**0.04**	7.4	18.1	ND	**8.5**	102	90.2	68.6	**86.9**	ND	ND	ND	**ND**
CA310	0.30	ND	NS	**0.15**	9.7	20.5	NS	**15.1**	191	158	NS	**174.5**	1.22	ND	0.98	**0.73**
CA330	0.050	ND	ND	**0.02**	7.8	17.3	ND	**8.4**	168	196	161	**175.0**	ND	ND	ND	**ND**
Ave	**0.11**	**0.05**	**0.27**	**0.14**	**9.3**	**12.0**	**3.4**	**8.4**	**66.1**	**72.7**	**64.7**	**69.4**	**19.86**	**13.94**	**9.87**	**14.56**
Shallow Feedlot Wells																
CA350	1.09	1.20	1.65	**1.31**	15.7	14.8	18.8	**16.4**	169	200	171	**180**	245	953	720	**639**
CA360	83.3	100	93.8	**92.4**	163.0	169.0	157.2	**163.1**	390	500	222	**371**	3150	2350	2300	**2600**
CA370	45.1	NS	NS	**45.1**	23.0	NS	NS	**23.0**	276	NS	NS	**276**	3160	NS	NS	**3160**
CA380	76.1	98.4	90.6	**88.4**	68.7	88.2	103.6	**86.8**	349	407	183	**313**	3860	1790	1500	**2383**
CA390	NS	NS	1.51	**1.5**	NS	NS	18.7	**18.7**	NS	NS	92.4	**92.4**	NS	NS	ND	**ND**
Ave	**51.4**	**66.5**	**46.9**	**45.7**	**67.6**	**90.7**	**74.6**	**77.0**	**296**	**369**	**167**	**246.4**	**2604**	**1698**	**1130**	**1757**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well	TKN (mg/L)				DOC (mg/L)				CO_2 (mg/L)				Methane (ug/L)			
Number	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow-Int Wells																
NW011	0.036	ND	ND	**0.01**	6.3	9.1	ND	**5.1**	66.4	71.3	68.6	**68.8**	6.01	ND	ND	**2.00**
NW021	ND	ND	0.470	**0.16**	3.9	ND	6.5	**3.5**	99.0	103	96.4	**99.5**	ND	ND	ND	**ND**
NW031	0.17	ND	0.198	**0.12**	5.3	ND	ND	**1.8**	122	129	112	**121.0**	1.01	ND	0.43	**0.48**
NW041	ND	ND	0.1	**0.03**	5.2	7.2	ND	**4.1**	73.0	73.9	74.4	**73.8**	ND	ND	ND	**ND**
NW051	ND	ND	0.132	**0.04**	8.1	8.2	5.0	**7.1**	97.7	102	104	**101.2**	ND	ND	ND	**ND**
NW061	1.27	1.53	ND	**0.93**	19.1	23.8	18.5	**20.5**	155	169	165	**163.0**	127	158	23	**102.7**
NW071	ND	ND	ND	**ND**	7.2	16.9	ND	**8.0**	59.8	61.6	59.0	**60.1**	ND	ND	ND	**ND**
NW081	ND	ND	0.115	**0.04**	11.2	15.5	ND	**8.9**	96.1	78.8	75.7	**83.5**	ND	ND	ND	**ND**
NW091	0.38	ND	0.728	**0.37**	16.7	14.8	6.4	**12.6**	117	120	109	**115.3**	11.7	12.5	ND	**8.1**
NW101	ND	ND	0.100	**0.03**	9.3	7.1	6.5	**7.6**	59.4	54.5	51.0	**55.0**	ND	ND	ND	**ND**
NW131	ND	ND	0.250	**0.08**	10.0	16.0	6.0	**10.7**	36.7	39.6	61.2	**45.8**	ND	ND	ND	**ND**
CA211	ND	ND	ND	**ND**	7.9	8.3	ND	**5.4**	82.3	87.1	82.7	**84.0**	ND	ND	ND	**ND**
CA221	0.20	ND	0.268	**0.16**	6.2	16.3	ND	**7.5**	77.4	81.0	80.5	**79.6**	45.5	46.2	24	**38.6**
CA231	ND	ND	0.107	**0.04**	12.0	18.5	5.6	**12.0**	37.6	36.1	32.3	**35.3**	ND	ND	ND	**ND**
CA241	0.03	ND	0.297	**0.11**	7.4	7.3	ND	**4.9**	45.8	40.9	37.8	**41.5**	ND	ND	ND	**ND**
CA251	ND	ND	0.113	**0.04**	6.9	ND	ND	**2.3**	62.0	68.6	60.7	**63.8**	ND	ND	ND	**ND**
CA261	ND	ND	ND	**ND**	2.9	15.8	ND	**6.2**	49.7	48.0	43.3	**47.0**	ND	ND	ND	**ND**
CA271	ND	ND	0.373	**0.12**	5.4	16.5	ND	**7.3**	71.3	58.1	48.8	**59.4**	1.2	ND	ND	**0.4**
CA281	ND	ND	0.165	**0.06**	7.5	14.5	ND	**7.3**	51.9	48.0	40.0	**46.6**	ND	ND	ND	**ND**
CA291	0.037	ND	0.347	**0.13**	3.8	14.4	ND	**6.1**	39.7	48.4	41.1	**43.1**	ND	ND	ND	**ND**
CA311	ND	ND	0.235	**0.08**	6.6	15.3	ND	**7.3**	127	118	116	**120.3**	ND	ND	ND	**ND**
CA331	0.069	ND	ND	**0.02**	6.8	18.2	ND	**8.3**	75.7	70.8	60.3	**68.9**	ND	ND	ND	**ND**
Ave	**0.10**	**0.07**	**0.18**	**0.12**	**8.0**	**12.0**	**2.5**	**7.5**	**77.4**	**77.6**	**73.6**	**76.2**	**8.75**	**9.85**	**2.16**	**6.92**
Shallow-Int Feedlot Wells																
CA351	0.615	0.825	0.453	**0.63**	9.3	9.9	10.2	**9.8**	132	147	117	**132**	ND	ND	ND	**ND**
CA361	NS	NS	73.7	**73.7**	NS	NS	159.6	**159.6**	NS	NS	194	**194**	NS	NS	2300	**2300**
CA381	NS	NS	4.79	**4.79**	NS	NS	14.9	**14.9**	NS	NS	107	**107**	NS	NS	NS	**NS**
Ave	**0.62**	**0.83**	**26.31**	**26.37**	**9.3**	**9.9**	**61.6**	**61.4**	**132**	**147**	**139**	**144**	**ND**	**ND**	**1150**	**1150**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	TKN (mg/L)				DOC (mg/L)				CO_2 (mg/L)				Methane (ug/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Intermediate Wells																
NW022	ND	ND	0.406	**0.14**	3.0	11.4	5.9	**6.8**	103	96.8	100	**99.9**	1.32	ND	0.64	**0.65**
NW032	03.1	ND	0.294	**0.20**	5.9	ND	ND	**2.0**	113	113	117	**114.3**	1.4	ND	0.88	**0.76**
NW052	0.225	ND	0.895	**0.37**	10.7	10.9	5.4	**9.0**	118	117	122	**119.0**	28.4	29.7	32	**30.0**
NW062	1.58	2.55	2.08	**2.07**	23.5	32.6	16.8	**24.3**	185	207	161	**184.3**	2010	573	450	**1011**
NW082	ND	ND	0.118	**0.04**	7.9	14.1	ND	**7.3**	98.6	94.4	95.5	**96.2**	ND	ND	ND	**ND**
NW102	ND	ND	ND	**ND**	8.9	5.9	ND	**4.9**	50.2	47.1	45.3	**47.5**	ND	ND	ND	**ND**
NW121	0.34	ND	0.591	**0.31**	10.2	ND	18.2	**9.5**	94.2	80.1	156	**110.1**	ND	ND	ND	**ND**
NW132	ND	ND	ND	**ND**	10.0	15.4	5.5	**10.3**	53.7	51.5	45.3	**50.2**	ND	ND	ND	**ND**
CA212	ND	ND	0.161	**0.05**	8.1	8.0	ND	**5.4**	105	97.7	90.6	**97.8**	ND	ND	ND	**ND**
CA222	0.036	ND	0.658	**0.23**	7.2	11.0	ND	**6.1**	94.2	97.2	92.8	**94.7**	87.5	95	82	**88.2**
CA232	ND	ND	ND	**ND**	10.9	25.4	5.4	**13.9**	50.2	51.5	51.0	**50.9**	ND	ND	0.29	**0.10**
CA242	ND	ND	0.106	**0.04**	7.1	ND	ND	**2.4**	81.8	80.5	78.8	**80.4**	1.16	ND	ND	**0.39**
CA252	0.03	ND	0.102	**0.04**	7.2	11.7	5.9	**8.3**	93.3	95.9	91.1	**93.4**	ND	ND	ND	**ND**
CA262	ND	ND	ND	**ND**	4.7	14.3	ND	**6.3**	95.9	102	94.6	**97.5**	1.13	ND	ND	**0.38**
CA272	ND	ND	0.373	**0.12**	5.1	16.1	7.2	**9.5**	75.2	74.4	75.7	**75.1**	ND	ND	ND	**ND**
CA282	ND	ND	0.176	**0.16**	5.7	17.7	ND	**7.8**	56.8	55.9	53.2	**55.3**	ND	ND	ND	**ND**
CA292	ND	ND	0.159	**0.05**	4.0	9.7	ND	**4.6**	63.4	65.1	65.6	**64.7**	ND	ND	ND	**ND**
CA312	0.050	ND	ND	**0.02**	6.1	15.7	ND	**7.3**	68.2	79.6	75.7	**74.5**	ND	ND	ND	**ND**
CA322	ND	ND	0.176	**0.06**	4.5	16.8	ND	**7.1**	75.2	73.9	66.4	**71.8**	1.03	ND	ND	**0.34**
CA332	ND	ND	ND	**ND**	3.0	14.8	ND	**5.9**	51.5	53.2	52.4	**52.4**	ND	ND	ND	**ND**
CA342	ND	ND	ND	**ND**	5.5	15.9	ND	**7.1**	108	129	106	**114.3**	ND	ND	ND	**ND**
Ave	**0.12**	**0.12**	**0.30**	**0.18**	**7.6**	**12.7**	**3.3**	**7.9**	**87.4**	**88.7**	**87.8**	**87.8**	**101.52**	**33.2**	**26.94**	**53.90**
Int Feedlot Wells																
CA352	0.255	0.33	0.172	**0.25**	9.4	16.5	10.4	**12.1**	108	126	96	**110**	2.94	2.31	1.1	**2.12**
CA362	NS	NS	5.91	**5.91**	NS	NS	ND	**ND**	NS	NS	108	**108**	NS	NS	14	**14**
CA382	NS	NS	ND	**ND**	NS	NS	8.8	**8.8**	NS	NS	106	**106**	NS	NS	1.4	**1.4**
Ave	**0.3**	**0.3**	**2.0**	**2.1**	**9.4**	**16.5**	**6.4**	**7.0**	**108**	**126**	**103**	**108**	**2.94**	**2.31**	**5.5**	**5.84**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	TKN (mg/L)				DOC (mg/L)				CO_2 (mg/L)				Methane (ug/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Deep Wells																
NW122	0.030	ND	0.298	**0.11**	8.1	7.0	11.3	**8.8**	80.1	80.1	83.3	**81.2**	1.45	ND	1.3	**0.92**
CA213	ND	ND	0.557	**0.19**	3.9	9.9	ND	**4.6**	65.1	69.1	68.6	**67.6**	2.45	2.98	ND	**1.81**
CA253	ND	ND	0.635	**0.21**	6.8	10.5	ND	**5.8**	78.3	80.5	77.0	**78.6**	1.61	ND	0.91	**0.84**
CA273	0.08	1.00	0.322	**0.47**	5.3	12.4	8.1	**8.6**	87.1	88.9	83.2	**86.4**	1.22	0.651	ND	**0.62**
CA313	0.08	ND	0.694	**0.26**	7.4	17.1	ND	**8.2**	104	89.8	89.3	**94.4**	ND	ND	0.54	**0.18**
CA343	0.11	ND	ND	**0.04**	8.0	16.6	ND	**8.2**	113	136	118	**122.3**	ND	ND	0.95	**0.32**
Ave	**0.05**	**0.17**	**0.42**	**0.21**	**6.6**	**12.3**	**3.2**	**7.4**	**87.9**	**90.7**	**86.6**	**88.4**	**1.12**	**0.61**	**0.62**	**0.78**

Notes:

DO - Dissolved Oxygen

TKN - Total Kjeldahl Nitrogen

NO2+NO3 - Nitrate plus Nitrite

CO2 - Carbon Dioxide

DOC - Dissolved Organic Carbon

NS - Not Sampled

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	Alkalinity (mg/L)				Fe^{2+} (mg/L)				Sulfate (mg/L)				Sulfide (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells																
NW010	124	120	101	**115**	0.01	0.14	0.04	**0.06**	25.2	27.3	19.8	**24.1**	0.36	ND	ND	**0.12**
NW020	291	282	290	**288**	ND	0.07	0.05	**0.04**	45.6	46.1	43.4	**45.0**	ND	ND	ND	**ND**
NW030	115	162	154	**144**	0.15	0.10	0.09	**0.11**	42.6	32.4	31.3	**35.4**	ND	ND	ND	**ND**
NW040	32.1	35	40.3	**36**	0.12	0.15	0.06	**0.11**	15.9	27	37.4	**26.8**	ND	ND	ND	**ND**
NW050	137	142	162	**147**	ND	0.13	ND	**0.04**	82.8	85.6	98.2	**88.9**	ND	ND	ND	**ND**
NW060	39.7	45	45.2	**43**	0.02	0.23	0.22	**0.16**	33.3	39.5	28.2	**33.7**	ND	ND	ND	**ND**
NW070	100	171	167	**146**	0.06	0.08	0.10	**0.08**	3.08	42.2	33.3	**26.2**	ND	ND	ND	**ND**
NW080	78.6	96	85.9	**87**	ND	0.11	0.02	**0.04**	43.4	47.5	44.3	**45.1**	ND	ND	ND	**ND**
NW090	181	163	192	**179**	0.74	0.56	0.09	**0.46**	20.1	43.3	54.2	**39.2**	ND	ND	ND	**ND**
NW100	41.5	25	25.2	**31**	0.03	0.04	ND	**0.02**	57.3	76.1	48.8	**60.7**	ND	ND	ND	**ND**
NW120	120	149	152	**140**	0.04	0.06	0.01	**0.04**	55.8	67.5	81.4	**68.2**	ND	ND	ND	**ND**
NW130	128	142	194	**155**	0.02	0.10	ND	**0.04**	37.9	31.6	40.2	**36.6**	ND	ND	ND	**ND**
CA210	160	214	231	**202**	ND	0.12	0.06	**0.06**	116	107	72.2	**98.4**	ND	ND	ND	**ND**
CA220	384	472	208	**355**	0.10	0.08	0.20	**0.13**	8.25	18.8	11.8	**13.0**	ND	ND	ND	**ND**
CA230	97.4	65	91.0	**84**	0.12	0.11	0.09	**0.11**	61.8	41.2	31.6	**44.9**	ND	ND	ND	**ND**
CA240	30.2	66	85.9	**61**	0.14	0.07	ND	**0.07**	41.6	61.5	72.8	**58.6**	ND	ND	ND	**ND**
CA250	125	156	162	**148**	0.14	0.15	0.05	**0.11**	38.4	56.4	44.7	**46.5**	ND	ND	ND	**ND**
CA260	62.5	101	139	**101**	0.18	0.14	0.22	**0.18**	51.8	77.7	74.7	**68.1**	ND	ND	ND	**ND**
CA270	178	132	149	**153**	0.09	0.11	0.05	**0.08**	40.8	41.1	50.0	**44.0**	ND	ND	ND	**ND**
CA280	50.5	51	40.4	**47**	0.19	0.04	0.03	**0.09**	11.8	16.2	9.68	**12.6**	ND	ND	ND	**ND**
CA290	232	205	156	**198**	0.07	0.09	ND	**0.05**	44.4	41.3	38.0	**41.2**	ND	ND	ND	**ND**
CA310	434	359	NS	**397**	0.06	0.13	0.37	**0.19**	47.9	64.5	NS	**56.2**	ND	ND	NS	**ND**
CA330	381	445	365	**397**	ND	0.07	0.15	**0.07**	41.5	53.7	44.4	**46.5**	ND	ND	ND	**ND**
Ave	**153**	**165**	**147**	**159**	**0.10**	**0.13**	**0.08**	**0.10**	**42.1**	**49.8**	**45.9**	**46.1**	**0.02**	**ND**	**ND**	**0.01**
Shallow Feedlot Wells																
CA350	383	455	389	**409**	21.25	22.10	17.80	**20.38**	96.7	49.9	87.8	**78.1**	ND	ND	ND	**ND**
CA360	886	1140	505	**844**	11.50	22.80	5.50	**13.27**	9.75	32.5	2.47	**14.9**	3.76	7.97	6.38	**6.04**
CA370	628	NS	NS	**628**	21.75	NS	NS	**21.75**	34.4	NS	NS	**34.4**	0.51	NS	NS	**0.51**
CA380	793	926	416	**712**	7.50	50.80	11.00	**23.10**	6.77	9.94	7.62	**8.1**	ND	8.87	4.03	**4.30**
CA390	NS	NS	210	**210**	NS	NS	0.01	**0.01**	NS	NS	85.3	**85.3**	NS	NS	ND	**ND**
Ave	**673**	**840**	**380**	**560**	**15.50**	**8.58**	**8.58**	**15.70**	**36.9**	**30.8**	**45.8**	**44.2**	**1.07**	**5.61**	**2.60**	**2.17**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well	Alkalinity (mg/L)				Fe^{2+} (mg/L)				Sulfate (mg/L)				Sulfide (mg/L)			
Number	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow-Int Wells																
NW011	151	162	156	**156**	ND	0.10	0.02	**0.04**	40.8	44.6	33.9	**39.8**	ND	ND	ND	**ND**
NW021	225	234	219	**226**	0.03	0.06	0.03	**0.04**	46.1	52	48.1	**48.7**	ND	ND	ND	**ND**
NW031	278	294	255	**276**	0.02	0.06	0.09	**0.06**	48.7	55.3	57.0	**53.7**	ND	ND	ND	**ND**
NW041	166	168	169	**168**	ND	0.10	0.05	**0.05**	36.8	40	41.2	**39.3**	ND	ND	ND	**ND**
NW051	222	232	237	**230**	ND	0.18	ND	**0.06**	93.9	116	90.3	**100.1**	ND	ND	ND	**ND**
NW061	353	383	374	**370**	ND	0.17	0.22	**0.13**	33.1	30.3	20.8	**28.1**	ND	ND	ND	**ND**
NW071	136	140	134	**137**	0.06	0.04	0.25	**0.12**	31.2	40.8	33.4	**35.1**	ND	ND	ND	**ND**
NW081	173	179	172	**175**	ND	0.11	0.02	**0.04**	50.7	58.3	53.4	**54.1**	ND	ND	ND	**ND**
NW091	265	272	248	**262**	0.17	0.18	0.05	**0.13**	34.5	46.3	37.9	**39.6**	ND	ND	ND	**ND**
NW101	135	124	116	**125**	0.02	ND	0.14	**0.05**	48.9	56.5	47.0	**50.8**	ND	ND	ND	**ND**
NW131	83.5	90	139	**104**	0.05	0.08	ND	**0.04**	34.2	43.3	38.5	**38.7**	ND	ND	ND	**ND**
CA211	187	195	188	**191**	ND	0.06	0.15	**0.07**	58.5	69.2	63.7	**63.8**	ND	ND	ND	**ND**
CA221	176	184	183	**181**	0.07	0.11	0.12	**0.10**	31.8	39.8	32.7	**34.8**	ND	ND	ND	**ND**
CA231	85.5	82	73.3	**80**	0.03	0.05	0.02	**0.03**	36.3	46	33.0	**38.4**	ND	ND	ND	**ND**
CA241	104	93	85.9	**94**	0.08	0.04	ND	**0.04**	32.4	39.8	44.0	**38.7**	ND	ND	ND	**ND**
CA251	141	156	138	**145**	ND	0.06	0.11	**0.06**	33.6	45.6	36.6	**38.6**	ND	ND	ND	**ND**
CA261	113	109	98.4	**107**	ND	0.09	0.02	**0.04**	40.2	50.7	39.9	**43.6**	ND	ND	ND	**ND**
CA271	162	132	111	**135**	0.11	0.10	0.04	**0.08**	53.1	51	55.6	**53.2**	ND	ND	ND	**ND**
CA281	118	109	90.9	**106**	0.01	0.07	0.03	**0.04**	40.9	48	41.9	**43.6**	ND	ND	ND	**ND**
CA291	87.9	110	93.4	**97**	0.07	0.04	ND	**0.04**	39.0	46.1	37.8	**41.0**	ND	ND	ND	**ND**
CA311	288	269	264	**274**	0.02	0.03	0.11	**0.05**	57.0	57.6	57.8	**57.5**	ND	ND	ND	**ND**
CA331	172	161	137	**157**	ND	0.03	0.13	**0.05**	33.9	30.8	14.7	**26.5**	ND	ND	ND	**ND**
Ave	**174**	**176**	**167**	**172**	**0.03**	**0.08**	**0.07**	**0.06**	**43.4**	**50.4**	**43.6**	**45.8**	**ND**	**ND**	**ND**	**ND**
Shallow-Int Feedlot Wells																
CA351	301	333	267	**300**	ND	0.16	ND	**0.05**	38.5	32.5	29.5	**33.5**	ND	ND	ND	**ND**
CA361	NS	NS	441	**441**	NS	NS	12.60	**12.60**	NS	NS	30.5	**3.1**	NS	NS	5.12	**5.12**
CA381	NS	NS	243	**243**	NS	NS	2.25	**2.25**	NS	NS	32.3	**32.3**	NS	NS	ND	**ND**
Ave	**301**	**333**	**317**	**328**	**ND**	**0.16**	**4.95**	**4.97**	**38.5**	**32.5**	**21.6**	**23.0**	**ND**	**ND**	**1.71**	**1.71**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well	Alkalinity (mg/L)				Fe^{2+} (mg/L)				Sulfate (mg/L)				Sulfide (mg/L)			
Number	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Intermediate Wells																
NW022	233	220	227	**227**	0.52	0.69	0.76	**0.66**	37.8	44	41.6	**41.1**	ND	ND	ND	**ND**
NW032	257	256	265	**259**	0.35	0.60	0.63	**0.53**	56.9	63.6	60.4	**60.3**	ND	ND	ND	**ND**
NW052	268	266	278	**271**	0.87	1.17	1.07	**1.04**	89.7	123	85.4	**99.4**	ND	ND	ND	**ND**
NW062	420	470	366	**419**	1.27	1.51	1.40	**1.39**	25.5	21.5	28.6	**25.2**	0.36	ND	1.26	**0.54**
NW082	224	226	217	**222**	0.02	0.07	0.02	**0.04**	54.2	64.5	53.4	**57.4**	ND	ND	ND	**ND**
NW102	114	107	103	**108**	0.05	0.03	0.01	**0.03**	38.1	73	33.4	**48.2**	ND	ND	ND	**ND**
NW121	427	326	354	**369**	ND	0.03	ND	**0.01**	50.4	50.2	40.7	**47.1**	ND	ND	ND	**ND**
NW132	122	117	103	**114**	0.08	ND	0.12	**0.07**	36.7	43.5	41.3	**40.5**	ND	ND	ND	**ND**
CA212	238	222	206	**222**	ND	0.03	0.10	**0.04**	64.6	62	56.4	**61.0**	ND	ND	ND	**ND**
CA222	214	221	211	**215**	0.22	0.24	0.90	**0.45**	49.7	53.7	46.6	**50.0**	ND	ND	ND	**ND**
CA232	114	117	116	**116**	0.03	0.06	0.05	**0.05**	30.0	37.3	36.2	**34.5**	ND	ND	ND	**ND**
CA242	186	183	179	**183**	0.03	0.01	ND	**0.01**	35.2	35.9	37.9	**36.3**	ND	ND	ND	**ND**
CA252	212	218	207	**212**	ND	0.06	0.03	**0.03**	43.2	54.7	48.4	**48.8**	ND	ND	ND	**ND**
CA262	218	231	215	**221**	0.05	0.15	ND	**0.07**	54.0	61.7	56.9	**57.5**	ND	ND	ND	**ND**
CA272	171	169	172	**171**	ND	0.65	0.05	**0.23**	48.6	53.3	51.7	**51.2**	0.23	ND	ND	**0.08**
CA282	129	127	121	**126**	0.10	0.06	0.10	**0.09**	40.2	47.3	41.7	**43.1**	ND	ND	ND	**ND**
CA292	144	148	149	**147**	0.02	0.09	ND	**0.04**	34.2	36.5	40.5	**37.1**	ND	ND	ND	**ND**
CA312	155	181	172	**169**	0.06	0.04	0.15	**0.08**	35.9	37.1	40.9	**38.0**	ND	ND	ND	**ND**
CA322	171	168	151	**163**	0.05	0.04	ND	**0.03**	25.1	33.7	28.4	**29.1**	ND	ND	ND	**ND**
CA332	117	121	119	**119**	0.25	0.01	0.10	**0.12**	30.5	37.5	37.4	**35.1**	ND	ND	ND	**ND**
CA342	246	294	241	**260**	0.32	0.77	0.07	**0.39**	50.3	72.6	58.0	**60.3**	ND	ND	ND	**ND**
Ave	**209**	**209**	**199**	**205**	**0.20**	**0.30**	**0.26**	**0.26**	**44.3**	**52.7**	**46.0**	**47.7**	**0.03**	**ND**	**0.06**	**0.03**
Int Feedlot Wells																
CA352	245	287	218	**250**	0.57	0.90	0.45	**0.64**	51.1	45	33.8	**43.3**	ND	ND	ND	**ND**
CA362	NS	NS	245	**245**	NS	NS	1.38	**1.38**	NS	NS	38.2	**38.2**	NS	NS	ND	**ND**
CA382	NS	NS	240	**240**	NS	NS	ND	**0.00**	NS	NS	27.5	**27.5**	NS	NS	ND	**ND**
Ave	**245**	**287**	**234**	**245**	**0.57**	**0.90**	**0.61**	**0.67**	**51.1**	**45.0**	**33.2**	**36.3**	**ND**	**ND**	**ND**	**ND**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	Alkalinity (mg/L)				Fe^{2+} (mg/L)				Sulfate (mg/L)				Sulfide (mg/L)			
	Jun-98	**Mar-99**	**Mar-00**	**Ave.**	**Jun-98**	**Mar-99**	**Mar-00**	**Ave.**	**Jun-98**	**Mar-99**	**Mar-00**	**Ave.**	**Jun-98**	**Mar-99**	**Mar-00**	**Ave.**
Deep Wells																
NW122	182	182	189	**184**	0.89	1.08	0.76	**0.91**	18.7	22.3	21.0	**20.7**	ND	ND	ND	**ND**
CA213	148	157	156	**154**	0.57	0.56	0.44	**0.52**	38.9	46.9	48.7	**44.8**	ND	ND	ND	**ND**
CA253	178	183	175	**179**	0.58	0.79	0.87	**0.75**	26.9	30.6	30.1	**29.2**	ND	ND	ND	**ND**
CA273	198	202	189	**196**	0.72	0.79	0.82	**0.78**	23.2	28.8	27.1	**26.4**	0.23	ND	ND	**0.08**
CA313	237	204	203	**215**	0.10	0.07	0.29	**0.15**	11.3	16.7	14.4	**14.1**	ND	ND	ND	**ND**
CA343	257	308	269	**278**	0.23	0.04	ND	**0.09**	46.3	51.2	49.4	**49.0**	ND	ND	ND	**ND**
Ave	**200**	**206**	**197**	**201**	**0.52**	**0.56**	**0.53**	**0.53**	**27.6**	**32.8**	**31.8**	**30.7**	**0.04**	**ND**	**ND**	**0.01**

Notes:

DO - Dissolved Oxygen

TKN - Total Kjeldahl Nitrogen

NO2+NO3 - Nitrate plus Nitrite

CO2 - Carbon Dioxide

DOC - Dissolved Organic Carbon

NS - Not Sampled

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	pH				Conductivity (mS/cm)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells								
NW010	6.77	6.81	6.47	**6.68**	376	332	283	**330**
NW020	6.75	7.20	6.80	**6.92**	815	676	734	**742**
NW030	6.44	6.91	6.69	**6.68**	494	511	454	**486**
NW040	5.59	5.99	5.85	**5.81**	308	241	496	**348**
NW050	6.01	6.36	6.31	**6.23**	1870	1430	1392	**1564**
NW060	6.20	6.49	6.51	**6.40**	555	359	359	**424**
NW070	6.87	7.30	6.67	**6.95**	218	584	481	**428**
NW080	6.08	6.32	6.26	**6.22**	802	753	678	**744**
NW090	5.92	5.99	5.96	**5.96**	685	600	657	**647**
NW100	5.95	5.99	5.91	**5.95**	1033	820	792	**882**
NW120	6.25	6.64	6.41	**6.43**	565	660	659	**628**
NW130	6.51	6.61	6.53	**6.55**	517	569	548	**545**
CA210	6.09	6.47	6.37	**6.31**	1830	1960	1470	**1753**
CA220	6.85	7.18	6.98	**7.00**	790	486	447	**574**
CA230	5.89	5.97	6.08	**5.98**	547	410	366	**441**
CA240	6.25	6.43	6.34	**6.34**	791	663	515	**656**
CA250	6.63	6.65	6.55	**6.61**	623	714	687	**675**
CA260	6.05	6.39	6.27	**6.24**	533	560	557	**550**
CA270	6.43	6.14	6.41	**6.33**	555	363	510	**476**
CA280	5.99	5.95	6.17	**6.04**	431	197	219	**282**
CA290	6.75	6.72	6.39	**6.62**	837	800	703	**780**
CA310	6.78	6.66	6.77	**6.74**	1590	840	819	**1083**
CA330	6.76	6.86	6.61	**6.74**	1009	1154	1014	**1059**
Ave	**6.34**	**6.52**	**6.40**	**6.42**	**773**	**682**	**645**	**700**
Shallow Feedlot Wells								
CA350	6.15	6.52	6.29	**6.32**	1381	1220	1510	**1370**
CA360	6.73	6.58	7.00	**6.77**	4050	3370	2900	**3440**
CA370	6.71	NS	NS	**6.71**	1433	NS	NS	**1433**
CA380	6.78	6.56	6.83	**6.72**	2510	2450	2350	**2437**
CA390	NS	NS	6.77	**6.77**	NS	NS	940	**940**
Ave	**6.59**	**6.55**	**6.72**	**6.66**	**2344**	**2347**	**1925**	**1924**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	pH				Conductivity (mS/cm)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow-Int Wells								
NW011	7.03	7.16	6.86	**7.02**	434	429	411	**425**
NW021	6.84	7.07	6.85	**6.92**	585	623	523	**577**
NW031	7.39	7.83	7.30	**7.51**	603	577	593	**591**
NW041	7.24	7.16	6.92	**7.11**	477	516	466	**486**
NW051	6.64	6.73	6.60	**6.66**	1172	1108	1163	**1148**
NW061	6.76	6.73	6.64	**6.71**	885	821	907	**871**
NW071	6.82	6.54	6.67	**6.68**	489	426	461	**459**
NW081	6.35	6.33	6.39	**6.36**	1021	869	1034	**975**
NW091	6.61	6.63	6.71	**6.65**	671	536	595	**601**
NW101	6.40	6.52	6.36	**6.43**	864	788	761	**804**
NW131	6.15	6.02	6.21	**6.13**	585	504	578	**556**
CA211	6.68	6.73	6.57	**6.66**	883	951	934	**923**
CA221	7.14	7.20	7.01	**7.12**	468	418	453	**446**
CA231	6.36	6.18	6.27	**6.27**	488	429	399	**439**
CA241	6.47	6.77	6.53	**6.59**	502	476	484	**487**
CA251	6.23	6.56	6.41	**6.40**	751	644	645	**680**
CA261	6.57	6.16	6.40	**6.38**	587	483	524	**531**
CA271	6.40	6.41	6.36	**6.39**	563	586	548	**566**
CA281	6.32	6.42	6.22	**6.32**	618	556	470	**548**
CA291	6.23	6.78	6.23	**6.41**	518	580	542	**547**
CA311	6.99	6.92	6.70	**6.87**	692	809	803	**768**
CA331	6.72	6.70	6.53	**6.65**	639	687	532	**619**
Ave	**6.65**	**6.71**	**6.58**	**6.65**	**569**	**628**	**628**	**638**
Shallow-Int Feedlot Wells								
CA351	6.43	6.61	6.58	**6.54**	799	759	670	**743**
CA361	NS	NS	6.86	**6.86**	NS	NS	2830	**2830**
CA381	NS	NS	6.75	**6.75**	NS	NS	651	**651**
Ave	**6.43**	**6.61**	**6.73**	**6.72**	**799**	**759**	**1384**	**1408**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	pH				Conductivity (mS/cm)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Intermediate Wells								
NW022	7.02	7.48	7.03	**7.18**	525	501	501	**509**
NW032	7.45	7.54	7.26	**7.42**	629	667	603	**633**
NW052	6.94	7.33	7.01	**7.09**	784	681	829	**765**
NW062	6.73	6.94	6.85	**6.84**	981	986	875	**947**
NW082	6.89	6.82	6.62	**6.78**	974	921	1050	**982**
NW102	6.53	6.65	6.49	**6.56**	703	561	566	**610**
NW121	7.08	7.21	6.80	**7.03**	845	870	903	**873**
NW132	6.27	6.49	6.21	**6.32**	681	673	677	**677**
CA212	6.83	7.17	6.96	**6.99**	812	639	616	**689**
CA222	7.22	7.40	7.40	**7.34**	581	517	510	**536**
CA232	6.66	6.80	6.62	**6.69**	380	364	370	**371**
CA242	7.17	7.28	7.06	**7.17**	475	457	444	**459**
CA252	6.65	6.74	6.58	**6.66**	886	848	834	**856**
CA262	7.03	7.04	6.96	**7.00**	635	695	619	**650**
CA272	6.64	6.64	6.72	**6.67**	580	549	603	**577**
CA282	6.57	6.94	6.52	**6.68**	559	448	491	**499**
CA292	6.59	6.76	6.48	**6.61**	502	526	531	**520**
CA312	6.84	6.60	6.67	**6.69**	556	558	606	**573**
CA322	6.58	6.75	6.53	**6.62**	549	642	599	**597**
CA332	6.87	6.72	6.58	**6.72**	332	497	432	**420**
CA342	6.70	6.80	6.74	**6.75**	482	775	719	**659**
Ave	**6.82**	**6.96**	**6.76**	**6.85**	**641**	**637**	**637**	**638**
Int Feedlot Wells								
CA352	6.89	7.14	7.03	**7.02**	607	566	502	**558**
CA362	NS	NS	7.37	**7.37**	NS	NS	553	**553**
CA382	NS	NS	7.40	**7.40**	NS	NS	453	**453**
Ave	**6.89**	**7.14**	**7.27**	**7.26**	**607**	**566**	**503**	**521**

TABLE 6-1

SUMMARY OF OFF-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	pH				Conductivity (mS/cm)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Deep Wells								
NW122	7.06	7.28	7.03	**7.12**	424	453	392	**423**
CA213	7.43	7.60	7.31	**7.45**	423	413	409	**415**
CA253	7.18	7.17	7.05	**7.13**	431	389	396	**405**
CA273	7.30	7.25	7.25	**7.27**	441	446	444	**444**
CA313	7.21	7.25	7.11	**7.19**	379	397	388	**388**
CA343	6.95	6.97	6.88	**6.93**	738	810	674	**741**
Ave	**7.19**	**7.25**	**7.11**	**7.18**	**473**	**485**	**451**	**469**

Notes:

DO - Dissolved Oxygen

TKN - Total Kjeldahl Nitrogen

NO2+NO3 - Nitrate plus Nitrite

CO2 - Carbon Dioxide

DOC - Dissolved Organic Carbon

NS - Not Sampled

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well	Redox (mV)				DO (mg/L)				NO_3+NO_2 (mg/L)				Ammonia (mg/L)			
Number	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells																
G0011	-66	-63	-70	**-66**	2.13	0.42	0.31	**0.95**	ND	ND	ND	**ND**	0.140	0.179	0.198	**0.17**
G0012	-20	-53	-28	**-34**	1.73	0.31	0.26	**0.78**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
G0013	-62	-79	-61	**-67**	1.79	0.23	0.27	**0.76**	ND	ND	ND	**ND**	0.363	0.369	0.473	**0.40**
G0014	-16	-50	-22	**-29**	1.19	0.99	0.41	**0.86**	ND	ND	ND	**ND**	0.199	0.115	0.223	**0.18**
G0015	-24	-50	-41	**-38**	1.52	0.90	0.65	**1.02**	ND	ND	ND	**ND**	0.129	ND	ND	**0.04**
G0016	118	120	110	**116**	2.09	2.81	2.56	**2.49**	2.08	1.66	ND	**1.25**	ND	ND	ND	**ND**
G0017	71	101	80	**84**	4.51	3.50	2.31	**3.44**	2.54	1.37	1.12	**1.68**	ND	ND	ND	**ND**
G0018	164	74	130	**123**	1.31	1.94	1.19	**1.48**	2.55	2.32	2.52	**2.46**	0.09	ND	ND	**0.03**
G0019	106	106	93	**102**	4.39	4.72	2.52	**3.88**	0.89	ND	ND	**0.30**	ND	ND	ND	**ND**
G0020	129	26	11	**55**	3.23	3.54	2.33	**3.03**	0.76	ND	ND	**0.25**	ND	ND	0.086	**0.03**
G0021	117	102	143	**121**	0.85	1.89	1.90	**1.55**	0.85	ND	ND	**0.28**	0.796	ND	1.19	**0.66**
G0022	166	95	111	**124**	4.03	5.37	4.89	**4.76**	3.29	3.85	3.80	**3.65**	ND	ND	ND	**ND**
G0023	147	123	127	**132**	2.01	3.99	1.39	**2.46**	2.47	3.58	3.94	**3.33**	0.738	ND	1.42	**0.72**
G0024	145	105	135	**128**	1.14	0.76	0.59	**0.83**	19.2	16.4	10.2	**15.3**	ND	ND	ND	**ND**
G0025	155	169	125	**150**	3.45	3.89	2.82	**3.39**	4.19	3.63	3.95	**3.92**	ND	ND	ND	**ND**
G0029	124	91	137	**117**	1.49	0.30	0.29	**0.69**	3.92	ND	7.05	**3.66**	ND	ND	ND	**ND**
G0030	134	145	135	**138**	1.15	0.42	0.27	**0.61**	3.28	4.76	2.00	**3.35**	0.176	0.176	0.146	**0.17**
G0031	158	190	118	**155**	1.12	0.99	1.11	**1.07**	6.68	7.93	9.59	**8.07**	ND	ND	ND	**ND**
G0032	188	181	111	**160**	0.23	0.56	0.29	**0.36**	14	13.5	15.2	**14.2**	ND	ND	ND	**ND**
G0033	90	195	123	**136**	4.32	7.00	8.37	**6.56**	38.2	34.1	37.8	**36.7**	ND	ND	ND	**ND**
G0042	125	107	104	**112**	3.90	4.89	4.40	**4.40**	1.15	1.08	2.69	**1.64**	ND	ND	ND	**ND**
G0043	137	120	103	**120**	8.58	7.00	4.92	**6.83**	2.28	2.55	1.61	**2.15**	ND	ND	ND	**ND**
G0044	95	190	94	**126**	6.76	1.17	4.59	**4.17**	1.80	2.63	2.53	**2.32**	ND	ND	ND	**ND**
G0046	124	102	91	**106**	3.52	5.01	3.73	**4.09**	1.79	1.76	1.47	**1.67**	ND	ND	ND	**ND**
G0047	131	105	116	**117**	1.08	2.18	2.00	**1.75**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
G0048	155	134	134	**141**	6.11	7.72	5.67	**6.50**	1.02	5.51	30.5	**12.34**	ND	0.256	ND	**0.09**
G0052	156	184	142	**161**	0.98	0.39	0.38	**0.58**	7.66	7.68	9.38	**8.24**	2.57	2.94	1.00	**2.17**
G0063	NS	65	65	**65**	NS	0.50	0.36	**0.43**	NS	ND	ND	**ND**	NS	ND	0.361	**0.18**
G0066	138	123	114	**125**	0.57	1.42	1.37	**1.12**	13.1	10.8	8.84	**10.91**	4.39	3.28	3.84	**3.84**
G0067	168	146	153	**156**	0.97	2.45	2.70	**2.04**	1.16	4.23	6.15	**3.85**	0.05	ND	ND	**0.02**
G0068	103	85	76	**88**	2.62	1.50	1.90	**2.01**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
G0079	NS	NS	51	**51**	NS	NS	1.71	**1.71**	NS	NS	4.54	**4.54**	NS	NS	ND	**ND**

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well	Redox (mV)				DO (mg/L)				NO_3+NO_2 (mg/L)				Ammonia (mg/L)			
Number	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
PZ001	NM	-45	-1	**-23**	NM	2.02	2.81	**2.42**	NM	ND	1.01	**0.51**	NM	ND	ND	**ND**
PZ004	NM	-70	-8	**-54**	NM	1.20	0.81	**1.01**	NM	ND	ND	**ND**	NM	ND	0.113	**0.06**
PZ005	NM	25	16	**21**	NM	3.32	2.41	**2.87**	NM	1.23	0.838	**1.03**	NM	ND	ND	**ND**
PZ006	NM	35	20	**28**	NM	0.43	0.91	**0.67**	NM	1.23	ND	**0.62**	NM	0.201	0.181	**0.19**
PZ007	NM	26	-23	**2**	NM	5.49	3.26	**4.38**	NM	1.01	ND	**0.51**	NM	ND	ND	**ND**
PZ008	NM	4	-34	**-15**	NM	4.43	3.02	**3.73**	NM	ND	ND	**ND**	NM	ND	ND	**ND**
PZ009	NM	97	80	**89**	NM	2.00	1.83	**1.92**	NM	ND	1.05	**0.53**	NM	ND	ND	**ND**
PZ010	NM	96	82	**89**	NM	1.01	0.76	**0.89**	NM	1.5	ND	**0.75**	NM	0.284	0.116	**0.20**
PZ011	NM	100	109	**105**	NM	0.23	0.25	**0.24**	NM	3.34	1.30	**2.32**	NM	8.05	9.31	**8.68**
PZ012	NM	98	90	**94**	NM	0.62	0.75	**0.69**	NM	5.44	1.89	**3.67**	NM	3.50	10.30	**6.90**
PZ013	NM	99	78	**89**	NM	0.14	0.36	**0.25**	NM	9.45	4.60	**7.03**	NM	16.5	13.6	**15.1**
PZ014	NM	-49	42	**-4**	NM	1.50	0.60	**1.05**	NM	ND	ND	**ND**	NM	ND	0.119	**0.06**
PZ015	NM	163	144	**154**	NM	7.59	5.92	**6.76**	NM	3.87	2.05	**2.96**	NM	ND	ND	**ND**
PZ016	NM	149	136	**143**	NM	7.70	5.48	**6.59**	NM	2.88	2.89	**2.89**	NM	ND	ND	**ND**
Ave.	**105**	**80**	**74**	**80**	**2.63**	**2.59**	**2.12**	**2.39**	**4.50**	**3.54**	**3.92**	**3.67**	**0.32**	**0.80**	**0.93**	**0.87**
Shallow-Int Wells																
G0026	54	34	116	**68**	1.93	0.32	0.29	**0.85**	5.37	1.7	1.66	**2.91**	ND	ND	ND	**ND**
G0027	-90	-107	-85	**-94**	1.75	0.49	0.32	**0.85**	ND	ND	ND	**ND**	0.914	0.831	0.507	**0.75**
G0028	-82	-80	-79	**-80**	1.53	0.82	0.23	**0.86**	ND	ND	ND	**ND**	ND	ND	0.140	**0.05**
G0075	12	53	37	**34**	0.53	1.10	1.54	**1.06**	1.91	4.36	4.26	**3.51**	ND	ND	ND	**ND**
G0077	111	71	85	**89**	0.74	0.12	0.24	**0.37**	10.1	4.8	8.27	**7.72**	0.738	1.55	0.272	**0.85**
Ave.	**1**	**-6**	**15**	**3**	**1.30**	**0.57**	**0.52**	**0.80**	**3.48**	**2.17**	**2.84**	**2.83**	**0.33**	**0.48**	**0.18**	**0.33**
Intermediate Wells																
G0045	118	39	49	**69**	1.33	0.12	0.56	**0.67**	ND	ND	ND	**ND**	2.67	1.4	0.561	**1.54**
G0049	181	107	107	**132**	0.35	0.25	0.35	**0.32**	0.091	ND	ND	**0.03**	1.76	3.52	1.64	**2.31**
G0076	-84	-74	-76	**-78**	0.66	0.12	0.20	**0.33**	ND	ND	ND	**ND**	0.976	1.33	1.69	**1.33**
G0078	60	20	43	**41**	0.57	0.20	0.55	**0.44**	ND	ND	ND	**ND**	ND	ND	ND	**ND**
Ave.	**69**	**23**	**31**	**41**	**0.73**	**0.17**	**0.42**	**0.44**	**0.02**	**ND**	**ND**	**0.01**	**1.35**	**1.56**	**0.97**	**1.30**
Deep Wells																
G0070	-56	-89	-82	**-76**	0.59	0.16	0.35	**0.37**	ND	ND	ND	**ND**	ND	ND	ND	**ND**

Notes:

DO - Dissolved Oxygen; TKN - Total Kjeldahl Nitrogen; NO2+NO3 - Nitrate plus Nitrite
CO2 - Carbon Dioxide; DOC - Dissolved Organic Carbon; NS - Not Sampled; NM - Not measured

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	TKN (mg/L)				DOC (mg/L)				CO_2 (mg/L)				Methane (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells																
G0011	0.103	0.506	0.542	**0.38**	17.8	12.8	ND	**10.2**	177	183	179	**180**	3.44	4.09	ND	**2.51**
G0012	ND	0.364	0.347	**0.24**	12.2	51.2	ND	**21.1**	186	194	181	**187**	4.94	8.91	3.5	**5.78**
G0013	0.221	0.703	1.00	**0.64**	16.1	6.8	ND	**7.6**	165	188	180	**178**	4.06	6.71	5.1	**5.29**
G0014	0.169	0.461	0.347	**0.33**	12.0	7.0	13.0	**10.7**	190	192	172	**185**	21.7	59.8	10	**30.50**
G0015	ND	0.315	0.385	**0.23**	14.9	8.8	6.4	**10.0**	186	201	200	**196**	1.55	ND	ND	**0.52**
G0016	0.221	0.433	0.358	**0.34**	10.9	13.1	18.4	**14.1**	169	172	172	**171**	ND	ND	ND	**ND**
G0017	0.198	0.521	0.309	**0.34**	8.3	14.3	11.1	**11.2**	175	209	158	**181**	ND	ND	ND	**ND**
G0018	0.040	0.212	0.268	**0.17**	5.2	8.5	ND	**4.6**	127	132	154	**138**	ND	ND	ND	**ND**
G0019	ND	0.257	0.266	**0.16**	9.4	9.1	6.3	**8.3**	162	180	157	**166**	ND	ND	ND	**ND**
G0020	ND	0.257	0.121	**0.13**	10.7	7.6	ND	**6.1**	124	147	128	**133**	1.35	ND	ND	**0.45**
G0021	0.485	1.72	1.33	**1.18**	8.2	13.6	ND	**7.3**	126	127	118	**124**	28.2	ND	ND	**9.40**
G0022	ND	0.106	ND	**0.04**	22.1	5.6	ND	**9.2**	84.9	98.6	94.6	**93**	ND	ND	ND	**ND**
G0023	0.165	0.519	1.49	**0.72**	6.3	16.6	9.9	**10.9**	59.9	114	90.6	**88**	1.53	ND	ND	**0.51**
G0024	ND	0.088	ND	**0.03**	11.5	5.8	12.8	**10.0**	74.4	95.9	63.4	**78**	ND	ND	ND	**ND**
G0025	ND	ND	0.119	**0.04**	10.7	ND	ND	**3.6**	47.1	46.6	42.2	**45**	ND	ND	ND	**ND**
G0029	ND	0.434	0.125	**0.19**	12.4	12.0	7.0	**10.5**	87.1	69.1	67.8	**75**	ND	ND	ND	**ND**
G0030	0.302	0.417	0.564	**0.43**	13.3	11.4	5.0	**9.9**	70.8	86.7	94.4	**84**	ND	ND	ND	**ND**
G0031	ND	ND	0.136	**0.05**	7.9	12.3	19.7	**13.3**	72.2	81.4	80.0	**78**	ND	ND	ND	**ND**
G0032	ND	ND	ND	**ND**	6.8	15.4	6.1	**9.4**	154	154	163	**157**	ND	ND	ND	**ND**
G0033	ND	ND	0.128	**0.04**	9.6	12.2	ND	**7.3**	77	80.5	81.8	**80**	ND	ND	ND	**ND**
G0042	0.203	0.822	0.717	**0.58**	17.1	ND	ND	**5.7**	149	182	198	**176**	1.7	ND	ND	**0.57**
G0043	ND	0.37	0.272	**0.21**	18.4	ND	ND	**6.1**	169	194	181	**181**	ND	ND	ND	**ND**
G0044	ND	0.47	0.98	**0.48**	17.0	ND	ND	**5.7**	207	209	222	**213**	ND	ND	ND	**ND**
G0046	0.108	0.941	0.455	**0.50**	15.2	5.2	22.3	**14.2**	208	257	228	**231**	ND	ND	ND	**ND**
G0047	ND	0.376	0.227	**0.20**	9.6	8.2	5.6	**7.8**	117	143	118	**126**	ND	ND	ND	**ND**
G0048	0.141	0.453	ND	**0.20**	7.2	15.4	7.2	**9.9**	114	144	75.7	**111**	ND	ND	ND	**ND**
G0052	2.14	2.36	1.07	**1.86**	10.4	11.2	12.0	**11.2**	48.4	59	58.9	**55**	1.51	ND	ND	**0.50**
G0063	NS	0.69	0.437	**0.56**	NS	ND	ND	**ND**	NS	209	199	**204**	NS	11.1	4	**7.55**
G0066	1.52	3.39	3.96	**2.96**	10.2	10.7	16.0	**12.3**	135	165	132	**144**	4.02	8.13	3.4	**5.18**
G0067	0.080	0.167	ND	**0.08**	6.2	14.4	ND	**6.9**	31.2	75.7	71.3	**59**	1.11	ND	ND	**0.37**
G0068	ND	0.546	0.676	**0.41**	14.9	ND	20.0	**11.6**	244	315	249	**269**	ND	ND	ND	**ND**
G0079	NS	NS	ND	**ND**	NS	NS	6.8	**6.8**	NS	NS	95.9	**96**	NS	NS	ND	**ND**

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	TKN (mg/L)				DOC (mg/L)				CO_2 (mg/L)				Methane (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
PZ001	NM	0.491	0.577	**0.53**	NM	ND	6.5	**3.3**	NM	199	219	**209**	NM	ND	ND	**ND**
PZ004	NM	0.449	0.668	**0.56**	NM	ND	9.2	**4.6**	NM	232	194	**213**	NM	ND	ND	**ND**
PZ005	NM	0.451	0.462	**0.46**	NM	ND	8.0	**4.0**	NM	183	172	**178**	NM	ND	ND	**ND**
PZ006	NM	0.791	0.451	**0.62**	NM	ND	ND	**ND**	NM	171	181	**176**	NM	7.16	ND	**3.58**
PZ007	NM	0.382	0.385	**0.38**	NM	5.0	ND	**2.5**	NM	169	161	**165**	NM	ND	ND	**ND**
PZ008	NM	0.822	0.367	**0.59**	NM	5.9	ND	**3.0**	NM	178	167	**173**	NM	ND	ND	**ND**
PZ009	NM	0.439	0.367	**0.40**	NM	11.8	5.4	**8.6**	NM	181	149	**165**	NM	ND	ND	**ND**
PZ010	NM	0.634	0.437	**0.54**	NM	14.2	14.6	**14.4**	NM	158	172	**165**	NM	ND	ND	**ND**
PZ011	NM	9.04	10.3	**9.67**	NM	13.0	ND	**6.5**	NM	148	148	**148**	NM	35.5	ND	**17.8**
PZ012	NM	9.42	11.60	**10.51**	NM	15.3	ND	**7.7**	NM	172	162	**167**	NM	23.2	ND	**11.6**
PZ013	NM	16.90	14.50	**15.70**	NM	11.3	18.7	**15.0**	NM	179	148	**164**	NM	ND	6.9	**3.45**
PZ014	NM	0.283	0.198	**0.24**	NM	12.3	7.9	**10.1**	NM	177	158	**168**	NM	ND	ND	**ND**
PZ015	NM	0.207	0.160	**0.18**	NM	13.8	9.0	**11.4**	NM	51	110	**81**	NM	ND	ND	**ND**
PZ016	NM	0.346	ND	**0.17**	NM	12.2	9.2	**10.7**	NM	80.5	68.6	**75**	NM	ND	ND	**ND**
Ave.	**0.20**	**1.30**	**1.24**	**1.18**	**11.8**	**9.4**	**6.4**	**8.6**	**131**	**155**	**144**	**146**	**2.50**	**3.66**	**0.72**	**2.29**
Shallow-Int Wells																
G0026	0.32	0.564	0.699	**0.53**	18.7	11.5	10.0	**13.4**	185	187	163	**178**	ND	ND	4.6	**1.53**
G0027	1.05	1.28	0.965	**1.10**	18.1	5.6	8.0	**10.6**	165	186	178	**176**	2.09	ND	0.65	**0.91**
G0028	0.273	0.37	0.571	**0.40**	18.9	ND	6.8	**8.6**	176	98.1	193	**156**	1.07	ND	ND	**0.36**
G0075	ND	0.153	0.928	**0.36**	10.0	10.0	5.6	**8.5**	87.6	103	88.0	**93**	4.03	ND	ND	**1.34**
G0077	ND	1.64	1.29	**0.98**	10.8	6.3	ND	**5.7**	92.4	96.8	94.6	**95**	ND	0.802	ND	**0.27**
Ave.	**0.33**	**0.80**	**0.89**	**0.67**	**15.3**	**6.7**	**6.1**	**9.4**	**141**	**134**	**143**	**140**	**1.44**	**0.16**	**1.05**	**0.88**
Intermediate Wells																
G0045	2.56	1.75	0.871	**1.73**	12.2	12.0	ND	**8.1**	176	193	169	**179**	1.97	ND	ND	**0.66**
G0049	0.743	3.7	1.73	**2.06**	3.7	12.5	ND	**5.4**	85.5	103	99.4	**96**	1.30	ND	ND	**0.43**
G0076	1.06	1.4	1.74	**1.40**	13.1	ND	ND	**4.4**	96.8	114	100	**104**	1.21	12.4	ND	**4.54**
G0078	ND	0.283	0.113	**0.13**	10.2	ND	ND	**3.4**	99.0	108	100	**102**	1.7	0.6	ND	**0.75**
Ave.	**1.09**	**1.78**	**1.11**	**1.33**	**9.8**	**6.1**	**ND**	**5.3**	**114.3**	**129.5**	**117.1**	**120**	**1.54**	**3.24**	**ND**	**1.59**
Deep Wells																
G0070	0.10	0.16	0.085	**0.11**	9.7	ND	8.2	**6.0**	79.2	91.1	81.8	**84.0**	1.08	1.20	ND	**0.76**

Notes:

DO - Dissolved Oxygen; TKN - Total Kjeldahl Nitrogen; NO2+NO3 - Nitrate plus Nitrite
CO2 - Carbon Dioxide; DOC - Dissolved Organic Carbon; NS - Not Sampled; NM - Not measured

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	Alkalinity (mg/L)				Fe^{2+} (mg/L)				Sulfate (mg/L)				Sulfide (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells																
G0011	402	415	407	**408**	4.10	4.20	2.73	**3.68**	298	927	908	**711**	ND	ND	ND	**ND**
G0012	422	440	412	**425**	0.37	0.73	0.59	**0.56**	656	671	896	**741**	ND	ND	ND	**ND**
G0013	374	427	409	**403**	2.70	2.60	2.44	**2.58**	1020	1270	1260	**1183**	ND	ND	ND	**ND**
G0014	432	436	391	**420**	0.17	0.30	0.18	**0.22**	277	496	483	**419**	ND	ND	ND	**ND**
G0015	423	456	455	**445**	1.35	0.30	0.46	**0.70**	610	571	960	**714**	ND	ND	ND	**ND**
G0016	384	392	391	**389**	0.06	0.02	0.03	**0.04**	298	390	39.9	**243**	ND	ND	ND	**ND**
G0017	398	474	358	**410**	ND	ND	0.02	**0.01**	329	273	181	**261**	ND	ND	ND	**ND**
G0018	289	300	351	**313**	0.02	0.08	ND	**0.03**	195	182	328	**235**	ND	ND	ND	**ND**
G0019	368	410	356	**378**	ND	0.10	0.10	**0.07**	104	114	105	**108**	ND	ND	ND	**ND**
G0020	281	333	291	**302**	0.09	0.24	0.14	**0.16**	67.6	68.9	73.5	**70**	ND	ND	ND	**ND**
G0021	287	288	269	**281**	ND	0.09	0.06	**0.05**	58.3	52.8	44.7	**52**	ND	ND	ND	**ND**
G0022	193	224	215	**211**	0.15	ND	0.02	**0.06**	26.6	34.6	24.3	**29**	ND	ND	ND	**ND**
G0023	136	258	206	**200**	ND	ND	0.05	**0.02**	28.3	35.8	30.1	**31**	ND	ND	ND	**ND**
G0024	169	218	144	**177**	ND	0.06	ND	**0.02**	31.1	37.2	22.4	**30**	ND	ND	ND	**ND**
G0025	107	106	96	**103**	ND	0.12	ND	**0.04**	15.3	15.8	15.7	**16**	ND	ND	ND	**ND**
G0029	198	157	154	**170**	ND	0.06	0.06	**0.04**	76	65.5	65.4	**69**	ND	ND	ND	**ND**
G0030	161	197	215	**191**	0.03	0.02	0.04	**0.03**	56.3	72.1	86.7	**72**	ND	ND	ND	**ND**
G0031	164	185	182	**177**	0.04	0.11	ND	**0.05**	60.4	68.8	65.5	**65**	ND	ND	ND	**ND**
G0032	350	350	371	**357**	ND	0.01	0.06	**0.02**	693	798	724	**738**	ND	ND	ND	**ND**
G0033	175	183	186	**181**	0.04	0.05	ND	**0.03**	49	56.8	51.9	**53**	ND	ND	ND	**ND**
G0042	339	414	449	**401**	ND	0.07	ND	**0.02**	408	617	605	**543**	ND	ND	ND	**ND**
G0043	383	442	412	**412**	0.14	0.16	0.03	**0.11**	300	365	297	**321**	ND	ND	ND	**ND**
G0044	471	475	505	**484**	0.03	0.18	0.07	**0.09**	286	380	416	**361**	ND	ND	ND	**ND**
G0046	473	585	518	**525**	0.04	0.21	0.01	**0.09**	357	501	394	**417**	ND	ND	ND	**ND**
G0047	266	325	268	**286**	0.03	ND	ND	**0.01**	102	106	112	**107**	ND	ND	ND	**ND**
G0048	258	328	172	**253**	0.13	0.10	ND	**0.08**	25.5	54.9	57.8	**46**	ND	ND	ND	**ND**
G0052	110	134	134	**126**	0.09	0.26	ND	**0.12**	49.8	67.8	52.8	**57**	ND	ND	ND	**ND**
G0063	NS	475	452	**464**	NS	ND	ND	**ND**	NS	922	629	**776**	ND	ND	ND	**ND**
G0066	306	375	300	**327**	ND	0.07	ND	**0.02**	40.4	37.4	21.8	**33**	ND	ND	ND	**ND**
G0067	70.9	172	162	**135**	0.14	0.01	0.08	**0.08**	7.62	26.7	25.9	**20**	ND	ND	ND	**ND**
G0068	555	715	566	**612**	ND	0.11	0.09	**0.07**	262	275	317	**285**	ND	ND	ND	**ND**
G0079	NS	NS	218	**218**	NS	NS	0.13	**0.13**	NS	NS	31.8	**32**	NS	NS	ND	**ND**

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	Alkalinity (mg/L)				Fe^{2+} (mg/L)				Sulfate (mg/L)				Sulfide (mg/L)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
PZ001	NM	452	497	**475**	NM	0.45	0.29	**0.37**	NM	703	626	**665**	NM	ND	ND	**ND**
PZ004	NM	528	442	**485**	NM	0.42	0.59	**0.51**	NM	766	795	**781**	NM	ND	ND	**ND**
PZ005	NM	415	391	**403**	NM	0.29	0.16	**0.23**	NM	568	549	**559**	NM	ND	ND	**ND**
PZ006	NM	388	412	**400**	NM	0.22	0.08	**0.15**	NM	665	534	**600**	NM	ND	ND	**ND**
PZ007	NM	384	366	**375**	NM	0.32	0.36	**0.34**	NM	288	323	**306**	NM	ND	ND	**ND**
PZ008	NM	404	379	**392**	NM	0.35	ND	**0.18**	NM	335	229	**282**	NM	ND	ND	**ND**
PZ009	NM	411	338	**375**	NM	0.09	0.04	**0.07**	NM	108	123	**116**	NM	ND	ND	**ND**
PZ010	NM	360	391	**376**	NM	0.05	0.06	**0.06**	NM	153	125	**139**	NM	ND	ND	**ND**
PZ011	NM	337	336	**337**	NM	0.10	0.08	**0.09**	NM	86	100	**93**	NM	ND	ND	**ND**
PZ012	NM	391	369	**380**	NM	0.14	ND	**0.07**	NM	74	64.8	**67**	NM	ND	ND	**ND**
PZ013	NM	407	336	**372**	NM	0.17	0.06	**0.12**	NM	140	106	**123**	NM	ND	ND	**ND**
PZ014	NM	403	358	**381**	NM	0.22	0.02	**0.12**	NM	87.9	93.8	**91**	NM	ND	ND	**ND**
PZ015	NM	116	249	**183**	NM	0.07	0.10	**0.09**	NM	28.2	27.0	**28**	NM	ND	ND	**ND**
PZ016	NM	183	156	**170**	NM	0.11	0.08	**0.10**	NM	28.4	22.3	**25**	NM	ND	ND	**ND**
Ave.	**298**	**353**	**327**	**332**	**0.32**	**0.29**	**0.20**	**0.25**	**226**	**302**	**290**	**282**	**ND**	**ND**	**ND**	**ND**
Shallow-Int Well																
G0026	421	424	371	**405**	0.06	0.12	0.11	**0.10**	1180	1150	988	**1106**	ND	ND	ND	**ND**
G0027	375	423	404	**401**	1.84	1.09	0.68	**1.20**	1180	1260	1110	**1183**	ND	ND	ND	**ND**
G0028	399	223	439	**354**	1.06	1.33	0.99	**1.13**	1140	1090	1110	**1113**	ND	ND	ND	**ND**
G0075	199	235	200	**211**	0.26	0.01	0.03	**0.10**	36.3	40.7	30.6	**36**	ND	ND	ND	**ND**
G0077	210	220	215	**215**	ND	ND	0.01	**0.00**	61.8	35.4	31.6	**43**	ND	ND	ND	**ND**
Ave.	**321**	**305**	**326**	**317**	**0.64**	**0.51**	**0.36**	**0.51**	**720**	**715**	**654**	**696**	**ND**	**ND**	**ND**	**ND**
Intermediate Wells																
G0045	399	438	383	**407**	0.04	0.04	0.08	**0.05**	686	786	720	**731**	ND	ND	ND	**ND**
G0049	194	233	226	**218**	0.03	ND	0.13	**0.05**	39.4	36.2	48.3	**41**	ND	ND	ND	**ND**
G0076	220	259	228	**236**	0.47	0.60	0.74	**0.60**	41.2	45.3	51.0	**46**	ND	ND	ND	**ND**
G0078	225	246	228	**233**	ND	ND	0.04	**0.01**	39.0	35.7	34.5	**36**	ND	ND	ND	**ND**
Ave.	**260**	**294**	**266**	**273**	**0.14**	**0.16**	**0.25**	**0.18**	**201**	**226**	**213**	**214**	**ND**	**ND**	**ND**	**ND**
Deep Wells																
G0070	180	207	186	**191**	0.46	0.47	0.54	**0.49**	17.9	23.9	18.3	**20**	ND	ND	ND	**ND**

Notes: DO - Dissolved Oxygen; TKN - Total Kjeldahl Nitrogen; NO2+NO3 - Nitrate plus Nitrite
CO2 - Carbon Dioxide; DOC - Dissolved Organic Carbon; NS - Not Sampled; NM - Not Measured

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	pH				Conductivity (mS/cm)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
Shallow Wells								
G0011	6.75	7.28	7.00	**7.01**	2450	2260	2210	**2307**
G0012	6.89	6.97	6.96	**6.94**	2150	1820	2090	**2020**
G0013	6.86	6.87	6.89	**6.87**	2830	2720	2770	**2773**
G0014	6.92	7.04	7.10	**7.02**	1740	1970	1630	**1780**
G0015	7.04	7.14	7.20	**7.13**	2140	1900	1950	**1997**
G0016	6.85	7.05	7.11	**7.00**	1550	1355	1490	**1465**
G0017	6.88	7.11	7.20	**7.06**	1550	1273	1081	**1301**
G0018	6.83	6.88	7.01	**6.91**	1294	951	1208	**1151**
G0019	6.98	7.28	7.22	**7.16**	949	923	842	**905**
G0020	6.82	7.23	7.19	**7.08**	727	700	690	**706**
G0021	7.11	7.41	7.28	**7.27**	705	602	614	**640**
G0022	6.80	7.37	7.15	**7.11**	497	480	465	**481**
G0023	6.72	6.60	6.95	**6.76**	488	594	495	**526**
G0024	6.17	6.85	6.37	**6.46**	644	594	370	**536**
G0025	6.40	6.46	6.81	**6.56**	286	274	247	**269**
G0029	6.43	7.13	6.56	**6.71**	645	450	512	**536**
G0030	6.44	6.96	6.75	**6.72**	567	615	753	**585**
G0031	6.58	7.04	6.65	**6.76**	557	542	553	**551**
G0032	7.21	7.53	7.05	**7.26**	2340	2270	2310	**2307**
G0033	6.53	7.05	6.65	**6.74**	663	784	750	**732**
G0042	7.01	7.01	7.05	**7.02**	1620	1810	1950	**1793**
G0043	7.11	7.14	7.20	**7.15**	1436	1395	1279	**1370**
G0044	7.03	7.04	7.02	**7.03**	1510	2350	1560	**1807**
G0046	6.95	7.02	7.17	**7.05**	1780	1730	1490	**1667**
G0047	7.11	7.26	7.22	**7.20**	750	769	717	**745**
G0048	6.59	6.43	6.83	**6.62**	543	719	662	**641**
G0052	6.10	6.57	6.21	**6.29**	453	460	444	**452**
G0063	NS	6.93	7.03	**6.98**	NS	2150	2370	**2260**
G0066	6.67	6.83	7.06	**3.85**	820	792	646	**753**
G0067	6.56	6.32	6.68	**6.52**	391	412	407	**403**
G0068	6.91	6.82	6.85	**6.86**	1760	1820	1458	**1679**
G0079	NS	NS	6.80	**6.80**	NS	NS	509	**509**

TABLE 6-2

SUMMARY OF ON-POST NATURAL ATTENUATION PARAMETERS CONCENTRATIONS
CORNHUSKER ARMY AMMUNITION PLANT

Well Number	pH				Conductivity (mS/cm)			
	Jun-98	Mar-99	Mar-00	Ave.	Jun-98	Mar-99	Mar-00	Ave.
PZ001	NM	6.99	7.10	**7.05**	NM	2050	1940	**1995**
PZ004	NM	6.93	7.07	**7.00**	NM	2110	2130	**2120**
PZ005	NM	7.10	7.10	**7.10**	NM	1800	1720	**1760**
PZ006	NM	7.03	7.09	**7.06**	NM	1800	1700	**1750**
PZ007	NM	7.06	7.21	**7.14**	NM	1200	1224	**1212**
PZ008	NM	7.04	7.21	**7.13**	NM	1332	1076	**1204**
PZ009	NM	7.17	7.20	**7.19**	NM	908	812	**860**
PZ010	NM	7.14	7.13	**7.14**	NM	970	902	**936**
PZ011	NM	7.09	7.09	**7.09**	NM	811	824	**818**
PZ012	NM	7.14	7.04	**7.09**	NM	881	790	**836**
PZ013	NM	7.12	7.13	**7.13**	NM	1089	886	**988**
PZ014	NM	7.35	7.30	**7.33**	NM	846	824	**835**
PZ015	NM	5.93	6.74	**6.43**	NM	303	517	**410**
PZ016	NM	6.39	6.78	**6.59**	NM	386	388	**387**
Ave.	**6.78**	**6.98**	**6.99**	**6.94**	**1195**	**1199**	**1132**	**1169**
Shallow-Int Well								
G0026	7.15	7.19	7.25	**7.20**	3160	2840	2510	**2837**
G0027	7.25	7.18	7.28	**7.24**	2970	2770	2720	**2820**
G0028	7.11	7.15	7.16	**7.14**	2730	2740	2650	**2707**
G0075	6.86	7.14	7.01	**7.00**	522	472	470	**488**
G0077	6.76	7.21	6.93	**6.97**	575	489	553	**539**
Ave.	**7.03**	**7.17**	**7.13**	**7.11**	**1991**	**1862**	**1781**	**1878**
Intermediate Wells								
G0045	6.99	7.16	7.21	**7.12**	2110	2100	2030	**2080**
G0049	6.95	6.78	7.17	**6.97**	500	493	523	**505**
G0076	7.12	7.48	7.27	**7.29**	550	502	494	**515**
G0078	7.20	7.59	7.37	**7.39**	531	489	497	**506**
Ave.	**7.07**	**7.25**	**7.26**	**7.19**	**923**	**896**	**886**	**902**
Deep Wells								
G0070	7.05	7.46	7.26	**7.26**	415	386	338	**380**

Notes: DO - Dissolved Oxygen; TKN - Total Kjeldahl Nitrogen; NO2+NO3 - Nitrate plus Nitrite
CO2 - Carbon Dioxide; DOC - Dissolved Organic Carbon; NS - Not Sampled; NM - Not Measured

TABLE 6-3

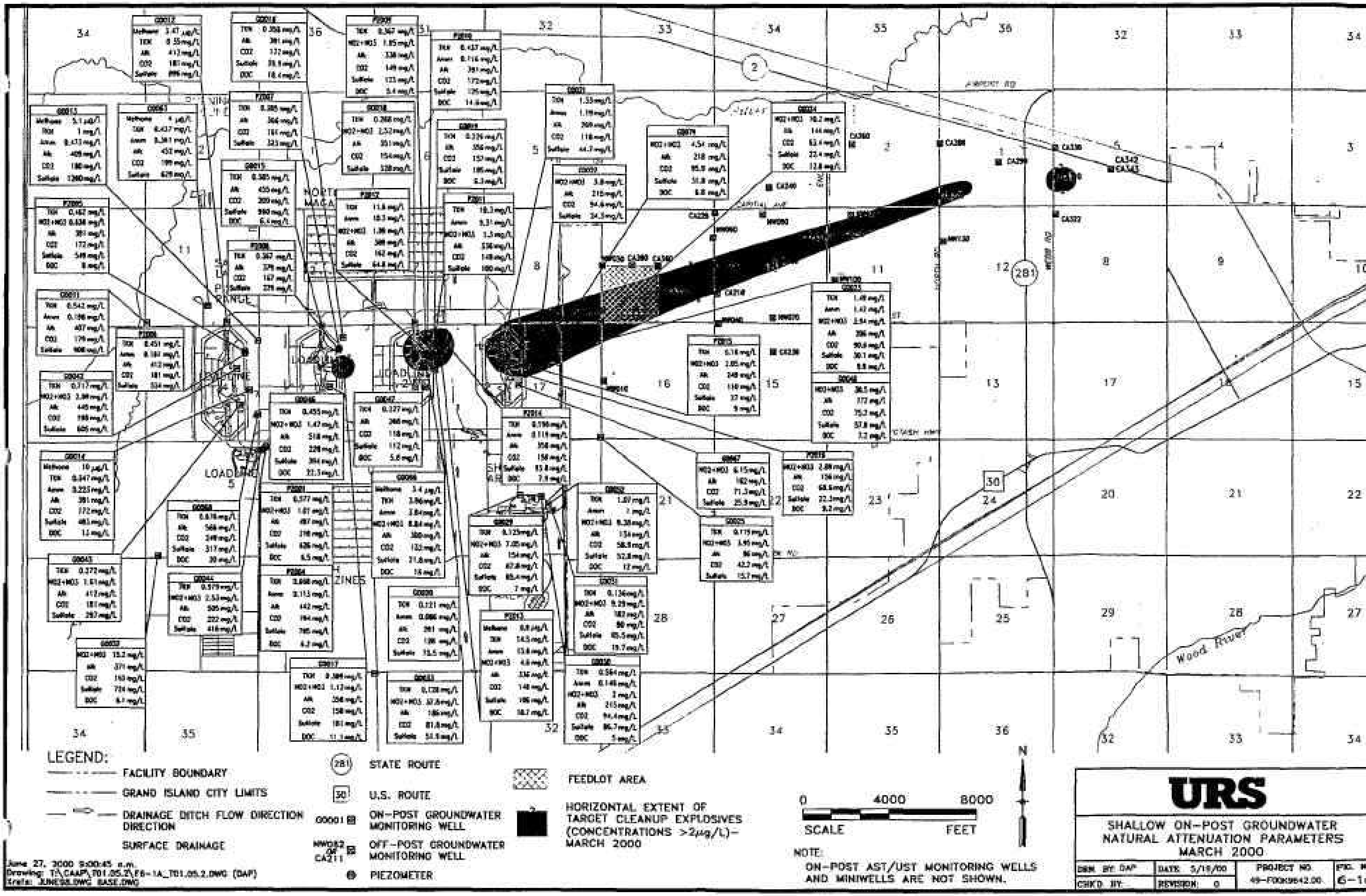
SUMMARY OF ESTIMATED DEGRADATION HALF-LIVES
CORNHUSKER ARMY AMMUNITION PLANT

		Estimated Half-Lives (years)											
		RDX				TNT				HMX			
Plume Areas	**Methods**	**Single Well[1]**	**Multiple Well[2]**	**Multiple Well[3]**	**Geometric Mean**	**Single Well[1]**	**Multiple Well[2]**	**Multiple Well[3]**	**Geometric Mean**	**Single Well[1]**	**Multiple Well[2]**	**Multiple Well[3]**	**Geometric Mean**
Load Line 1		5.1	6.1	6.0	**5.7**	5.7	NA+	NA+	**5.7**	4.5	9.3	8.8	**7.2**
Feed Lot		7.0	3.8	2.9	**4.3**	3.7	1.6	2.8	**2.5**	0.6	NA+	NA+	**0.6**
Distal Off-Post Plume		2.9	14.8	16.6	**8.9**	ND	ND	ND	**ND**	5.1	10.8	9.2	**8.0**

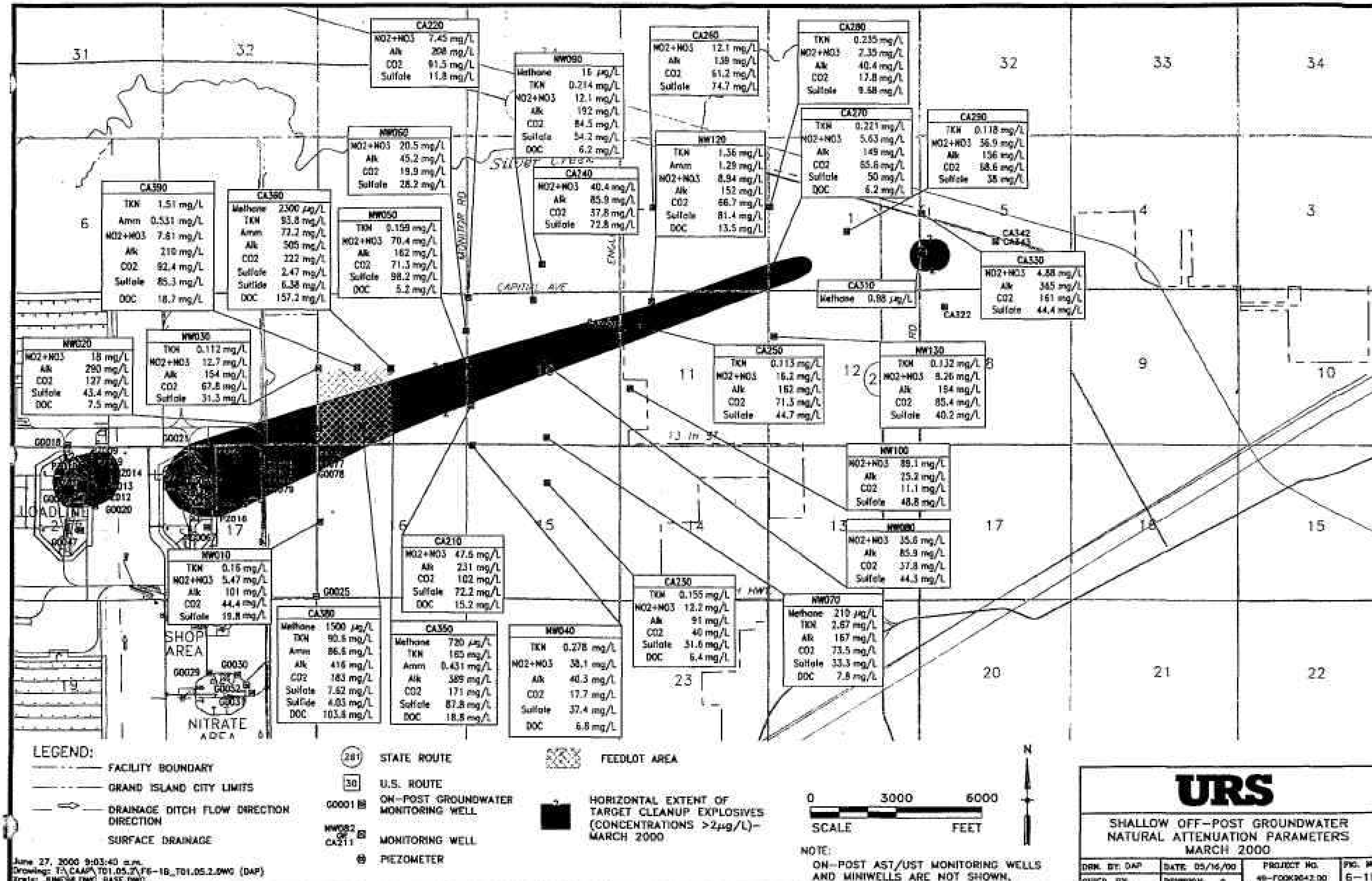
Notes:
Half-life estimates were calculated using three methods. The results above are tabulated by method according to the following column numbers.

[1] Single well estimate using decreasing concentrations over time using Graves (1995)
[2] Multiple well estimates using concentrations along the groundwater flow path using Graves (1995)
[3] Multiple well estimates using concentrations along the groundwater flow path using Buscheck and Alcantar (1995)

NA+ Not Available. Concentrations increase along flowpath within area.
ND Nondetect



LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION DIRECTION
SURFACE DRAINAGE
STATE ROUTE
U.S. ROUTE
ON-POST GROUNDWATER MONITORING WELL
OFF-POST GROUNDWATER MONITORING WELL
PIEZOMETER
FEEDLOT AREA
HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (CONCENTRATIONS >2μg/L)- MARCH 2000
0 4000 8000
SCALE FEET
N
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
URS
SHALLOW ON-POST GROUNDWATER NATURAL ATTENUATION PARAMETERS MARCH 2000
DATE 5/10/00
REVISION: 0
PROJECT NO.
FIG. NO.
6-1a
June 27, 2000 9:00:45 a.m.
Wood River


CA220
NO2+NO3 7.45 mg/L
Alk 208 mg/L
CO2 91.5 mg/L
Sulfate 11.8 mg/L
NW090
Methane 16 µg/L
TKN 0.214 mg/L
NO2+NO3 12.1 mg/L
Alk 192 mg/L
CO2 84.5 mg/L
Sulfate 54.2 mg/L
DOC 6.2 mg/L
CA260
NO2+NO3 12.1 mg/L
Alk 139 mg/L
CO2 61.2 mg/L
Sulfate 74.7 mg/L
CA280
TKN 0.235 mg/L
NO2+NO3 7.35 mg/L
Alk 40.4 mg/L
CO2 17.8 mg/L
Sulfate 9.68 mg/L
CA270
TKN 0.221 mg/L
NO2+NO3 5.63 mg/L
Alk 149 mg/L
CO2 65.6 mg/L
Sulfate 50 mg/L
DOC 6.2 mg/L
CA290
TKN 0.118 mg/L
NO2+NO3 36.9 mg/L
Alk 156 mg/L
CO2 58.6 mg/L
Sulfate 38 mg/L
NW060
NO2+NO3 20.5 mg/L
Alk 45.2 mg/L
CO2 19.9 mg/L
Sulfate 28.2 mg/L
CA240
NO2+NO3 40.4 mg/L
Alk 85.9 mg/L
CO2 37.8 mg/L
Sulfate 72.8 mg/L
NW120
TKN 1.36 mg/L
Amm 1.29 mg/L
NO2+NO3 8.94 mg/L
Alk 152 mg/L
CO2 66.7 mg/L
Sulfate 81.4 mg/L
DOC 13.5 mg/L
CA390
TKN 1.51 mg/L
Amm 0.531 mg/L
NO2+NO3 7.81 mg/L
Alk 210 mg/L
CO2 92.4 mg/L
Sulfate 85.3 mg/L
DOC 18.7 mg/L
CA360
Methane 2300 µg/L
TKN 93.8 mg/L
Amm 77.2 mg/L
Alk 505 mg/L
CO2 222 mg/L
Sulfate 2.47 mg/L
Sulfide 6.38 mg/L
DOC 157.2 mg/L
NW050
TKN 0.159 mg/L
NO2+NO3 70.4 mg/L
Alk 162 mg/L
CO2 71.3 mg/L
Sulfate 98.2 mg/L
DOC 5.2 mg/L
CA310
Methane 0.88 µg/L
CA342
CA343
CA330
NO2+NO3 4.88 mg/L
Alk 365 mg/L
CO2 161 mg/L
Sulfate 44.4 mg/L
CA322
NW020
NO2+NO3 18 mg/L
Alk 290 mg/L
CO2 127 mg/L
Sulfate 43.4 mg/L
DOC 7.5 mg/L
NW030
TKN 0.112 mg/L
NO2+NO3 12.7 mg/L
Alk 154 mg/L
CO2 67.8 mg/L
Sulfate 31.3 mg/L
CA250
TKN 0.113 mg/L
NO2+NO3 16.2 mg/L
Alk 162 mg/L
CO2 71.3 mg/L
Sulfate 44.7 mg/L
NW130
TKN 0.132 mg/L
NO2+NO3 9.26 mg/L
Alk 154 mg/L
CO2 85.4 mg/L
Sulfate 40.2 mg/L
NW100
NO2+NO3 89.1 mg/L
Alk 25.2 mg/L
CO2 11.1 mg/L
Sulfate 48.8 mg/L
NW080
NO2+NO3 35.6 mg/L
Alk 85.9 mg/L
CO2 37.8 mg/L
Sulfate 44.3 mg/L
NW010
TKN 0.16 mg/L
NO2+NO3 5.47 mg/L
Alk 101 mg/L
CO2 44.4 mg/L
Sulfate 19.8 mg/L
CA210
NO2+NO3 47.6 mg/L
Alk 231 mg/L
CO2 102 mg/L
Sulfate 72.2 mg/L
DOC 15.2 mg/L
CA230
TKN 0.155 mg/L
NO2+NO3 13.2 mg/L
Alk 91 mg/L
CO2 40 mg/L
Sulfate 31.6 mg/L
DOC 6.4 mg/L
NW070
Methane 210 µg/L
TKN 2.67 mg/L
Alk 167 mg/L
CO2 73.5 mg/L
Sulfate 33.3 mg/L
DOC 7.8 mg/L
CA380
Methane 1500 µg/L
TKN 90.6 mg/L
Amm 86.6 mg/L
Alk 416 mg/L
CO2 183 mg/L
Sulfate 7.62 mg/L
Sulfide 4.03 mg/L
DOC 103.6 mg/L
CA350
Methane 720 µg/L
TKN 165 mg/L
Amm 0.431 mg/L
Alk 389 mg/L
CO2 171 mg/L
Sulfate 87.8 mg/L
DOC 18.8 mg/L
NW040
TKN 0.278 mg/L
NO2+NO3 38.1 mg/L
Alk 40.3 mg/L
CO2 17.7 mg/L
Sulfate 37.4 mg/L
DOC 6.8 mg/L
31
32
32
33
34
6
5
4
3
11
12
9
10
17
15
14
13
17
18
15
23
20
21
22
19
Silver Creek
CAPITAL AVE
MONITOR RD
ENGL
RD
13 th St
HWY
G0018
G0021
G0077
G0078
G0020
G0025
G0029
G0030
G0031
G0052
G0047
LOADLINE
SHOP AREA
NITRATE AREA
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
281 STATE ROUTE
30 U.S. ROUTE
G0001 ON-POST GROUNDWATER MONITORING WELL
NW082 OR CA211 MONITORING WELL
PIEZOMETER
FEEDLOT AREA
HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (CONCENTRATIONS >2µg/L)–MARCH 2000
0 3000 6000
SCALE FEET
N
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
URS
SHALLOW OFF-POST GROUNDWATER NATURAL ATTENUATION PARAMETERS MARCH 2000
DRN. BY: DAP
DATE: 05/16/00
PROJECT NO. 49-F00K9042.00
FIG. NO. 6-1b
CHKD. BY:
REVISION: 0
June 27, 2000 9:03:40 a.m.
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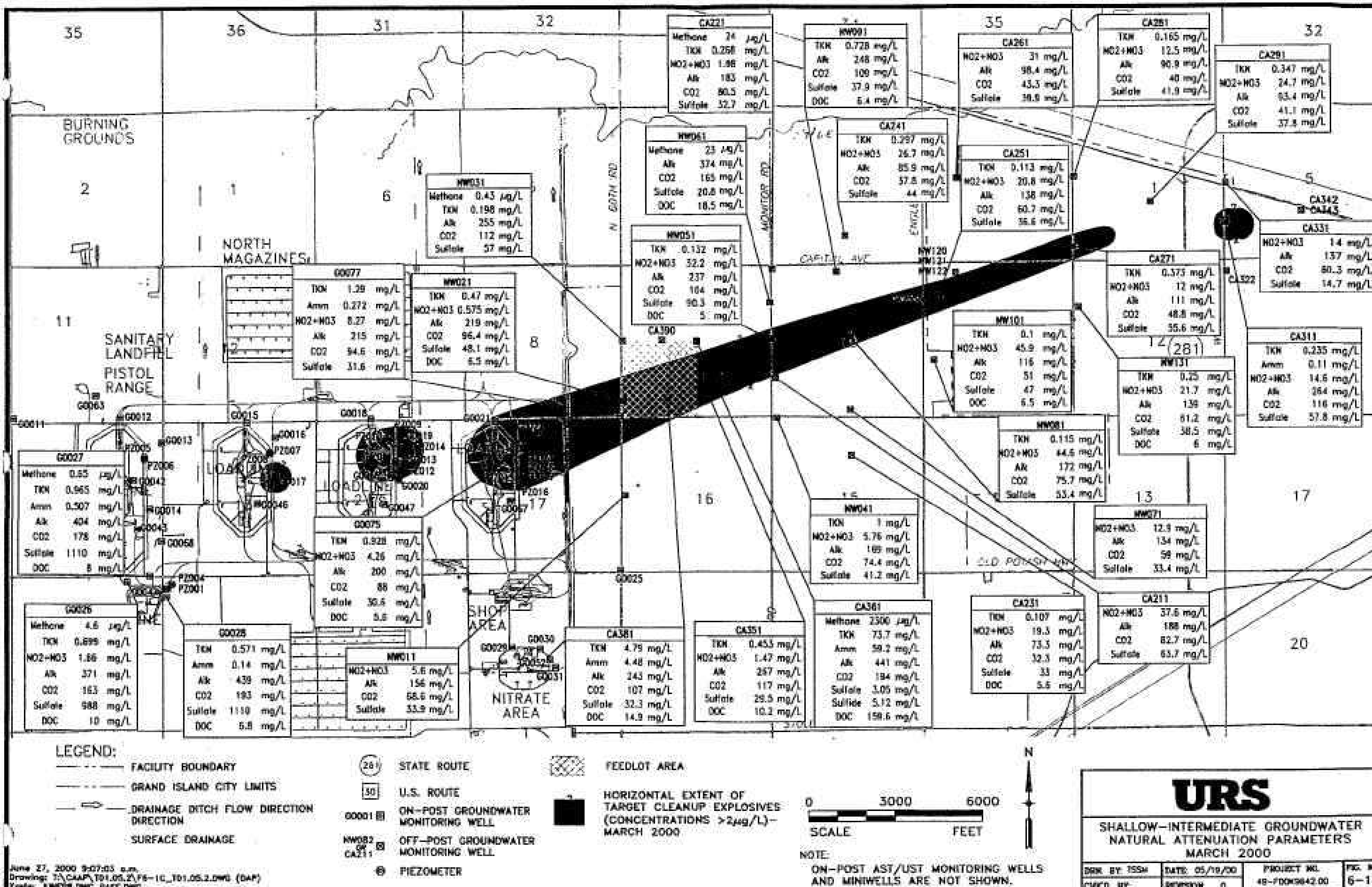
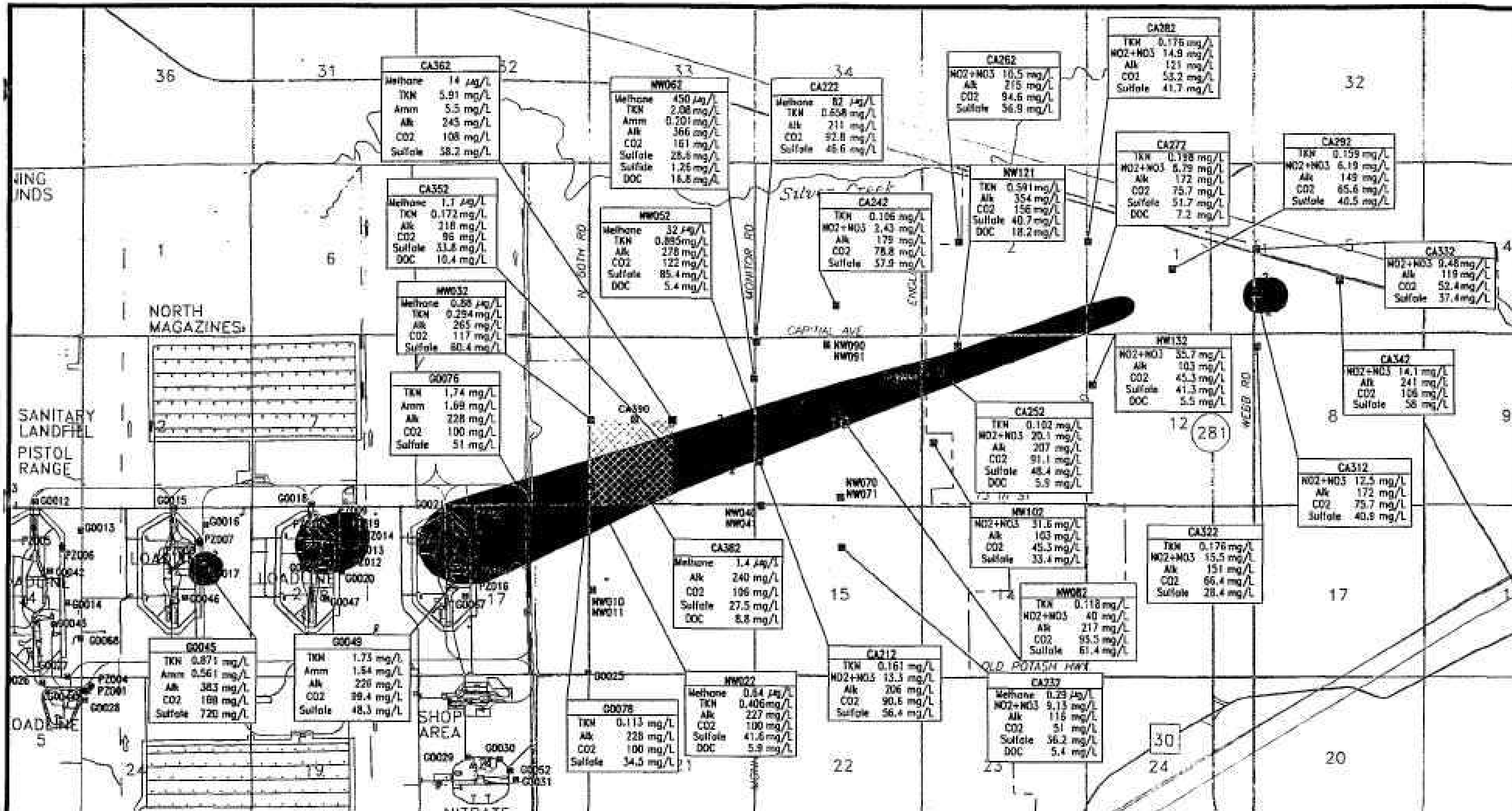
Xrefs: JUNE98.DWG BASE.DWG


CA221
Methane 24 µg/L
TKN 0.258 mg/L
NO2+NO3 1.98 mg/L
Alk 183 mg/L
CO2 80.5 mg/L
Sulfate 32.7 mg/L
NW091
TKN 0.728 mg/L
Alk 248 mg/L
CO2 109 mg/L
Sulfate 37.9 mg/L
DOC 6.4 mg/L
CA261
NO2+NO3 31 mg/L
Alk 98.4 mg/L
CO2 43.3 mg/L
Sulfate 38.9 mg/L
CA281
TKN 0.165 mg/L
NO2+NO3 12.5 mg/L
Alk 90.9 mg/L
CO2 40 mg/L
Sulfate 41.9 mg/L
CA291
TKN 0.347 mg/L
NO2+NO3 24.7 mg/L
Alk 93.4 mg/L
CO2 41.1 mg/L
Sulfate 37.8 mg/L
NW061
Methane 23 µg/L
Alk 374 mg/L
CO2 165 mg/L
Sulfate 20.8 mg/L
DOC 18.5 mg/L
CA241
TKN 0.297 mg/L
NO2+NO3 26.7 mg/L
Alk 85.9 mg/L
CO2 37.8 mg/L
Sulfate 44 mg/L
CA251
TKN 0.113 mg/L
NO2+NO3 20.8 mg/L
Alk 138 mg/L
CO2 60.7 mg/L
Sulfate 36.6 mg/L
NW031
Methane 0.43 µg/L
TKN 0.198 mg/L
Alk 255 mg/L
CO2 112 mg/L
Sulfate 57 mg/L
NW051
TKN 0.132 mg/L
NO2+NO3 32.2 mg/L
Alk 237 mg/L
CO2 104 mg/L
Sulfate 90.3 mg/L
DOC 5 mg/L
CA331
NO2+NO3 14 mg/L
Alk 137 mg/L
CO2 60.3 mg/L
Sulfate 14.7 mg/L
CA271
TKN 0.373 mg/L
NO2+NO3 12 mg/L
Alk 111 mg/L
CO2 48.8 mg/L
Sulfate 55.6 mg/L
G0077
TKN 1.29 mg/L
Amm 0.272 mg/L
NO2+NO3 8.27 mg/L
Alk 215 mg/L
CO2 94.6 mg/L
Sulfate 31.6 mg/L
NW021
TKN 0.47 mg/L
NO2+NO3 0.575 mg/L
Alk 219 mg/L
CO2 96.4 mg/L
Sulfate 48.1 mg/L
DOC 6.5 mg/L
NW101
TKN 0.1 mg/L
NO2+NO3 45.9 mg/L
Alk 116 mg/L
CO2 51 mg/L
Sulfate 47 mg/L
DOC 6.5 mg/L
CA311
TKN 0.235 mg/L
Amm 0.11 mg/L
NO2+NO3 14.6 mg/L
Alk 264 mg/L
CO2 116 mg/L
Sulfate 57.8 mg/L
NW131
TKN 0.25 mg/L
NO2+NO3 21.7 mg/L
Alk 139 mg/L
CO2 61.2 mg/L
Sulfate 38.5 mg/L
DOC 6 mg/L
NW081
TKN 0.115 mg/L
NO2+NO3 64.6 mg/L
Alk 172 mg/L
CO2 75.7 mg/L
Sulfate 53.4 mg/L
G0027
Methane 0.65 µg/L
TKN 0.965 mg/L
Amm 0.507 mg/L
Alk 404 mg/L
CO2 178 mg/L
Sulfate 1110 mg/L
DOC 8 mg/L
G0075
TKN 0.928 mg/L
NO2+NO3 4.26 mg/L
Alk 200 mg/L
CO2 88 mg/L
Sulfate 30.6 mg/L
DOC 5.6 mg/L
NW041
TKN 1 mg/L
NO2+NO3 5.76 mg/L
Alk 169 mg/L
CO2 74.4 mg/L
Sulfate 41.2 mg/L
NW071
NO2+NO3 12.9 mg/L
Alk 134 mg/L
CO2 59 mg/L
Sulfate 33.4 mg/L
G0026
Methane 4.6 µg/L
TKN 0.699 mg/L
NO2+NO3 1.66 mg/L
Alk 371 mg/L
CO2 163 mg/L
Sulfate 988 mg/L
DOC 10 mg/L
G0028
TKN 0.571 mg/L
Amm 0.14 mg/L
Alk 439 mg/L
CO2 193 mg/L
Sulfate 1110 mg/L
DOC 5.8 mg/L
NW011
NO2+NO3 5.6 mg/L
Alk 156 mg/L
CO2 68.6 mg/L
Sulfate 33.9 mg/L
CA381
TKN 4.79 mg/L
Amm 4.48 mg/L
Alk 243 mg/L
CO2 107 mg/L
Sulfate 32.3 mg/L
DOC 14.9 mg/L
CA351
TKN 0.453 mg/L
NO2+NO3 1.47 mg/L
Alk 267 mg/L
CO2 117 mg/L
Sulfate 29.5 mg/L
DOC 10.2 mg/L
CA361
Methane 2300 µg/L
TKN 73.7 mg/L
Amm 59.2 mg/L
Alk 441 mg/L
CO2 194 mg/L
Sulfate 3.05 mg/L
Sulfide 5.12 mg/L
DOC 159.6 mg/L
CA231
TKN 0.107 mg/L
NO2+NO3 19.3 mg/L
Alk 73.3 mg/L
CO2 32.3 mg/L
Sulfate 33 mg/L
DOC 5.5 mg/L
CA211
NO2+NO3 37.6 mg/L
Alk 188 mg/L
CO2 82.7 mg/L
Sulfate 63.7 mg/L
BURNING GROUNDS
NORTH MAGAZINES
SANITARY LANDFILL
PISTOL RANGE
SHOP AREA
NITRATE AREA
CAPITAL AVE
OLD POTASH HWY
N 60TH RD
MONITOR RD
ENGLE
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION DIRECTION
SURFACE DRAINAGE
STATE ROUTE
U.S. ROUTE
ON-POST GROUNDWATER MONITORING WELL
OFF-POST GROUNDWATER MONITORING WELL
PIEZOMETER
FEEDLOT AREA
HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (CONCENTRATIONS >2µg/L)- MARCH 2000
0 3000 6000
SCALE FEET
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
URS
SHALLOW-INTERMEDIATE GROUNDWATER NATURAL ATTENUATION PARAMETERS MARCH 2000
DATE: 05/10/00
PROJECT NO. 48-F00K9842.00
FIG. NO. 6-1c
June 27, 2000 9:07:03 a.m.



LEGEND:

- FACILITY BOUNDARY
- GRAND ISLAND CITY LIMITS
- DRAINAGE DITCH FLOW DIRECTION
- SURFACE DRAINAGE
- (281) STATE ROUTE
- [30] U.S. ROUTE
- G0001 ON-POST GROUNDWATER MONITORING WELL
- NW082 OR CA211 OFF-POST GROUNDWATER MONITORING WELL
- PIEZOMETER
- FEEDLOT AREA
- HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (CONCENTRATIONS >2µg/L)–MARCH 2000

0 3000 6000
SCALE FEET

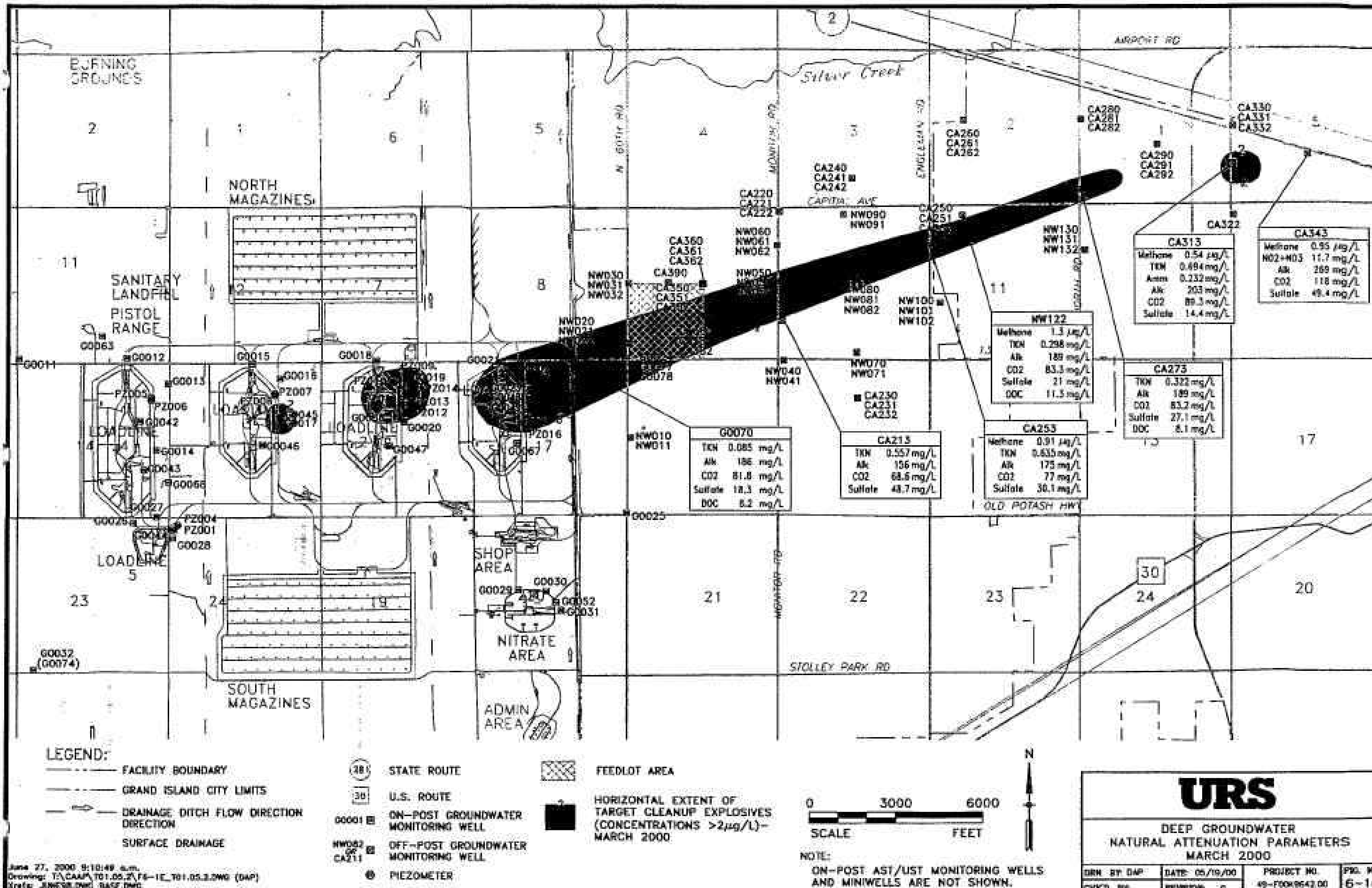
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.

June 27, 2000 9:08:59 a.m.
Drawing: T:\CAAP\T01.05.2\FS-10_T01.05.2.DWG (DAP)
Xrefs: JUNE98.DWG BASE.DWG

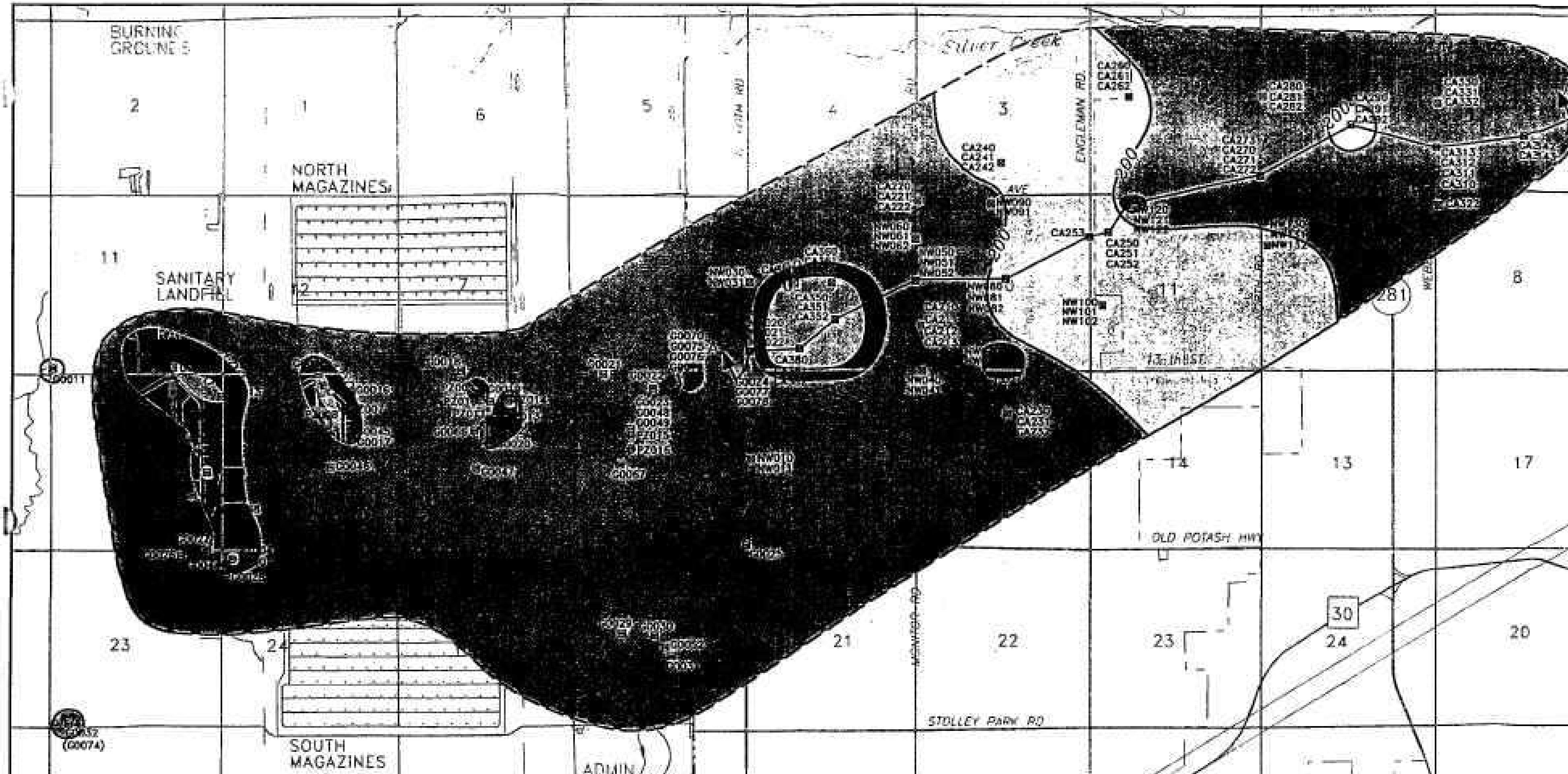
URS

INTERMEDIATE GROUNDWATER NATURAL ATTENUATION PARAMETERS MARCH 2000

DRN. BY: DAP	DATE: 05/19/00	PROJECT NO.	FIG. NO.
CHK'D. BY:	REVISION: 0	49-FDOK9642.00	6-1d



BURNING GROUNDS
SANITARY LANDFILL
PISTOL RANGE
NORTH MAGAZINES
SOUTH MAGAZINES
LOADLINE 1
LOADLINE 2
LOADLINE 3
LOADLINE 4
LOADLINE 5
SHOP AREA
NITRATE AREA
ADMIN AREA
AIRPORT RD
Silver Creek
CAPITAL AVE
N 60TH RD
MONITOR RD
ENGLEMAN RD
OLD POTASH HWY
STOLLEY PARK RD
G0070
TKN 0.085 mg/L
Alk 186 mg/L
CO2 81.8 mg/L
Sulfate 18.3 mg/L
DOC 8.2 mg/L
CA213
TKN 0.557 mg/L
Alk 156 mg/L
CO2 68.6 mg/L
Sulfate 48.7 mg/L
NW122
Methane 1.3 µg/L
TKN 0.298 mg/L
Alk 189 mg/L
CO2 83.3 mg/L
Sulfate 21 mg/L
DOC 11.3 mg/L
CA253
Methane 0.91 µg/L
TKN 0.635 mg/L
Alk 175 mg/L
CO2 77 mg/L
Sulfate 30.1 mg/L
CA273
TKN 0.322 mg/L
Alk 189 mg/L
CO2 83.2 mg/L
Sulfate 27.1 mg/L
DOC 8.1 mg/L
CA313
Methane 0.54 µg/L
TKN 0.694 mg/L
Amm 0.232 mg/L
Alk 203 mg/L
CO2 89.3 mg/L
Sulfate 14.4 mg/L
CA343
Methane 0.95 µg/L
NO2+NO3 11.7 mg/L
Alk 269 mg/L
CO2 118 mg/L
Sulfate 49.4 mg/L
LEGEND:
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
DRAINAGE DITCH FLOW DIRECTION
SURFACE DRAINAGE
STATE ROUTE
U.S. ROUTE
ON-POST GROUNDWATER MONITORING WELL
OFF-POST GROUNDWATER MONITORING WELL
PIEZOMETER
FEEDLOT AREA
HORIZONTAL EXTENT OF TARGET CLEANUP EXPLOSIVES (CONCENTRATIONS >2µg/L)-MARCH 2000
0 3000 6000
SCALE FEET
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
URS
DEEP GROUNDWATER NATURAL ATTENUATION PARAMETERS MARCH 2000
DRN BY: DAP
DATE: 05/19/00
CHK'D BY:
REVISION: 0
PROJECT NO.
FIG. NO. 6-1e
June 27, 2000 9:10:49 a.m.



AVERAGE REDOX POTENTIAL

(AVERAGE VALUES FROM PAST THREE LTM EVENTS)

- < 0mV
- 0 TO 100mV
- 100 TO 200mV
- > 200mV

LEGEND:

- G0001 ON-POST GROUNDWATER MONITORING WELL
- NW082 OR CA211 OFF-POST GROUNDWATER MONITORING WELL
- ON-POST PIEZOMETER
- A A' GEOLOGIC CROSS SECTION
- LIMIT OF DATA INTERPRETATION

SCALE 0 3000 6000 FEET

N

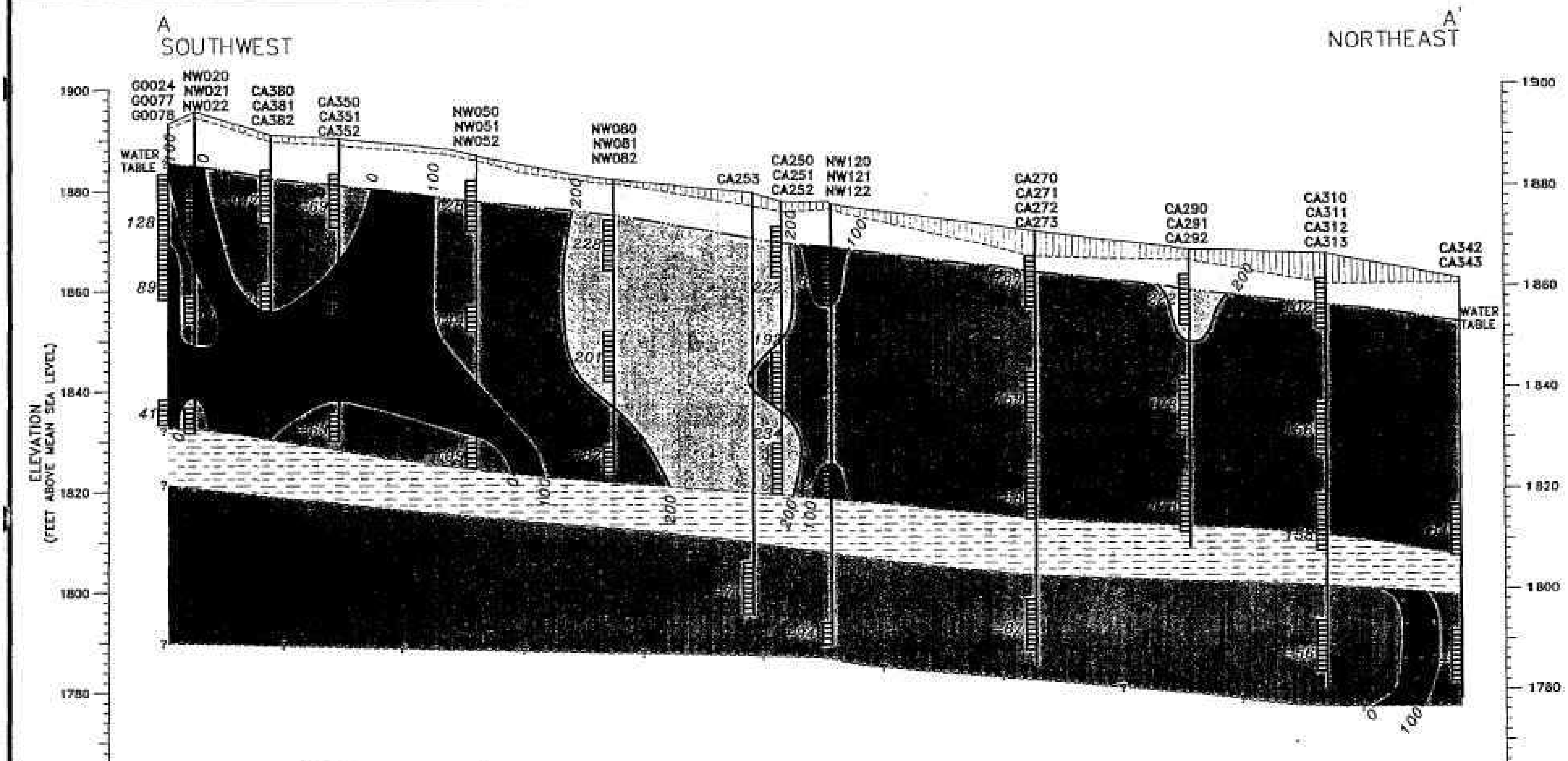
NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.

URS

SHALLOW GROUNDWATER REDOX POTENTIAL

DSN. BY: BAG	DATE: 05/31/00	PROJECT NO.	FIG. NO.
CHKD. BY:	REVISION: 0	49-F00K9642.00	6-2a

June 27, 2000 9:12:24 a.m.
Drawing: T:\CAAP\T01.05.2\K9602-03.DWG (DAP)
Xrefs: BASE.DWG



LEGEND

MONITORING WELL SCREEN INTERVAL WITH AVERAGE REDOX MEASUREMENTS (IN MILLIVOLTS)(mV)(AVERAGE OF PAST THREE LTM EVENTS)

TOPSOIL/CLAY AND SILT

GRAND ISLAND FORMATION (ALLUVIAL SAND AQUIFER)

FULLERTON FORMATION (BLUE CLAY AQUITARD)

HOLDREGE FORMATION (GRAVEL-PALEOVALLEY FILL AQUIFER)

WATER TABLE-MARCH 2000

AVERAGE REDOX POTENTIAL

< 0 mV

0 TO 100 mV

100 TO 200 mV

> 200 mV

VERTICAL SCALE
20 10 0 20

HORIZONTAL SCALE
2000 1000 0 2000

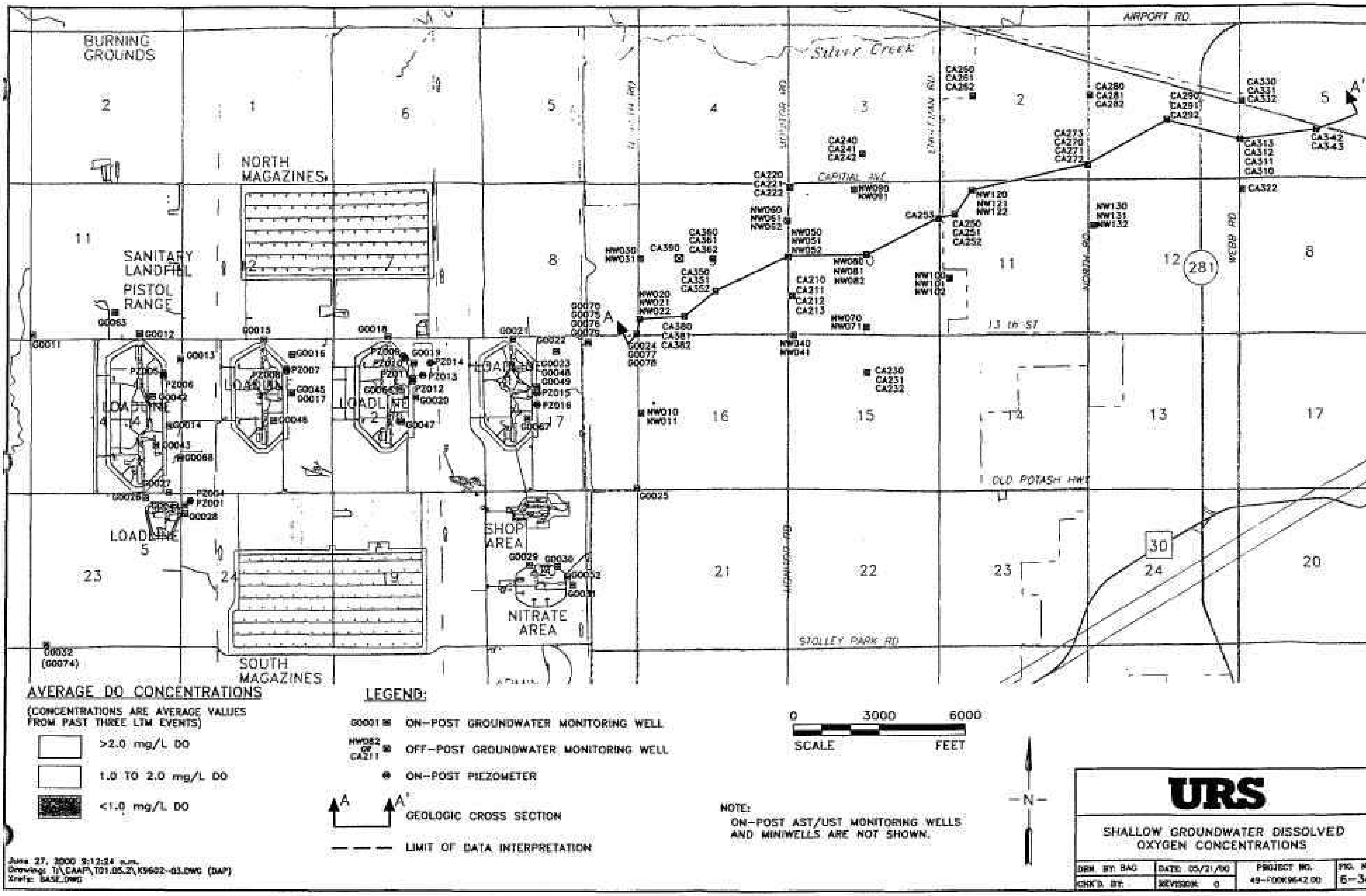
NOTE: VERTICAL EXAGGERATION IS 100:1

URS

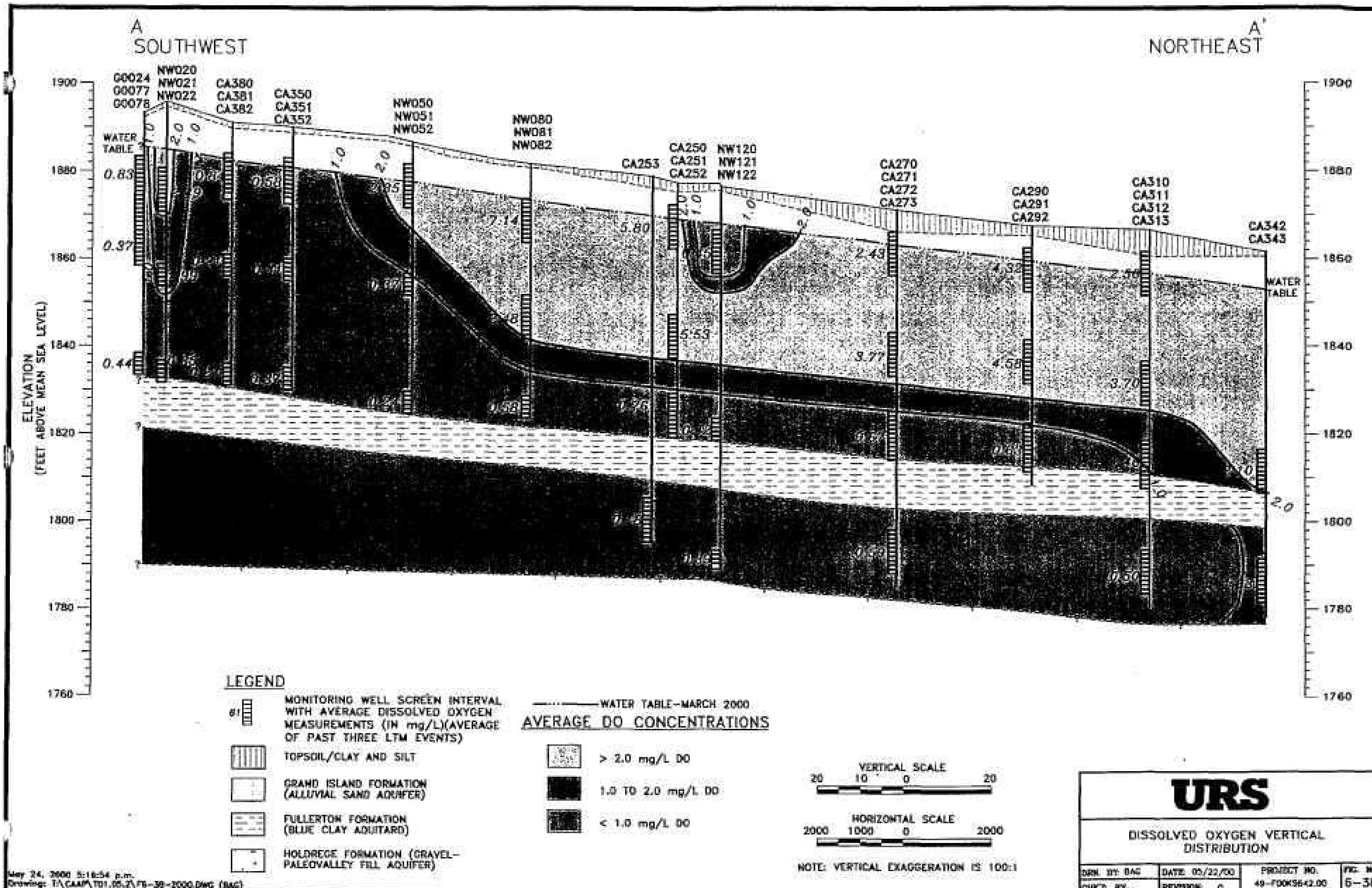
REDOX POTENTIAL VERTICAL DISTRIBUTION

DRN. BY: BAG	DATE: 05/22/00	PROJECT NO. 49-FOOK9642.00	FIG. NO. 6-2b
CHK'D BY:	REVISION: 0		

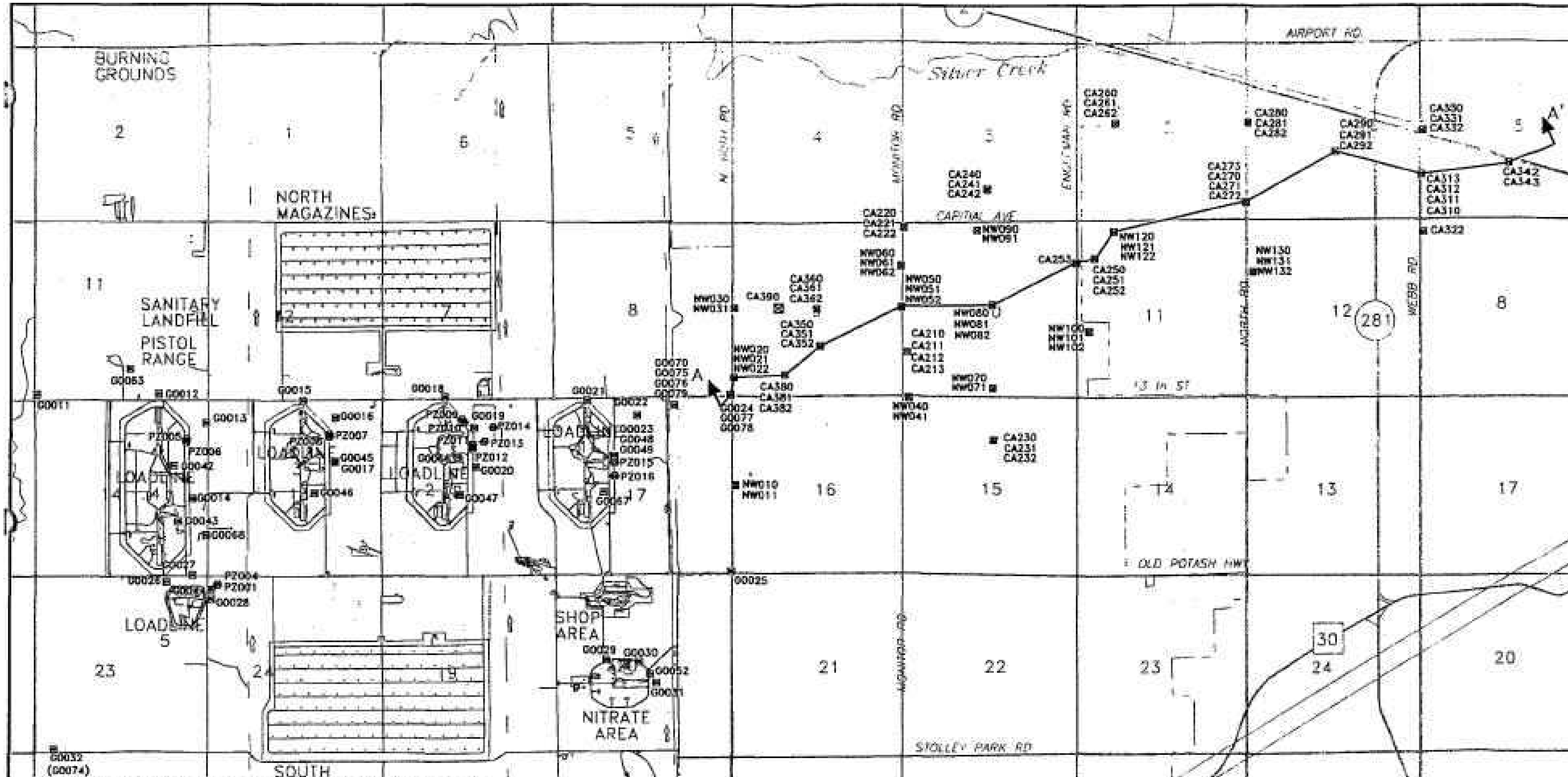
May 24, 2000 5:16:13 p.m.
Drawing: I:\CAAP\701.05.2\F6-2B-2000.DWG (BAG)



AIRPORT RD.
Silver Creek
BURNING GROUNDS
NORTH MAGAZINES
SANITARY LANDFILL
PISTOL RANGE
LOADLINE 1
LOADLINE 2
LOADLINE 3
LOADLINE 4
LOADLINE 5
SHOP AREA
NITRATE AREA
SOUTH MAGAZINES
CAPITAL AVE
13 th ST
OLD POTASH HWY
STOLLEY PARK RD
NORTH RD
WEBB RD
281
30
A
A'
AVERAGE DO CONCENTRATIONS
(CONCENTRATIONS ARE AVERAGE VALUES FROM PAST THREE LTM EVENTS)
>2.0 mg/L DO
1.0 TO 2.0 mg/L DO
<1.0 mg/L DO
LEGEND:
G0001 ON-POST GROUNDWATER MONITORING WELL
NW082 or CA211 OFF-POST GROUNDWATER MONITORING WELL
ON-POST PIEZOMETER
GEOLOGIC CROSS SECTION
LIMIT OF DATA INTERPRETATION
0 3000 6000
SCALE FEET
NOTE: ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.
N
URS
SHALLOW GROUNDWATER DISSOLVED OXYGEN CONCENTRATIONS
DRN. BY: BAG
DATE: 05/21/00
CHK'D. BY:
REVISION: 0
PROJECT NO. 49-F00K9642.00
FIG. NO. 6-3a
June 27, 2000 9:12:24 a.m.
Drawing: T:\CAAP\T01.05.2\K9602-03.DWG (DAP)
Xrefs: BASE.DWG



A
SOUTHWEST
A'
NORTHEAST
ELEVATION (FEET ABOVE MEAN SEA LEVEL)
1900
1880
1860
1840
1820
1800
1780
1760
G0024
G0077
G0078
NW020
NW021
NW022
CA380
CA381
CA382
CA350
CA351
CA352
NW050
NW051
NW052
NW080
NW081
NW082
CA253
CA250
CA251
CA252
NW120
NW121
NW122
CA270
CA271
CA272
CA273
CA290
CA291
CA292
CA310
CA311
CA312
CA313
CA342
CA343
WATER TABLE
0.83
0.37
0.44
7.14
5.80
5.53
2.43
3.77
4.32
4.58
2.56
3.70
0.50
1.0
2.0
LEGEND
MONITORING WELL SCREEN INTERVAL WITH AVERAGE DISSOLVED OXYGEN MEASUREMENTS (IN mg/L)(AVERAGE OF PAST THREE LTM EVENTS)
TOPSOIL/CLAY AND SILT
GRAND ISLAND FORMATION (ALLUVIAL SAND AQUIFER)
FULLERTON FORMATION (BLUE CLAY AQUITARD)
HOLDREGE FORMATION (GRAVEL-PALEOVALLEY FILL AQUIFER)
WATER TABLE-MARCH 2000
AVERAGE DO CONCENTRATIONS
> 2.0 mg/L DO
1.0 TO 2.0 mg/L DO
< 1.0 mg/L DO
VERTICAL SCALE
20 10 0 20
HORIZONTAL SCALE
2000 1000 0 2000
NOTE: VERTICAL EXAGGERATION IS 100:1
URS
DISSOLVED OXYGEN VERTICAL DISTRIBUTION
DRN. BY: BAG
CHK'D. BY: -
DATE: 05/22/00
REVISION: 0
PROJECT NO. 49-F00K5642.00
FIG. NO. 6-3b
May 24, 2000 5:18:54 p.m.



AVERAGE NO?3? + NO?2? CONCENTRATIONS

(CONCENTRATIONS ARE AVERAGE VALUES FROM PAST THREE LTM EVENTS)

- < 1 mg/L
- 1 TO 10 mg/L
- >10 mg/L

LEGEND:

- G0001 ON-POST GROUNDWATER MONITORING WELL
- NW082 or CA211 OFF-POST GROUNDWATER MONITORING WELL
- ON-POST PIEZOMETER
- A A' GEOLOGIC CROSS SECTION
- LIMIT OF DATA INTERPRETATION

0 3000 6000
SCALE FEET

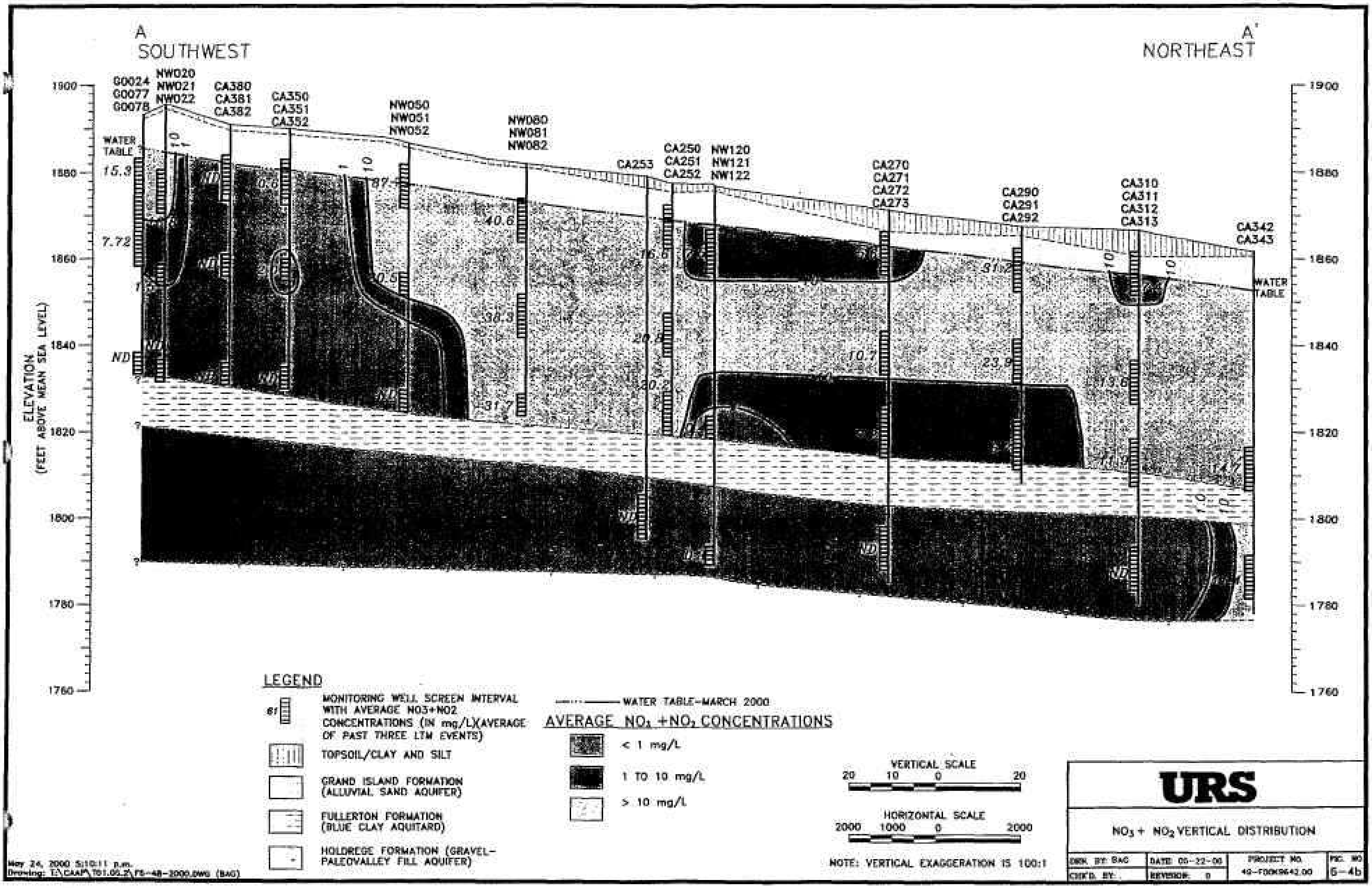
N

NOTE:
ON-POST AST/UST MONITORING WELLS AND MINIWELLS ARE NOT SHOWN.

June 27, 2000 9:12:24 a.m.
Drawing: T:\CAAP\T01.05.Z\K9802-03.DWG (DAP)
Xrefs: BASE.DWG

SHALLOW GROUNDWATER $NO_3 + NO_2$ CONCENTRATIONS

DWN. BY: TSSM	DATE: 08/12/99	PROJECT NO. 49-FOOK9642.00	FIG. NO. 6-4a
CHK'D. BY:	REVISION: 0		


A
SOUTHWEST
A'
NORTHEAST
ELEVATION (FEET ABOVE MEAN SEA LEVEL)
1900
1880
1860
1840
1820
1800
1780
1760
G0024
G0077
G0078
NW020
NW021
NW022
CA380
CA381
CA382
CA350
CA351
CA352
NW050
NW051
NW052
NW080
NW081
NW082
CA253
CA250
CA251
CA252
NW120
NW121
NW122
CA270
CA271
CA272
CA273
CA290
CA291
CA292
CA310
CA311
CA312
CA313
CA342
CA343
WATER TABLE ?
WATER TABLE
15.3
7.72
ND
0.6
87.4
40.6
0.5
38.3
31.7
16.5
20.8
30.2
31.2
10.7
23.9
13.6
10
LEGEND
MONITORING WELL SCREEN INTERVAL WITH AVERAGE NO3+NO2 CONCENTRATIONS (IN mg/L)(AVERAGE OF PAST THREE LTM EVENTS)
TOPSOIL/CLAY AND SILT
GRAND ISLAND FORMATION (ALLUVIAL SAND AQUIFER)
FULLERTON FORMATION (BLUE CLAY AQUITARD)
HOLDREGE FORMATION (GRAVEL-PALEOVALLEY FILL AQUIFER)
WATER TABLE-MARCH 2000
AVERAGE NO3 +NO2 CONCENTRATIONS
< 1 mg/L
1 TO 10 mg/L
> 10 mg/L
VERTICAL SCALE
20 10 0 20
HORIZONTAL SCALE
2000 1000 0 2000
NOTE: VERTICAL EXAGGERATION IS 100:1
URS
NO3 + NO2 VERTICAL DISTRIBUTION
DRN. BY: BAG
CHK'D. BY:
DATE: 05-22-00
REVISION: 0
PROJECT NO.
FIG. NO.
5-4b
May 24, 2000 5:10:11 p.m.

APPENDIX C Numerical Groundwater Contaminant Fate and Transport Backup

As an additional line of evidence in support of natural attenuation of the off-post explosives plume, a numerical groundwater contaminant fate and transport model was developed. The numerical model simulated baseline contaminant transport and transport under remediation conditions. The baseline contaminant fate and transport simulation and the new Proposed Remedy simulation were used to evaluate natural attenuation of the off-post explosives plume.

This appendix includes selected text and figures from the Groundwater Flow and Contaminant Fate and Transport Modeling Final Report (URS 2001). The entire report can be found in the administrative record at the Grand Island Public Library. All section numbers, text, tables, and figures remain unchanged from the original report.

SECTION ONE Introduction

1.1 PURPOSE AND AUTHORITY FOR THE PROJECT

The United States Army Corps of Engineers (USACE) has contracted URS Greiner Woodward Clyde (URSGWC) to complete the long-term monitoring (LTM) program for selected groundwater monitoring wells at the Cornhusker Army Ammunition Plant (CHAAP), located near Grand Island, Nebraska. Work for this assignment is being performed under Contract No. DCAC31-94-D-0059, Delivery Order 0001. The purpose of this report is to present the results of:

- Initial groundwater flow modeling completed by URSGWC, which consisted of recalibration and verification of an existing MODFLOW groundwater flow model.
- Simulation of the on-post groundwater extraction system and evaluation of extraction well capture zones.
- Optimization of the current on-post groundwater extraction system extraction rates and recommendations for a modified on-post groundwater extraction alternative.
- Construction of a three-dimensional numerical solute transport model.
- Simulation of baseline contaminant fate and transport.
- Simulation of contaminant transport under remediation system conditions to evaluate the effectiveness at controlling contaminant transport and at removing contaminant sources.

1.2 SITE HISTORY

CHAAP is located on an 11,936-acre tract approximately 2 miles west of Grand Island, Nebraska. The site also includes an off-post area (to the northeast) consisting of groundwater impacted by explosive compounds that originated at CHAAP.

CHAAP was constructed and became fully operational in 1942 as a U. S. Government- owned, contractor-operated facility. CHAAP was responsible for the production of artillery shells, mines, bombs, and rockets for World War II and the Korean and Vietnam conflicts. The plant was operated intermittently for 30 years with the most recent operations ending in 1973. From 1942-1945, various bombs, shells, boosters and supplementary charges were produced at CHAAP using primarily 2,4,6-trinitrotoluene (TNT). From 1950-1955, artillery shells and rockets were produced using a mixture of TNT, cyclonite (RDX), and cyclotetramethylenetetranitramine (HMX). CHAAP was activated again from 1965-1973 to produce bombs, projectiles, and gravel mini-mines. Explosive wastes and residues associated with munitions loading, assembly, and packing operations have resulted in a groundwater contamination plume that originates at waste leach pits and cesspools of the

CHAAP load lines and extends east-northeastward into the city of Grand Island, Nebraska.

The explosive compounds have migrated east-northeast with the predominant direction of groundwater flow. The more mobile compounds, RDX and HMX, have migrated the greatest distances. Highly sorbing compounds such as 2,4,6-TNT have migrated shorter distances. The March 1999 Annual Sampling Event Report (URSGWC 1999b) provides the most comprehensive description of the current nature and extent of groundwater contamination.

Evaluation and remediation of explosives contamination at CHAAP has been an on-going process. The U. S. Army conducted an incineration project (1987-1988) designed to excavate and treat soils beneath unlined leach pits and cesspools of the CHAAP load lines. The purpose of the project was to remove the soil sources of explosives contamination. The project reduced the sources of contamination; however, at many locations remediation action levels could not be achieved before groundwater was encountered. Water quality sampling on-and off-post has been completed repeatedly since the middle 1980s to monitor the extent of groundwater contamination by various contractors under the direction of the United States Army Environmental Center (USAEC).

An on-post groundwater extraction and treatment system was installed in summer 1998 by CET Environmental under the direction of the USACE. Full-time operation began in December 1998. The groundwater extraction system includes six wells with a total extraction flow rate of about 750 gallons per minute. The groundwater is being treated with granular activated carbon and discharged to on-post drainage canals.

The USACE has contracted with URSGWC for six groundwater sampling events for the CHAAP LTM program. The time period for annual sampling is 1996 through 2001. Additional work by URSGWC under this contract included installation of monitoring wells and piezometers, groundwater flow and contaminant fate and transport computer modeling, and an explosives natural attenuation evaluation.

1.3 GROUNDWATER MODELING SCOPE OF WORK

The original objectives for the groundwater flow modeling effort were to recalibrate the MODFLOW (McDonald and Harbaugh 1988) groundwater flow model constructed by Dames and Moore (1995), verify the flow model results based on water level data collected from before and after system startup, and evaluate extraction well capture zones. The scope of work for Modification No. 1 included the additional objectives of optimizing the remediation system pumping rates with the groundwater flow model, and developing a contaminant fate and transport model for the site to evaluate the natural attenuation alternative and remediation system effectiveness.

The overall modeling scope of work to be completed by URSGWC is subsequently presented.

1.3.1 Groundwater Flow Modeling Scope of Work

The groundwater flow modeling scope of work included:

- Recalibration of the original MODFLOW flow model constructed by Dames and Moore (1995) during design of the groundwater pump and treat system for OU1. The flow model was recalibrated to May 1998 pre-pumping water levels. The flow model simulated baseline steady-state groundwater flow conditions for the uppermost aquifer present at the site.

- Simulation of the drawdown effects of the on-post groundwater extraction system and verification of the original flow model results based on water level data collected before and after system startup.

- Simulation of advective particle capture zones for the groundwater extraction system using MODPATH (Pollock 1989). Model-predicted capture zones were compared to the explosives plumes to verify capture.

- Evaluation of optimum current and future extraction rates for capture of the plumes.

- Optimization of the groundwater extraction system to meet project remedial objectives.

1.3.2 Contaminant Fate and Transport Modeling Scope of Work

The contaminant fate and transport modeling scope of work included:

- Construction of a three-dimensional, numerical solute transport model using MT3DMS (Zheng 1998). The transport model was used in conjunction with the recalibrated MODFLOW flow model. The transport model retrieved the flow terms from the MODFLOW simulations and calculated chemical concentrations over time. The existing grid and model setup was used as a basis for the fate and transport model. Chemical concentrations were input into the model by discretizing the March 1999 groundwater plume sampling results onto the model grid.

- Evaluation of baseline contaminant fate and transport conditions (i.e., the natural attenuation alternative) for the off-post portion of the plume for two chemicals of concern (e.g., RDX and TNT).

- Evaluation of various remediation alternatives' effectiveness using the two chemicals of concern (e.g., RDX and TNT).

SECTION FOUR Contaminant Fate and Transport Model

The objective of the numerical contaminant fate and transport modeling effort was to:

- Simulate baseline contaminant transport conditions to evaluate natural attenuation of the off-post plume

- Simulate contaminant transport under various groundwater extraction conditions to evaluate remedial alternatives effectiveness

4.1 MODELING APPROACH, METHODOLOGY, AND ASSUMPTIONS

The approach, methods, and assumptions used to simulate groundwater contaminant fate and transport at CHAAP are discussed in the following sections.

4.1.1 Modeling Approach and Methodology

Groundwater flow conditions at the site were simulated using MODFLOW. The MODFLOW modeling approach and methodology is discussed in Section 3. Contaminant fate and transport of explosives was simulated using MT3DMS (Zheng 1998), a three-dimensional block-centered, finite-difference, numerical transport model. MT3DMS retrieves the hydraulic heads, flow terms, and source sink terms from the MODFLOW groundwater flow model results and calculates chemical concentrations over time. The MT3DMS models were constructed using Visual MODFLOW (Guiger 1995). Visual MODFLOW is a pre-and post-processor and does not affect results generated by running MT3DMS.

The same model grid dimensions, groundwater configurations, and flow parameters used in the groundwater flow model were used in the transport model.

Chemicals Selected for MT3DMS Models

Contaminant fate and transport models were constructed based on the concentrations of RDX and TNT. These chemicals were selected based on:

- Frequency of occurrence
- Detected concentrations exceeded health advisory levels established for the CHAAP site in the ROD
- Mobility in groundwater
- Nature and extent of contamination in the off-post plume

4.1.2 Modeling Assumptions

MT3DMS uses chemical characteristic input values to calculate contaminant dispersion and degradation and MODFLOW output to calculate advection (i.e., transport). MT3DMS accounts for the effects of sorption/ desorption, dispersion, and natural degradation (biotic and abiotic) or other chemical reactions that can be simulated with a first-order decay rate term for the removal of a chemical from the modeled system. The model cannot simulate more complicated chemical reaction systems, such as precipitation/resolution based on changing local conditions, the rate of exhaustion of bionutrients based on variable uptake by indigenous microorganisms, or the transformation of a chemical into a degradation by-product.

In addition to the general MT3DMS modeling assumptions listed in Appendix D, key assumptions for this modeling effort included the following:

- The steady-state MODFLOW model assumptions, setup, and results are appropriate for the contaminant transport model.
- In an effort to be conservative, off-post irrigation well pumping was not included in the groundwater contaminant fate and transport modeling simulations. Irrigation well pumping during the life of the remedial alternative would slightly shorten the expected clean-up times by removing additional contaminant mass. Historical contaminant migration data and plume geometry indicated irrigation wells have not significantly impacted contaminant migration patterns over time.
- Dissolved RDX and TNT concentrations measured from the March 1999 LTM sampling event were used to interpret isoconcentration maps. These isoconcentration maps were used as initial model input concentrations.
- Current dissolved concentrations near the source area of Load Line 1, 2, and 3 were used as the initial value for continuous source concentrations. The sources were conservatively assumed to decay to lower concentrations based on historic concentration decreases.
- RDX and TNT are subject to adsorption, dispersion, and biodegradation approximated with first-order decay rates as they are transported through the saturated zones of the aquifer.

4.2 CONTAMINANT FATE AND TRANSPORT MODEL SETUP AND INPUT PARAMETERS

The CHAAP contaminant transport model was constructed using the same overall model setup as the MODFLOW groundwater flow model. The fate and transport model setup included inputting the finite-difference grid, hydrostratigraphic layers (i.e., model layers 1 through 3), groundwater flow boundary conditions, and chemical-specific input parameters. The groundwater flow components were previously described in Section 3. The chemical-specific input parameters are documented in this section.

4.2.1 Initial Target Compound Concentrations

Chemical data from the March 1999 groundwater monitoring report (LTRSGWC 1999b)(**Figures 2-3 and 2-4**) were used to interpret initial individual explosive isoconcentration maps. The isoconcentration maps were used as the basis for initial concentration input to the baseline contaminant fate and transport model. Isoconcentration maps were input for the two main chemicals of concern: RDX and TNT. RDX occurs in model layers 1, 2, and 3. TNT occurs only in model layers 1 and 2.

Isoconcentration maps were spatially discretized into blocks of explosive concentrations matching the grid spacing used for the MODFLOW groundwater flow model. Additionally, the concentrations were assigned discrete values in a range of concentrations input to the model (e.g., 2.5, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, 2500, and 2850 ug/L). A conservative approach (i.e., likely overestimating total explosive mass) was used when discretizing chemical input into the model.

Initial concentrations plots were constructed from MT3DMS results at a time period of about 1-week. These initial concentration plots are included in **Appendix E.** Considering the modeling objectives (e.g., long-term simulations), these plots were considered to be appropriate and conservative representations of the current nature and extent of contamination.

4.2.2 Continuous Source Concentrations

Groundwater monitoring results indicate there are continuing sources of dissolved explosives in groundwater at Load Lines 1, 2, and 3. The nature and extent of the current explosives plumes more closely represent plumes from continuous sources rather than slug sources. Therefore, continuous source boundary conditions were used at Load Lines 1,2,and 3. Source concentrations were initially set equal to March 1999 results. The sources were then assigned a degradation schedule to approximate the source decay half-lives calculated from historic explosive concentration trends. That is, the modeled source area provided continuous mass input into the dissolved plume, at decreasing concentrations over time. This approach is considered conservative based on the historic concentration trends and results of natural attenuation calculations for Load Lines 1, 2, and 3 (URSGWC 1999b).

The table below summarizes continuous source data input included in Appendix E.

Summarized Continuous Source Input Data

Continuous Source Location		RDX		TNT	
		Initial Concentration (ug/L)	Decay Half-Life (years)	Initial Concentration (ug/L)	Decay Half-Life (years)
Load Line 1	G0023	24	5.7	130	5.7
Load Line 2	G0066	134	3.2	2850	4.0
Load Line 3	G0017	7	7.7	10	10.6

4.2.3 Contaminant Transport Model Input Parameters

MT3DMS requires the user to define each contaminant model (e.g., RDX and TNT) with a number of site-specific and chemical-specific input parameters and to make some simplifying assumptions based on existing site information. Contaminant fate and transport model input values are summarized in Table 4-1. The model input parameters were based on the hydrogeologic characteristics of the model layers, site chemical and geotechnical analyses, and estimates of chemical characteristics from recent literature values.

The input parameters for the contaminant transport models were established as follows:

- **Time (t).** MT3DMS used the steady-state, time independent, flow field generated by MODFLOW to simulate contaminant fate and transport over- time. Models were simulated until target compounds were predicted to be below the target cleanup goals.

- **Bulk Density (pB).** The bulk density of CHAAP soils was based on soil samples collected during installation of piezometer and monitoring wells in April and May 1998 (URSGWC 1999b). Bulk density was input the same for all three modeled layers at an average value of 118 lbS/ft3. Site-wide bulk density values ranged from 108 to 130 lbs/ft3.

- **Dispersivity (Dl, Dt, Dv).** Chemical dispersivity input values were assumed based on varying distances chemicals have been transported from source areas. Longitudinal dispersivity (Dl) values were assumed to be ten percent of the downgradient transport distance. Longitudinal dispersivities ranged from 100 to 2500 feet. Transverse dispersivities (Dt) and vertical dispersivities (Dv) were estimated as a fraction of the longitudinal values. Longitudinal dispersivity values are typically reported to be much larger than transverse values, which are much larger than vertical values (Gelhar et al. 1992; Anderson 1979). The ratios of longitudinal to transverse to vertical dispersivity (e.g., Dl: Dt: Dv) were input at 10,000:1000:1. These ratios were established during model calibration based on the geometry of the existing plumes (i.e., long and narrow).

- **Biodegradation Half-life (t1/2).** Historical concentration data were used to establish contaminant reduction trends and estimate biodegradation half-lives (URSGWC 1999b). The methodologies of Graves (1995) and Buscheck and Alcantar (1995) were used to establish a range of estimated half-lives for RDX and TNT. These methods were used for three distinct plume areas. These areas included: on-post source areas, feedlot area, and the distal plume. Biodegradation half-life analysis is included in **Appendix E.** RDX and TNT half-life values input to the model in each area are shown in the table below.

Biodegradation Half-life Input

Plume Location	RDX Half-life (years)	TNT Half-life (years)
On-Post	5.7	5.7
Feed Lot	4.3	2.5
Distal Plume	8.9	5.7

  Half-life values were input to the model as first-order decay constants (k) using k = ln(2)/t1/2. These values were selected from the upper range of estimated values to conservatively estimate biodegradation rates for the natural attenuation evaluation. These values were considered to be representative of natural decay processes occurring at the site based on the current distribution of explosives and the results of the long-term monitoring of natural attenuation field parameters (URSGWC 1999b).

- **Organic Carbon/Water Partition Coefficient (Koc).** Organic carbon/water partition coefficient (Koc) values selected for each chemical were based on mean values estimated from a range of reported literature values (Townsend 1996). RDX and TNT values input to the model were 1.17 ft3/b (73 mL/g) and 8.41 ft3/lb (525 mL/g), respectively.

- **Total Organic Carbon (TOC).** The TOC content of CHAAP soils was based on soil samples collected during the June 1998 LTM sampling event (URSGWC 1999b). TOC was input the same for all three modeled layers at a value of 0.089 percent. Site wide TOC values range from about 0.2 percent to 0.04 percent.

- **Sorption Distribution Coefficient (Kd).** Soil/water partition coefficients (Kd) were estimated for each chemical from the product of the Koc and TOC values listed above. RDX and TNT values input to the model were 6.5×10^{-11} ft3/lb and 4.7×10^{-10} ft3/lb, respectively.

- **Retardation Factor (R).** The model uses the bulk density, the sorption coefficient, and effective aquifer porosity to calculate a retardation factor using the following equation:

$$R = 1 + \frac{Kd \times pB}{n}$$

Using the above values, retardation factors of 1.5 and 4.5 were calculated by the model for RDX and TNT, respectively.

4.3 BASELINE CONTAMINANT FATE AND TRANSPORT MODEL CALIBRATION, SENSITIVITY, AND LIMITATIONS

The contaminant fate and transport model setup and input parameters were calibrated to accurately simulate the extent of the current explosives plume and predict future behavior of the plume. This effort included qualitative model calibration, sensitivity analysis, and understanding the limitations of the model predictions.

4.3.1 Contaminant Fate and Transport Model Calibration

Contaminant fate and transport model setup and calibration were completed to reproduce the current chemical concentrations at the site as closely as possible. An iterative calibration process was used to refine MT3DMS input based on model-predicted results. Historical source release information (e.g., mass release and dates of multiple releases) cannot be accurately estimated because of the multiple nature of the source releases over time. Therefore, calibration of the contaminant fate and transport model relied on 1996 to 1999 groundwater monitoring data, and the more conventional method of inputting sources at the original time of release was not implemented. The calibration procedures completed included:

- Discretizing current RDX and TNT concentrations into the various layers to closely simulate current conditions.

- Using historical data to calculate degradation rates for various source and plume areas. For example Load Line 1, Load Line 2, Load Line 3, feed lot area, and distal plume.

- Using historical and current data to develop continuous source input.

  - Initial values based on March 1999 sample results

  - Degradation rates based on historic concentration trends

  - Lateral and vertical spatial distribution based on current and historic plume geometry and concentration distribution

- Discretizing dispersivity based on distance contaminant traveled from the source area.

  - Longitudinal Dispersivity (Dl) = 1/10 transport distance

  - Ratio of longitudinal to transverse to vertical dispersivity (e.g., Dl:Dt:Dv) determined from historic and current plume geometry

These parameters were systematically varied until the model-predicted plume behavior most accurately simulated the existing plume and historical trends.

4.3.2 Contaminant Fate and Transport Model Sensitivity

Sensitivity of the contaminant fate and transport model was evaluated qualitatively to describe possible variability in the subsequent model-predicted remedial alternative results. Contaminant fate and transport modeling was sensitive to both the contaminant and groundwater flow input parameters. **Section 3.3.2** summarized the groundwater flow model sensitivity to groundwater flow input parameters. Contaminant fate and transport sensitivity to groundwater flow input was not specifically evaluated. Generally contaminant fate and transport sensitivity was analogous to the groundwater flow model sensitivity to groundwater flow input parameters.

The contaminant fate and transport results were sensitive to most contaminant fate and transport input parameters. These parameters included: continuous source concentrations, initial concentrations, biodegradation half-life, retardation factor, and dispersivity. Fluctuating these parameters within reasonable estimated ranges created noticeable differences in model-predicted results.

The degree of contaminant fate and transport model sensitivity to contaminant specific input parameters was variable. Qualitative sensitivity analysis results are summarized in the table below.

Summary of Contaminant Fate and Transport Model Sensitivity

Input Parameter	Sensitivity	Summary
Continuous Source	High	⇩ Mass - ⇩ Clean-up time ⇧ Decay rate - ⇩ Clean-up time
Initial Concentration	High	⇩ Mass - ⇩ Clean-up time
Biodegradation Half-life	Moderate	⇧ Decay rate - ⇩ Clean-up time
Retardation Factor	Moderate	⇧ Retardation factor - ⇩ Transport distance
Dispersivity	Low	⇩ Dispersivity - ⇩ Transport distance

4.3.2 Contaminant Fate and Transport Model Limitations

Limitations of the contaminant fate and transport model are directly related to the model assumptions listed in Section 4.1.2 and Appendix D. These limitations included a single concentration value within each cell, equilibrium-controlled sorption/ desorption, and irreversible linear decay rates. The largest limitations for the CHAAP site include:

- Continuous source and dissolved explosive decay rates were estimated model input and not model-calculated over time as the natural attenuation capacity of the aquifer (e.g., assimilative capacity) changed. These estimated sources had little to no effect on explosives modeling results off-post because of low off-post explosive concentrations and very high assimilative capacity of the aquifer.

- Target explosives calibration was limited to the current interpreted plumes and historic trends.

These limitations were compensated for by:

- Conservative mass input at the continuous groundwater source areas (i.e., likely overestimating mass)

- Conservative initial concentration input (i.e., likely overestimating mass)

- Chemical and location specific degradation rates

4.4 CONTAMINANT FATE AND TRANSPORT MODEL-PREDICTED RESULTS

After model calibration and sensitivity analysis indicated the model reasonably predicted contaminant fate and transport, the model was used to predict baseline contaminant fate and transport conditions. Then the model was used to predict the effectiveness of the groundwater remediation alternatives previously analyzed using the groundwater flow model. This evaluation was completed using the MT3DMS contaminant fate and transport model. Four different groundwater remediation alternatives were evaluated with MT3DMS. The four alternatives included:

- Baseline Contaminant Fate and Transport Conditions (e.g., Natural Attenuation with no remedial groundwater pumping)

- Optimized On-Post Extraction with Off-Post Natural Attenuation

- Optimized On-Post Extraction with EW-7 and Off-Post Natural Attenuation

- Optimized On-Post Extraction with EW-7 and Distal Extraction

The baseline contaminant fate and transport conditions used the steady- state, non-pumping groundwater flow pattern to predict contaminant transport under natural groundwater flow conditions. This alternative was modeled to compare pumping alternatives to a baseline alternative. Excluded from contaminant fate and transport remedial alternative modeling are the design extraction rate and original operating extraction rate alternatives. These alternatives were shown to be ineffective during groundwater flow modeling.

Remedial alternative evaluation was based on contaminant fate and transport model-predicted clean-up times. Model-predicted clean-up times represent the time predicted for explosive concentrations to decrease below the target cleanup goals. Clean-up times were evaluated for three plume areas: 1) on-post, 2) feed lot area, and 3) distal plume. The results of this evaluation are shown on **Table 4-2**. For comparative purposes, model predicted results for RDX and TNT are shown on **Figures 4-1 and 4-2**, respectively. These figures show results of the alternatives described below.

4.4.1 Baseline Contaminant Fate and Transport

A baseline MT3DMS contaminant fate and transport model was constructed using the current explosive concentrations and extents interpreted from the March 1999 LTM results (URSGWC 1999b). Contaminant transport under this hypothetical alternative assumes no groundwater removal from the affected area. For example, no remedial extraction well, irrigation well, or domestic well pumping. Model-predicted clean-up times for the baseline contaminant fate and transport conditions were:

- Distal Plume - 13 years

- Feedlot Area - 33 years

- On-post - 50 years

4.4.2 Optimized On-Post Extraction with Off-Post Natural Attenuation

The optimized on-post extraction with off-post natural attenuation alternative described in **Section 3.4.3** was evaluated using MT3DMS. Contaminant transport under this alternative simulated the performance of the current remedial system into the future. Model-predicted cleanup times for the optimized extraction rate alternative were:

- Distal Plume – 13 years
- Feedlot Area – 19 years
- On-post – 45 years

Model-predicted results indicated on-post pumping did not significantly impact contaminant fate and transport of the existing off-post plume. However, model-predicted results indicated the off-post plume will naturally attenuate to below target clean-up goals in about 20 years.

4.4.3 Optimized On-Post Extraction with EW-7 and Off-Post Natural Attenuation

The optimized on-post extraction with EW-7 and off-post natural attenuation alternative described in **Section 3.4.4** was evaluated using MT3DMS. Contaminant transport modeled with this alternative simulated the performance of the proposed, currently under construction, system into the future. Model-predicted clean-up times for the optimized extraction rate with additional well alternative were:

- Distal Plume – 11 years
- Feedlot Area – 19 years
- On-post – 45 years

Model-predicted results indicated on-post pumping did not significantly impact contaminant fate and transport of the existing off- post plume. However, model-predicted results indicated the off-post plume will naturally attenuate to below target clean- up goals in about 20 years.

4.4.4 Optimized On-Post Extraction with EW-7 and Distal Extraction

The original remedial alternative design (Rust 1996) included three distal extraction wells. During construction of the on-post portion of the remedial design, real estate agreements could not be reached that would facilitate the off-post piping network associated with distal extraction wells. This prohibited the distal wells from being constructed. Subsequent to this delay, the distal plume appeared to be declining in size and concentration (URSGWC 1999b).

The distal extraction alternative was evaluated to determine if distal extraction would decrease the optimized extraction alternative clean-up time.

The optimized on-post extraction with EW-7 and distal extraction alternative described in **Section 3.4.5** was evaluated using MT3DMS. Contaminant transport modeled with this alternative simulated the performance of the proposed, currently under construction, system with the addition of three distal wells. Model-predicted clean-up times for this alternative were:

- Distal Plume – 11 years
- Feedlot Area – 19 years
- On-post – 45 years

4.5 CONTAMINANT FATE AND TRANSPORT MODELING CONCLUSIONS

Contaminant fate and transport modeling of extraction alternatives indicated the optimized on-post extraction with EW-7 and off-post natural attenuation alternative would remove contamination emanating from Load Lines 1, 2, and 3, and contain the on- post contamination. Model-predicted results indicated distal extraction would not decrease the overall clean- up times significantly.

Groundwater flow modeling of extraction alternatives indicated the current system could be enhanced and optimized to capture contamination emanating from Load Lines 1, 2, and 3. The optimized on-post extraction with an additional well (i.e., EW-7) alternative was recommended (URSGWC 1999a) to provide effective containment of the on-post explosives plume. The recommended alternative included:

- Eliminating pumping from EW-1, EW-2, and EW-3 because contaminants were below the health advisory level
- Increasing extraction rates at EW-4, EW-5, and EW-6
- Installation of an additional well at the post boundary

Contaminant fate and transport modeling results confirmed the recommendation made during the groundwater flow modeling (URSGWC 1999a). The recommended alternative remains optimized on-post extraction with an additional well (i.e., EW-7) and natural attenuation of the off-post plume. This recommendation is supported by declining explosives concentrations off-post and the model-predicted response of the explosives plume to on-post extraction. Key model-predicted results in support of this recommendation include:

- Model-predicted on-post clean-up time decreased by 5 years due to on-post extraction
- Model-predicted feedlot clean-up time decreased by 14 years due to on-post extraction
- Model results indicated distal well pumping would not decrease off-post cleanup times

EW-7 has been constructed and operated since the spring of 2000. Water level data indicate EW-7 provides containment of the on- post explosive plume. Continued operation of EW-7 at a minimum of 250 gallons per minute is recommended.

TABLE 4-1

CONTAMINANT FATE AND TRANSPORT MODEL INPUT PARAMETERS

Modeled Chemical and Location	Constant Source (initial concentration - degradation half-life)[1]	Biodegradation Half-Life ($t_{1/2}$ - years)[2]	First Order Rate Constant (k - 1/day)[3]	Sorption Coefficient (k_d - ft^3/lb)[4]	Retardation Factor (R)[5]	Dispersivity (D_l - feet)[6]	Dispersivity Ratio ($D_l:D_t;D_l:D_v$)[7]
RDX							
- Distal Plume	--	8.9	2.1E-04	6.5E-11	1.5	800 to 2500	1,000:1; 10,000:1
- Feed Lot Area	--	4.3	4.4E-04	6.5E-11	1.5	400 to 800	1,000:1; 10,000:1
- On-Post	--	5.7	3.3E-04	6.5E-11	1.5	100 to 400	1,000:1; 10,000:1
Load Line 1	24 µg/L at 5.7 years	--	--	--	--	--	--
Load Line 2	134 µg/L at 3.2 years	--	--	--	--	--	--
Load Line 3	7 µg/L at 3.2 years	--	--	--	--	--	--
TNT							
- Distal Plume	--	5.7	7.6E-04	4.7E-10	4.5	800 to 2500	1,000:1; 10,000:1
- Feed Lot Area	--	2.5	7.6E-04	4.7E-10	4.5	400 to 800	1,000:1; 10,000:1
- On-Post	--	5.7	3.3E-04	4.7E-10	4.5	100 to 400	1,000:1; 10,000:1
Load Line 1	130 µg/L at 3.2 years	--	--	--	--	--	--
Load Line 2	2850 µg/L at 3.2 years	--	--	--	--	--	--
Load Line 3	10 µg/L at 3.2 years	--	--	--	--	--	--

Notes:
[1] Estimated from March 1999 sample results, historic explosives trends (URSGWC 1999), and calibrated model-predicted results.

[2] Estimated from historic explosive concentration trends (URSGWC 1999) and calibrated model-predicted results.

[3] $k=\ln(2)/t_{1/2}$

[4] $K_d=K_{oc}$ *TOC; RDX $K_{oc}=1.17$ ft^3/lb and TNT $K_{oc}=8.41$ ft^3/lb (Townsend 1996); TOC=0.089% (URSGWC 1999).

[5] $R=1+(\rho\beta*K_d)/\eta$; $\rho\beta=118$ lb/ft^3 and $\eta=0.25$ (URSGWC 1999)

[6] Assumded D_l valued based on 1/10 transport distance (Gelhar et al. 1992, Anderson 1979)

[7] D_t and D_v based on exixting and calibrated model-predicted plume geometries.

TABLE 4-2
MODEL-PREDICTED CLEAN-UP TIMES [1] (years)

Alternative[2]	On-Post RDX	On-Post TNT	Feedlot Area RDX	Feedlot Area TNT	Distal Plume RDX	Distal Plume TNT
[3] Baseline Fate and Transport Conditions	24	50	15	33	13	12
[4] Optimized On-post Extraction with Off-Post Natural Attenuation	24	45	15	19	13	6
[5] Optimized On-post Extraction with EW-7 and Off-post with Natural Attenuation	24	45	13	19	11	6
[6] Optimized On-post Extraction with EW-7 and Distal Extraction	24	45	13	19	11	6

Notes:

[1] Clean-up time represents model-predicted year when all results are below 2 µg/L.

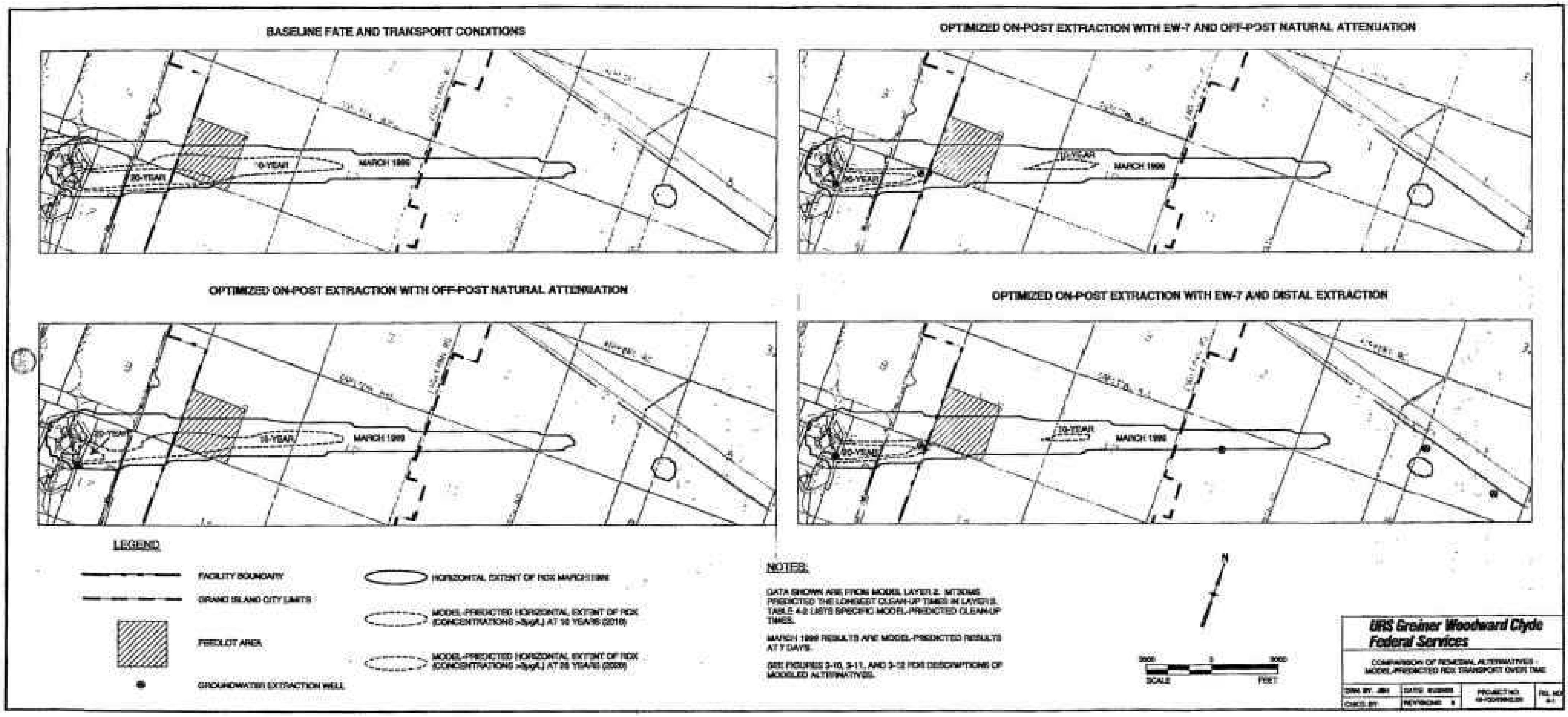
[2] See Figures 3-10, 3-11, and 3-12 for remedial pumping alternative details.

[3] No remedial groundwater pumping.

[4] Remedial groundwater pumping; EW-4 at 75 gpm, EW-5 at 225 gpm, and EW-6 at 450 gpm.

[5] Remedial groundwater pumping; EW-4 at 75 gpm, EW-5 at 225 gpm, EW-6 at 200 gpm, and EW-7 at 250 gpm.

[6] Remedial groundwater pumping using optimized pumping with EW-7 plus; Distal-1 at 150 gpm, Distal-2 at 700 gpm, and Distal-3 at 300 gpm.



BASELINE FATE AND TRANSPORT CONDITIONS
OPTIMIZED ON-POST EXTRACTION WITH EW-7 AND OFF-POST NATURAL ATTENUATION
OPTIMIZED ON-POST EXTRACTION WITH OFF-POST NATURAL ATTENUATION
OPTIMIZED ON-POST EXTRACTION WITH EW-7 AND DISTAL EXTRACTION
MARCH 1999
10-YEAR
20-YEAR
LEGEND
FACILITY BOUNDARY
GRAND ISLAND CITY LIMITS
FEEDLOT AREA
GROUNDWATER EXTRACTION WELL
HORIZONTAL EXTENT OF RDX MARCH 1999
MODEL-PREDICTED HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2μg/L) AT 10 YEARS (2010)
MODEL-PREDICTED HORIZONTAL EXTENT OF RDX (CONCENTRATIONS >2μg/L) AT 20 YEARS (2020)
NOTES:
DATA SHOWN ARE FROM MODEL LAYER 2. MT3DMS PREDICTED THE LONGEST CLEAN-UP TIMES IN LAYER 2. TABLE 4-2 LISTS SPECIFIC MODEL-PREDICTED CLEAN-UP TIMES.
MARCH 1999 RESULTS ARE MODEL-PREDICTED RESULTS AT 7 DAYS.
SEE FIGURES 3-10, 3-11, AND 3-12 FOR DESCRIPTIONS OF MODELED ALTERNATIVES.
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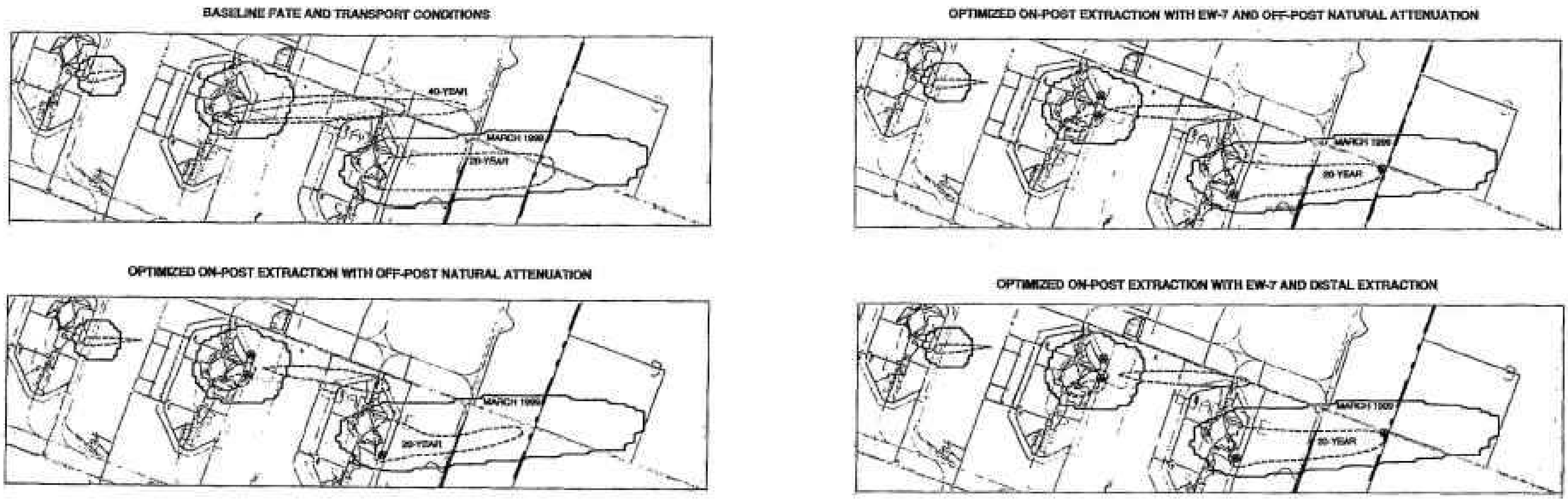

LEGEND

FACILITY BOUNDARY

FEEDLOT AREA

GROUNDWATER EXTRACTION WELL

HORIZONTAL EXTENT OF TNT MARCH 1999

MODEL-PREDICTED HORIZONTAL EXTENT OF TNT (CONCENTRATIONS >2ug/L) AT 20 YEARS (2020)

MODEL-PREDICTED HORIZONTAL EXTENT OF TNT (CONCENTRATIONS >2ug/L) AT 40 YEARS (2040)

NOTES:

DATA SHOWN ARE FROM MODEL LAYER 1. MT3DMS PREDICTED THE LONGEST CLEAN-UP TIMES IN LAYER 1. TABLE 4-2 LISTS SPECIFIC MODEL-PREDICTED CLEAN-UP TIMES.

MARCH 1999 RESULTS ARE MODEL-PREDICTED RESULTS AT 7 DAYS.

SEE FIGURES 3-10, 3-11, AND 3-12 FOR DESCRIPTIONS OF MODELED ALTERNATIVES.

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COMPARISON OF REMEDIAL ALTERNATIVES - MODEL-PREDICTED TNT TRANSPORT OVER TIME

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