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INTERIM REMEDIAL ACTION PERFORMANCE MONITORING AND GROUNDWATER
QUALITY REPORT AT OPERABLE UNIT 4 (OU 4) NTC ORLANDO FL
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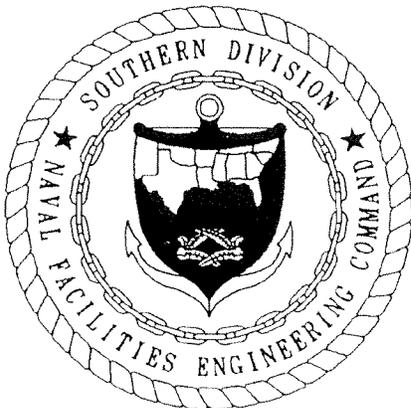


**FULL-SCALE CONCEPTUAL DESIGN AND
PERFORMANCE SPECIFICATION
IN-SITU CHEMICAL OXIDATION
USING POTASSIUM PERMANGANATE**

**OPERABLE UNIT 4
NAVAL TRAINING CENTER, ORLANDO, FLORIDA**

**UNIT IDENTIFICATION CODE: N65928
CONTRACT NO. N62467-89-D-0317/135**

MARCH 2001



Harding Lawson Associates



March 30, 2001

Document No.: 2545.041

Commanding Officer
SOUTHNAVFACENGCOM
ATTN: Ms. Barbara Nwokike, Code 187300
Naval Facilities Engineering Command
2155 Eagle Drive
North Charleston, SC 29406

**SUBJECT: Final KMnO₄ Conceptual Design
Operable Unit (OU) 4
Naval Training Center (NTC), Orlando, Florida
Contract No. N62467-89-D-0317/CTO 135**

Dear Barbara:

Enclosed please find two copies of the Final NTC Orlando OU 4 Potassium Permanganate (KMnO₄) Conceptual Design and Performance Specification. This report documents the design basis and requirements for the construction of a full-scale KMnO₄ treatment system for the OU 4 PCE source area.

If you have questions or comments regarding this document, please contact me at (781) 213-5652 or John Kaiser at (407) 522-7570.

Very truly yours,

HARDING LAWSON ASSOCIATES

A handwritten signature in cursive script that reads "Mark J. Salvetti".

Mark J. Salvetti, P.E.
Task Order Manager

Enclosures

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**FULL-SCALE CONCEPTUAL DESIGN AND
PERFORMANCE SPECIFICATION
IN-SITU CHEMICAL OXIDATION
USING POTASSIUM PERMANGANATE**

OPERABLE UNIT 4

**NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

Unit Identification Code: N65928

Contract No.: N62467-89-D-0317/135

Prepared by:

**Harding Lawson Associates
2533 Greer Road, Suite 6
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Prepared for:

**Department of the Navy, Southern Division
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Barbara Nwokike, Code 1873, Engineer-in-Charge

March 2001



CERTIFICATION OF TECHNICAL
DATA CONFORMITY (MAY 1987)

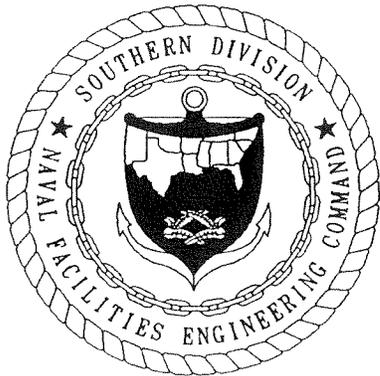
The Contractor, Harding Lawson Associates, hereby certifies that, to the best of its knowledge and belief, the technical data delivered herewith under Contract No. N62467-89-D-0317/135 are complete and accurate and comply with all requirements of this contract.

DATE: March 30, 2001

NAME AND TITLE OF CERTIFYING OFFICIAL: Mark Salvetti, P.E.
Task Order Manager

NAME AND TITLE OF CERTIFYING OFFICIAL: John Kaiser
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(DFAR 252.227-7036)



FOREWORD

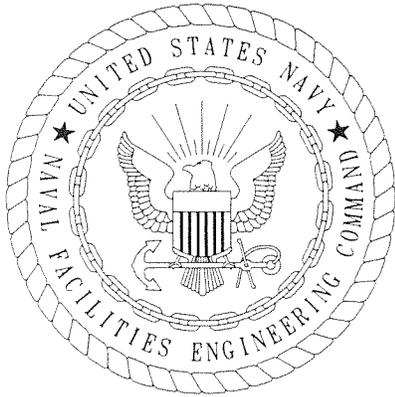
To meet its mission objectives, the U.S. Navy performs a variety of operations, some of which require the use, handling, storage, and/or disposal of hazardous materials. Through accidental spills and leaks, or as a result of past conventional methods of disposal, hazardous materials may have entered the environment in ways unacceptable by current standards. As knowledge of the long-term effects of hazardous materials on the environment has grown, the Department of Defense (DOD) has initiated various programs to investigate and remediate conditions related to suspected past releases of hazardous materials at their facilities. Two of these programs are the Installation Restoration (IR) program and the Base Realignment and Closure (BRAC) program.

The IR program complies with the Base Closure and Realignment Act of 1988 (Public Law 100-526, 102 Statute 2623) and the Defense Base Closure and Realignment Act of 1990 (Public Law 101-510, 104 Statute [1808]), which require the DOD to observe pertinent environmental legal provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Executive Order 12580, and the statutory provisions of Defense Environmental Restoration Program, the National Environmental Policy Act, and any other applicable statutes that protect natural and cultural resources.

The goal of the BRAC program is to expedite and improve environmental response actions to facilitate the disposal and reuse of a BRAC installation while protecting human health and the environment.

The Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), the U.S. Environmental Protection Agency (USEPA), and the Florida Department of Environmental Protection (FDEP) collectively coordinate the cleanup activities through the BRAC cleanup team, called the Orlando Partnering Team (OPT). This team approach is intended to foster partnering, accelerate the environmental cleanup process, and expedite timely, cost-effective, and environmentally responsible disposal and reuse decisions.

Questions regarding the BRAC program at Naval Training Center (NTC), Orlando should be addressed to the SOUTHNAVFACENGCOM BRAC Environmental Coordinator, Mr. Wayne Hansel, at (407) 895-6714, or the SOUTHNAVFACENGCOM Engineer-in-Charge, Ms. Barbara Nwokike, at (843) 820-5566.



The engineering evaluations and professional opinions rendered in this document for the full scale conceptual design for in-situ chemical oxidation using potassium permanganate for Operable Unit 4, Naval Training Center, Orlando, Florida, were conducted or developed in accordance with commonly accepted procedures consistent with applicable standards of practice. This document is not intended to be used for construction.

HARDING LAWSON ASSOCIATES
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Willard A. Murray, Ph.D.
Professional Engineer No. 39866
Expires: February 28, 2003

EXECUTIVE SUMMARY

Harding Lawson Associates (HLA), under contract to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), has prepared this conceptual design and performance specification for a full-scale, in-situ chemical oxidation system at Operable Unit (OU) 4, Naval Training Center (NTC), Area C, in Orlando, Florida. This document has been prepared under contract number N62467-89-D-0317/135.

OU 4 is located in Area C of the NTC and consists of Study Areas 12, 13 and 14. Study Area 13 contains a former laundry and dry-cleaning facility (Building 1100), which was constructed in 1943 and used until 1994. Subsurface investigations conducted at OU 4 identified a PCE source area beneath Building 1100 and an associated chlorinated solvent-contaminated groundwater plume migrating west from the building toward Lake Druid. The PCE source area is the target of the full-scale, in-situ chemical oxidation system described in this document. Volatile organic compounds (VOCs) detected in groundwater and surface water from Lake Druid included PCE, trichloroethene (TCE), *cis*-1,2-dichloroethene (DCE), *trans*-1,2-DCE and vinyl chloride (VC) (almost exclusively in the lake, not groundwater).

In-situ chemical oxidation using potassium permanganate (KMnO₄) was identified as an innovative technology with the potential to treat the PCE source area and groundwater contaminated with VOCs. In-situ chemical oxidation is accomplished when an aqueous solution of KMnO₄ is injected or flushed through the source area. The basic stoichiometry for the oxidation of PCE is as follows:



Oxidation of chlorinated compounds to CA's occurs at pH's above 3. Carbon dioxide is formed instead at lower pH's. This reaction does not generate excess heat or vapor, and any excess KMnO₄ is stable, allowing it to be flushed through the source area by pumping to maximize contact with the contaminant zone.

An in-situ chemical oxidation pilot study was conducted from February through August 2000 to assess the effectiveness of KMnO₄ for remediation of a portion of the PCE source area and VOC-contaminated groundwater. VOC concentrations in the source area were reduced from as high as 23,000 µg/L to below detection levels of 1 µg/L (greater than 99.99% destruction). Based upon the promising results of the pilot study, a full-scale in-situ chemical oxidation system will be implemented to treat the entire source area.

The purpose of this document is to provide a conceptual design and performance specifications for the full-scale in-situ chemical oxidation system. The system will extract VOC-contaminated groundwater, add KMnO₄, oxidize VOCs in the extracted groundwater to concentrations below the Florida Maximum Contaminant Level (MCL) of 3 µg/L, and inject the KMnO₄ solution to treat VOCs in-situ.

The source area will be divided into three treatment cells, which will be further divided vertically into a shallow and deep zone due to the presence of a cemented sand layer at approximately 20 feet below ground surface. Dividing the source area in this manner will allow effective delivery of the KMnO₄ solution to the subsurface and minimize the treatment duration. Therefore, recovery and injection wells will be screened in the shallow and deep zones for each treatment cell resulting in 6 recovery wells and 6 injection wells. Based upon flow path modeling using Visual MODFLOW, the total system flow will be 15 gpm. KMnO₄ dosage is based upon ex-situ PCE oxidation kinetics since PCE oxidizes more slowly than TCE or DCE. Kinetics calculations indicate 1.5 g/L of KMnO₄ will be required upon system startup to meet MCLs in the extracted groundwater prior to injection. It is anticipated that influent VOC

EXECUTIVE SUMMARY

concentrations will quickly decrease, as observed in the pilot study, and consequently, the KMnO_4 dosage may be decreased accordingly. A KMnO_4 concentration of 1 g/L should be adequate to achieve significant in-situ oxidation of VOCs, but even lower concentrations could be used based on performance monitoring results. In addition, the deeper zone may be remediated more quickly than the shallow zone due to a higher hydraulic conductivity. The total duration of treatment is expected to be 6 to 12 months.

Descriptions of the chemical oxidation process, system requirements, and critical operation and maintenance procedures are provided such that the Comprehensive, Long-Term Environmental Action – Navy (CLEAN) and/or Remedial Action Contract (RAC) contractor will be able to use this information as a blueprint for the final design, construction, operation and maintenance of the full-scale system. The insight and experience gained during operation and maintenance of the pilot-scale system serves as the basis for the conceptual design and performance specifications of the full-scale treatment system, which are outlined in this document.

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Naval Training Center
Orlando, Florida**

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GLOSSARY

ABB-ES	ABB Environmental Services, Inc.
bls	below land surface
BRAC	Base Realignment and Closure (Act)
CA	carboxylic acid
CLEAN	the Comprehensive, Long-Term Environmental Action – Navy
DCE	dichloroethene
DE	diatomaceous earth
DF	disk filtration
DRMO	Defense Reutilization and Marketing Office
FFI	Focused Field Investigation
FS	Feasibility Study
Ft/day	feet per day
Ft/ft	feet per foot
g/L	gram per liter
gpm	gallons per minute
HLA	Harding Lawson Associates
ID	Inside diameter
IRA	Interim Remedial Action
IW	Injection well
KMnO ₄	potassium permanganate
MCL	maximum contaminant level
µG/L	micrograms per liter
MnO ₂	manganese dioxide
NTC	Naval Training Center
OU	Operable Unit
PCE	tetrachloroethene
PVC	polyvinyl chloride
RAC	Remedial Action Contract
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RDF	rotary drum filtration

GLOSSARY

SOUTHNAV-
FACENCOM Southern Division, Naval Facilities Engineering Command

TCE trichloroethene

UIC Underground Injection Control
USGS US Geological Survey

VC vinyl chloride

VOC volatile organic compound

1.0 INTRODUCTION

Harding Lawson Associates (HLA), under contract to Southern Division, Naval Facilities Engineering Command (SOUTHNAVFACENGCOM), has prepared this conceptual design and performance specification for a full-scale, in-situ chemical oxidation system at Operable Unit (OU) 4, Naval Training Center (NTC), Area C, in Orlando, Florida. This document has been prepared under contract number N62467-89-D-0317/135.

In-situ chemical oxidation using potassium permanganate was selected in the Proposed Plan for OU 4 (HLA, 2001a) as the preferred alternative for remediation of a tetrachloroethene (PCE) source area beneath Building 1100. The purpose of this document is to provide conceptual design and performance specifications for a full-scale, in-situ chemical oxidation system. Descriptions of the chemical oxidation process, system requirements, and critical operation and maintenance procedures are provided such that the Comprehensive, Long-Term Environmental Action – Navy (CLEAN) and/or Remedial Action Contract (RAC) contractor will be able to use this information as a blueprint for the final design, construction, operation and maintenance of the full-scale system.

1.1 SITE BACKGROUND.

Operable Unit (OU) 4 is located in Area C of the Naval Training Center in Orlando, Florida (see Figure 1). OU 4 consists of Study Areas 12 (Defense Reutilization and Marketing Office [DRMO] Warehouses and Salvage Yard), 13 (former base laundry and dry cleaning facility) and 14 (DRMO Storage Area) and is shown on Figure 2. Building 1100, located in Study Area 13, was constructed in 1943 and used as a laundry and dry-cleaning facility until 1994. Subsurface investigations conducted at OU 4 have identified groundwater contamination associated with the laundry and dry-cleaning operations. The results of the investigations conducted at OU 4 to date are summarized in the Interim Remedial Action Focused Field Investigation (FFI) Report (ABB-ES, 1997a), Focused Investigation/Source Confirmation Report (ABB-ES, 1997b), Remedial Investigation (RI) Work Plan (ABB-ES, 1997c), the RI Report (HLA, 2001b), and the Feasibility Study (FS) Report (HLA, 2001c).

The investigations have identified a PCE source area beneath Building 1100 and an associated chlorinated solvent-contaminated groundwater plume migrating west from the building toward Lake Druid (see Figure 3). The PCE source area shown on Figure 3 is the target of the full-scale, in-situ chemical oxidation system described in this document. Volatile organic compounds (VOCs) detected in groundwater and surface water from Lake Druid included PCE, trichloroethene (TCE), *cis*-1,2-dichloroethene (DCE), *trans*-1,2-DCE and vinyl chloride (VC) (almost exclusively in the lake, not groundwater). An Interim Remedial Action (IRA), consisting of two groundwater extraction wells and an air stripper, has been implemented to capture the portion of the groundwater plume with the highest VOC concentrations and prevent migration into Lake Druid. The approximate areal extents of the VOC groundwater plume and target PCE source area are shown on Figure 3. The source for the southern portion of the plume was likely a small release that has either been depleted or removed, as VOC concentrations are several orders of magnitude lower than in the northern portion of the plume. The Proposed Plan identified enhanced in-situ bioremediation as the preferred alternative for the southern plume, although currently phytoremediation is also being considered.

CHAPTER 1

1.2 IN-SITU CHEMICAL OXIDATION PILOT TEST.

A treatability study for assessing the performance of an in-situ chemical oxidation system was conducted in from February to August 2000 as part of the FS evaluation of various alternatives to remediate the PCE source area and VOC-contaminated groundwater. This pilot-scale test was conducted by HLA and is summarized in an interim letter report (HLA, 2000) and final report (HLA, 2001d). Treatment involved the flushing of an aqueous potassium permanganate (KMnO₄) solution through a circulation cell that encompassed an approximately 40-foot wide by 90-foot long portion of the source area adjacent to the northeast corner of Building 1100. Groundwater was extracted, dosed with KMnO₄, then injected upgradient of the extraction wells, creating the circulation cell. PCE concentrations in the source area were reduced from as high as 23,000 µg/L to below detection levels of 1 µg/L (greater than 99.99% destruction) in 10 weeks. Chemical oxidation using KMnO₄ was selected as the preferred remedial alternative based upon these results. The insight and experience gained during operation and maintenance of the pilot-scale system serves as the basis for the conceptual design and performance specifications outlined in this document.

1.3 CONTENTS.

The primary elements of this document include the site plan, process flow diagrams for elements of the chemical oxidation system, and system specifications and requirements for the design, construction, operation and maintenance of the treatment system. These specifications are intended to assist the CLEAN and/or RAC contractor in identifying specific permits, methods and materials of construction, and equipment necessary for achieving the performance requirement of the in-situ chemical oxidation treatment system. Design elements for which the CLEAN and/or RAC contractor is solely responsible will be noted where applicable (e.g., piping and instrumentation diagrams).

2.0 SITE CHARACTERIZATION

The summary of site characterization data presented here is consistent with the latest investigations conducted at OU 4. This summary should be used as the basis for any final design elements relating to the in-situ chemical oxidation system to minimize or avoid any interpretations of the site characteristics. The summary information presented here is intended to provide distinguishing characteristics for OU 4 that are relevant to the final design of the treatment system and is not all inclusive. Additional data and information may be found in the FFI Report (ABB-ES, 1997a), the source investigation (ABB-ES, 1997b), the RI (HLA, 2001b), the FS (HLA, 2001c) and the In-Situ Chemical Oxidation Pilot Study Report (HLA, 2001d).

2.1 SITE GEOLOGY.

Results of site investigations indicate that the stratigraphy in the vicinity of Building 1100, and throughout OU 4, is fairly homogeneous and comprised of three distinct units that are continuous throughout most of the site. Grain-size plots are included in the FFI Report (ABB-ES, 1997a) and the pilot study work plan (HLA, 1999). The first unit, extending from ground surface to approximately 20 feet below land surface (bls), is composed of silty, fine-grained sand. The second unit (the "hard layer") is a cemented, very dense layer of silty, fine-grained sand approximately 2 to 5 feet thick in the vicinity of Building 1100. The third unit underlies the cemented sand layer and extends to approximately 50 to 60 feet bls. This deeper unit is composed of silty, fine-grained sand intermingled with layers of clayey silt. The grain-size distribution of the silty, fine-grained sand is virtually identical for all three units.

2.2 HYDROGEOLOGY.

In the vicinity of the site, the aquifer can be characterized as a surficial aquifer since it is unconfined and underlain by a low permeability layer of clay (the Hawthorn Group). The groundwater table is 6 to 8 feet bls at Building 1100 and dips west toward Lake Druid. The United States Geologic Survey (USGS) modeled groundwater flow at the site and identified two distinct hydrogeological zones above and below the cemented sand layer. The USGS determined the hydraulic conductivity of the upper (0 to 20 ft bls) and lower (~20 to 50 ft bls) zones to be 10 and 40 ft/day, respectively. Vertical hydraulic conductivity was one-third of the hydraulic conductivity in both the shallow and deep zones. The cemented sand layer does not appear to act as a hydraulic or chemical barrier, and has been assumed to have the same hydraulic characteristics as the upper layer (USGS, 1998).

The overall hydraulic gradient for OU 4 was determined to be 0.008 feet per foot based upon potentiometric surface data (see RI; HLA, 2001b). Water level measurements during the KMnO_4 pilot test indicated a lower, local gradient ranging from approximately 0.0032 to 0.0038 ft/ft. An average of 0.005 ft/ft was assumed to be representative of the treatment area encompassed by the chemical oxidation system and was subsequently used in flow path modeling of KMnO_4 injection. Table 1 provides a summary of the hydrogeological data.

2.3 GROUNDWATER CHEMISTRY.

Detailed baseline groundwater chemistry data for OU 4 can be found in the RI (HLA, 2001b) and is summarized in Table 2. Additional baseline data from the KMnO_4 pilot study is included in the pilot study report (HLA, 2001d).

CHAPTER 2

2.4 SOURCE AREA.

The target of the in-situ chemical oxidation system is the PCE source area located partially beneath the north end of Building 1100. The source area was delineated during a focused investigation conducted in 1997. A GeoProbe was used to collect groundwater data from beneath the Building 1100 floor slab, and also from areas on the north and west sides of the building. Although high concentrations of VOCs were detected in groundwater, no evidence of residual PCE in saturated or unsaturated soil was found (ABBES, 1997b).

The total mass of PCE within the source area has been estimated at approximately 6000 lbs. (HLA, 2001c) and is estimated to be 60 ft wide, 270 ft long and 35 ft deep. Residual PCE, particularly residual trapped in lower permeability areas, will likely require more time to oxidize than the dissolved chlorinated compounds and may be the limiting factor for treatment duration. This phenomenon was observed during the pilot test where VOC concentrations in groundwater leveled off at various monitoring points, then eventually decreased to non-detectable levels (HLA, 2001d).

3.0 PROCESS DESCRIPTION

In-situ chemical oxidation for the OU 4 source area involves the injection of a chemical oxidant (KMnO₄) into the zone of contamination. Byproducts of the oxidation reaction include carboxylic acids (CAs), chloride (when chlorinated compounds are oxidized), and a manganese dioxide (MnO₂) precipitate. The oxidation is non-specific, and all compounds present that can be oxidized will react. Double-bonded chlorinated compounds (such as PCE, TCE, DCE, etc) are readily destroyed when contacted with KMnO₄.

KMnO₄ has been shown to be an effective oxidant for PCE and TCE (Schnarr et al, 1997; Hood et al, 1998; West et al, 1997, HLA, 2001d). In-situ oxidation is accomplished when an aqueous solution of KMnO₄ is injected or flushed through the source area. The basic stoichiometry for the oxidation of PCE is as follows:



Oxidation of chlorinated compounds to CA's occurs at pH's above 3. Carbon dioxide is formed instead at lower pH's (Huang et al, 2000). This reaction does not generate excess heat or vapor, and any excess KMnO₄ is stable, allowing it to be flushed through the source area by pumping to maximize contact with the contaminant zone. KMnO₄ has also been shown to be more effective at oxidizing PCE and TCE than the Fenton's process (West et al, 1997).

The in-situ chemical oxidation system will reduce the concentration of VOCs in the source area. The system will extract VOC-contaminated groundwater, add KMnO₄, oxidize the VOCs in the extracted groundwater to concentrations below the Florida Maximum Contaminant Level (MCL) of 3 µg/L, and inject the KMnO₄ solution to treat VOCs in-situ.

The source area will be divided both vertically and horizontally to effectively deliver oxidant to the source area and minimize the duration of treatment. The source area will be split areally into three cells, each with dedicated injection and extraction wells (see Figure 4). The pilot study system had difficulty delivering the oxidant solution to both the shallow and deep zones using single injection wells (IW) with long screens through both zones. To address this, each cell in the full-scale design shall contain two pairs of injection and recovery wells. One injection and recovery well pair will be screened above the hard layer and the other will be screened below the hard layer. This arrangement will also allow targeting of the KMnO₄ solution and preferential injection into just the deep or shallow zone should it be deemed necessary.

Groundwater will be extracted using six extraction wells (three screened in the shallow zone, three screened in the deep zone) with submersible pumps. The treatment area is discussed in greater detail in Section 4.2.

The groundwater will be pumped to a 1,600-gallon tank, where it will be dosed with KMnO₄. Dosing requirements and feed system details are given in Sections 4.3 and 4.4, respectively. Groundwater, dosed with KMnO₄, will flow by gravity through three additional 1,600-gallon tanks to provide adequate residence time for the ex-situ oxidation of VOCs to concentrations below MCLs prior to injection. None of the tanks will be stirred. After the fourth tank, groundwater will be pumped to a skid-mounted filtration system. The filter will remove manganese dioxide precipitate from the process stream and is

described in further detail in Section 4.8. The filtrate will be pumped to each injection well (three screened in the shallow zone, three screened in the deep zone) via two pumps, one for the shallow wells and one for the deep wells. Flow rates to each well will be regulated using appropriate valving and flow meters.

A conceptual process flow diagram for the in-situ chemical oxidation system is shown in Figure 5. The CLEAN and/or RAC contractor will provide a complete piping and instrumentation diagram for the system.

4.0 SYSTEM REQUIREMENTS

The majority of the equipment used for the KMnO_4 pilot study was rented from Carus Chemical, who also provided all of the KMnO_4 for the pilot. Carus provided the extraction and injection pumps, mixing tanks, KMnO_4 feeders, the filtration system, the control system, and two technicians for startup support. HLA field-fabricated the extraction and injection well piping and operated the system. Carus is located in Peru, Illinois, and is the sole domestic producer of KMnO_4 .

The following process details assume that a system similar to the pilot study system will also be rented from Carus for the full-scale treatment. This arrangement has benefits, including operational support, experience with chemical handling and material compatibility requirements, cost, and avoidance of capital equipment acquisition. Rental costs during the expected short duration of full-scale treatment should be much less than full-scale detailed design and construction costs that would otherwise be incurred. The Navy also will not acquire capital equipment that would later need to be surplus and/or stored.

As of March 2001, the pilot study equipment is still available from Carus. Carus has also begun a corporate program to develop improved treatment systems for groundwater remediation. Points of contact at Carus are provided in Appendix A. Based on the HLA pilot study experiences, Carus should be contacted early in the planning stages to ensure the equipment can be available and customized as necessary prior to delivery at OU 4. Specific areas likely requiring careful coordination include the control system (particularly integration with the extraction and injection pumps) and MnO_2 filtration requirements.

Design and performance criteria for the proposed in-situ chemical oxidation system include the following:

4.1 TARGET TREATMENT LEVELS

Anticipated initial VOC concentrations in extracted groundwater and target in-situ treatment levels are given in Table 3. As described in Section 3.0, VOC concentrations must be reduced to below the Florida MCL of $3 \mu\text{g/L}$ prior to the injection of dosed, extracted groundwater. The target treatment levels for groundwater in the source area after treatment are based on eventually meeting surface water standards at Lake Druid. Based on an evaluation of natural attenuation at OU 4 (HLA, 1998), the average total concentration of VOCs in the source area should be approximately $80 \mu\text{g/L}$. However, this estimate was based on aquifer conditions evaluated in 1997. Plantings of poplars and willow trees between the source area and the lake are currently planned for spring 2002. These plantings may accelerate the attenuation of source area VOCs migrating towards the lake, and achieve surface water standards more readily at higher source area concentrations. VOC concentrations in groundwater will be measured during the long-term monitoring program for OU 4.

4.2 TREATMENT AREAS AND FLOW RATES

Extraction rates are expected to be well below the capacity of each well, eliminating the need for low water level shutoffs. Although the pilot study used a single aboveground pump to extract groundwater from the three extraction wells, the full-scale flow rates and the desired system flexibility favor individual submersible pumps.

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The proposed system is designed to hydraulically capture the horizontal and vertical extent of the source area. Treatment areas and required flow rates were calculated from a groundwater model using Visual MODFLOW (see Appendix B), based on the aquifer properties used in the USGS report (USGS, 1998). The treatment area dimensions of Cells 1 and 2 are approximately 100 feet long by 80 feet wide by 35 feet deep. Cell 3 dimensions are approximately 70 feet long by 45 feet wide by 35 feet deep. Cell coverage areas overlap to ensure treatment of the source area (Figure 4).

To achieve these coverage dimensions, flow rates in the shallow zone for Cells 1, 2, and 3 will be 2, 2, and 1 gpm, respectively. Flow rates in the deep zone are twice as high as shallow zone flow rates to adequately spread the KMnO_4 solution front. Thus, flow rates in the deep zone for Cells 1 and 2 are 4 gpm each and 2 gpm for Cell 3. The total flow rate for the system is therefore 15 gpm.

It is anticipated that the total system flow rate will decrease as some zones will remediate more quickly than others. During the pilot study, the KMnO_4 saturated the shallow zone more quickly, which was the opposite of what was expected (i.e., the deep zone hydraulic conductivity is 4 times the shallow zone hydraulic conductivity, and the KMnO_4 is therefore expected to saturate the deep zone more quickly). However, with the dedicated injection wells, the full-scale system should address both the shallow and deep zones. The progress of the KMnO_4 across each zone will be monitored, and the KMnO_4 dose and system flow rates may be adjusted accordingly. With extraction and injection wells dedicated to the shallow and deep zones, addition of the KMnO_4 solution can cease when either zone becomes saturated. The total duration for treatment of the source area is expected to be 6 to 12 months.

4.3 KMnO_4 DOSAGE.

KMnO_4 dosage is based upon PCE oxidation kinetics since PCE oxidation is the rate-limiting step (i.e., TCE and DCE oxidize faster than PCE). The pilot study used a KMnO_4 concentration of 4 g/L. However, this may have been higher than necessary for the in-situ oxidation reaction. Based upon recent discussions with Colorado School of Mines researchers, at lower KMnO_4 concentrations, less of the natural TOC in the aquifer will be oxidized, leaving a higher percentage of the injected KMnO_4 available to oxidize VOCs. The lower KMnO_4 concentration will oxidize the VOCs more slowly, but this is not a concern since the source area will be flooded and soaked in the oxidant. The lower KMnO_4 concentration will also likely result in the production of less MnO_2 .

The KMnO_4 dosage is also critical for extracted groundwater treatment to MCLs prior to injection. The lower the dosage, the longer the ex-situ residence time necessary to achieve MCLs, and therefore the number of tanks (reactors) needed increases. The recommended full scale KMnO_4 concentration is initially 1.5 g/L. This recommendation is a compromise where dosage is minimized (and therefore the chemical costs) while the ex-situ residence time necessary to achieve MCLs prior to injection is kept within a reasonable time frame.

Based on pilot study results, initial average VOC concentrations in the combined 15 gpm extracted groundwater stream will be approximately 5,000 $\mu\text{g/L}$. At a KMnO_4 dosage of 1.5 g/L, PCE concentrations of 3 $\mu\text{g/L}$ or less can be achieved with four 1,600-gallon tanks (see calculations in Appendix C). This dosage assumes the first tank is a pseudo-constantly stirred tank reactor (CSTR) due to the high circulation rate of Tank 1 water to the KMnO_4 feed system (see Section 4.4), and the other tanks are unstirred (i.e., plug flow conditions). Actual performance may vary, as Tank 1 reaction performance will be better than predicted using the CSTR equations (the tank is not stirred enough to be a CSTR), while performance of Tanks 2 to 4 may be less efficient than predicted, as conditions in those

tanks are not really plug flow. This behavior was noted during the pilot study; ex-situ VOC concentrations must be monitored during startup and the KMnO_4 concentration possibly adjusted to meet MCLs based on actual reaction results.

The VOC concentrations in the extracted groundwater may be higher or lower than predicted above. The total extraction rate from the shallow wells (where the highest VOC concentrations are found) is 5 gpm, but the deep well extraction rate is 10 gpm. Since lower VOC concentrations are present in the deep zone, the combined stream will likely see some dilution due to the lower VOC concentrations in the 10-gpm flow. Regardless of the initial VOC concentrations in the extracted groundwater, as the system operates the VOC concentrations in the extracted groundwater will decrease, allowing reductions in the dosage of KMnO_4 . A KMnO_4 concentration of 1 g/L should be adequate to achieve significant in-situ oxidation of VOCs, but even lower concentrations could be used based on performance monitoring results.

4.4 KMNO₄ FEED SYSTEM

The KMnO_4 feed system used in the pilot test consisted of two Merrick Industries Omega Drum Invert Series 82-50 drum inverters fitted with Model 25-07 Helix Feeders (screw feeders) and a polyethylene washdown dissolver. Each drum inverter emptied a 330-pound drum of KMnO_4 into the hopper of the screw feeder. The drum inverters were piped in series and wired so that the second feeder began operating once the first KMnO_4 drum was empty. The controls for the feeders shut down the entire system if both drums of KMnO_4 were depleted. Photographs of the feed system are included in the final pilot study report (HLA, 2001d).

Each screw feeder is manually controlled by adjusting the setting on a potentiometer fitted to each unit. The relationship between the potentiometer setting and feed rate must be established for each feeder by field calibration; adjustments to KMnO_4 feed rate are then made manually as necessary. A pump transfers water from the first mixing tank to the KMnO_4 feed system. Both screw feeders empty into a polyethylene washdown tank where the KMnO_4 was dissolved by a portion of the water circulated from the first mixing tank. This "washdown" stream carries the KMnO_4 to the bottom of the washdown tank and into an eductor. The eductor draws in the washdown stream using the rest of the water circulated from the mixing tank, and conveys the combined streams back to the first tank.

At a KMnO_4 dosage of 1.5 g/L and an extracted groundwater flow of 15 gpm, approximately 180 pounds per day of KMnO_4 will be necessary. Using two drum inverters would provide slightly more than a 3-day capacity of KMnO_4 before both drums would need to be replaced. Drum replacement frequency is expected to quickly decrease as the VOC concentrations in extracted groundwater decrease and lower KMnO_4 dosages are used. The pilot study feed system is therefore expected to be adequate for full-scale operation, although the feed system requirements should be discussed with Carus Chemical to determine if a different arrangement is more practical.

Approximately 40 unopened 330-pound drums of KMnO_4 left over from the pilot study are currently stored in Building 1100. The feed system chosen for the full-scale design must make use of this inventory of KMnO_4 .

4.5 TANK RETENTION

The polyethylene mixing tanks are supplied by Carus and have a 1,600-gallon capacity. It was assumed that each tank could safely hold 1,500 gallons. Based upon this volume and the flow, VOC concentration,

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and KMnO_4 dosages assumed above, the reaction kinetics calculation indicated that four (4) 1,600-gallon tanks are required for the treatment system to meet Florida MCLs for PCE prior to injection. Calculations are included in Appendix C.

Tanks 2 through 4 should be piped so that water enters through a fitting at the bottom, and exits from near the top of the tank. This arrangement helps ensure a maximum residence time in each tank.

4.6 WELL COMPLETION AND DEVELOPMENT

Several types of wells will be installed at the site to meet the objectives and requirements of the treatment system: shallow monitoring wells ("microwells"), deep zone monitoring wells ("monitoring wells"), injection wells, and extraction wells. This conceptual design assumes that Building 1100 will remain intact. The small access door on the north side of the building limits the size of the vehicle that will fit inside the building, and the relatively low ceiling (less than 15 feet high) also prevents the erection of a drill rig boom. However, the cost of removing even a portion of Building 1100 (due to lead paint and asbestos) will be high, and the building also offers a relatively secure and dry location for the KMnO_4 feed system and storage. Well locations are shown on Figure 4.

Microwells installed using a Geoprobe-type rig will be used for all shallow groundwater monitoring points. Microwells shall be constructed using 0.5-inch ID, Schedule 80 PVC with 0.01-inch pre-packed slotted screen. Microwells will be installed to the top of the cemented sand layer (approximately 20 feet bls) and screened over the last ten feet. A general completion diagram is shown on Figure 6.

A van-mounted Geoprobe system was used inside the building during the source investigation (ABB-ES, 1997b). The vehicle tires were deflated and the suspension compressed by loading the full field team inside in order to fit the vehicle through the access door on the north side of Building 1100. A similar approach should be possible to install shallow wells within the building to monitor the full-scale remediation.

Microwells will be developed using a peristaltic pump. Pump tubing shall be lowered to the bottom of the well so that fines are agitated and removed from the well in the development water. Development shall continue until a minimum of 10 well casing volumes of water are removed from the well and the pH, temperature, specific conductivity and reduction-oxidation potential of the groundwater have stabilized.

Monitoring wells will be constructed of 2-inch ID, flush-threaded, Schedule 40 PVC riser with 2-inch ID, Schedule 40 PVC, 0.020-inch slotted screen. The filter pack material shall be a clean 20/30 silica sand mixture. Monitoring wells will be screened for a length of 15 feet from below the cemented sand layer (~20 feet bls) to a depth of approximately 35 feet bls. Well risers will have flush mount completions as shown in Figure 7. Monitoring well development will be based on stabilization of groundwater parameters and the total volume purged. Installation of monitoring wells inside Building 1100 will require a low-profile drill rig or a tripod.

Injection and extraction wells shall be constructed of 4-inch, flush-threaded, Schedule 40 PVC riser with 4-inch, Schedule 40 PVC, 0.030-slotted screen. Filter pack material shall be a clean 6/20 silica sand mixture. Vertical wells installed in the shallow zone will be screened from 5 to 20 feet bls, and will penetrate the cemented sand layer (to deliver oxidant to residual PCE that may be trapped in this layer). Vertical wells installed in the deep zone will be screened 15 feet below the cemented sand payer from 20 feet bls to 35 feet bls. Vertical wells will be flush-mounted and completed as shown in Figure 7.

Monitoring wells, extraction wells, and injection wells for the pilot study were installed using Rotosonic drilling. Although the cost per foot is higher for Rotosonic than for hollow-stem auger drilling, Rotosonic has distinct advantages at OU 4. Hollow stem drilling at OU 4 is difficult due to flowing sands into the augers after removal of the plug. Rotosonic does not suffer from this problem, is faster than hollow-stem auger drilling, produces far fewer cuttings, and installs wells that develop more easily and are more efficient than hollow-stem because of the minimal borehole smearing produced by Rotosonic. Therefore, where possible, Rotosonic is the recommended drilling method for large (i.e., non-microwell) wells installed for the full-scale system.

Because Rotosonic drill rigs will not fit within Building 1100, the four injection and extraction wells for Cell 2 must be installed at an angle from the north side of Building 1100. Angled wells in the shallow zone will be screened from approximately 10 to 20 feet bls. The midpoint of the shallow well screens shall be 15 feet bls and 17 feet inside the north side of the building. Deep zone angled wells will be screened approximately 20 to 35 feet bls. The midpoint of the deep well screens shall be 27.5 feet bls and 17 feet inside the north side of the building. If the point of entry is 10 feet from the edge of Building 1100, the total screen length for each of the shallow and deep angled wells is approximately 20 feet. Total screen length and well angle will change based on the distance of the point of entry from Building 1100. A diagram of angled well screen lengths and locations is shown on Figure 8. Well risers will have flush mount completions as shown in Figure 7.

Thorough development of the injection and recovery wells will be crucial for adequate performance. Development of these wells should follow a performance-based approach. Each well should be surged with a surge block, and then pumped while measuring specific capacity. These steps should be repeated until the specific capacity stabilizes and the pumped water is clear. The wells should then be surged and pumped harder. Again, this cycle should be repeated until the specific capacity stabilizes and the extracted water is clear. Refer to the NTC, Orlando Project Operations Plan (ABB-ES, 1997d) for further details on well development procedures.

4.7 PUMPS

Pumps will be required to extract groundwater and inject the KMnO_4 solution. The pilot study used a variable-speed ITT Jabsco flexible impeller pump to draw groundwater out of the extraction wells via suction. Impeller material was Viton to withstand the KMnO_4 solution. However, as noted previously, because of the extraction rates and the desired treatment system flexibility, the full-scale system will use a submersible pump in each of the six extraction wells. These pumps should be Grundfos or equivalent. It is expected that the extraction pumps will be supplied by the RAC, separate from the treatment system rented from Carus.

The KMnO_4 solution will flow by gravity between the four mixing tanks. Pumps will be required to transfer the solution through the filtration system, and then to inject the filtered water into the injection wells. The specifics of this portion of the system will be based on the filtration technology chosen to remove the MnO_2 particulates (see Section 4.8). The filtration and injection pumps will likely be provided by Carus as part of the rented treatment system. The details of this portion of the system must therefore be discussed with Carus and placed in their scope.

The ITT Jabsco pumps used for the pilot study worked well, and should be considered where applicable in the full-scale design. The Viton impellers withstood the KMnO_4 solution, although Viton is somewhat brittle and therefore the impellers will likely require replacement after approximately each month of continuous use.

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4.8 FILTRATION SYSTEM

A filtration system will be necessary to remove MnO_2 precipitate that forms in the tanks as a result of the $KMnO_4$ oxidation reaction. Up to 300 grams per day of MnO_2 may be produced during full-scale operation. The pilot test used an in-line cartridge filtration system, however, the cartridge filters required frequent changeout and were not effective in removing the precipitate (HLA, 2001d). As a result, other filtration systems were reviewed for their applicability to the full-scale treatment system. MnO_2 particles are approximately one micron in diameter, therefore, particle filtration and microfiltration processes were considered for the review.

Rotary drum filtration (RDF) is a particle filtration process where a rotating drum, partially submerged in a tank containing process water, filters process water via a vacuum on the drum. A layer of diatomaceous earth (DE) on the drum is required to remove particles approximately one micron in size. Solids retained on the drum are scraped off by a blade, which also removes part of the DE layer. As a result of DE loss, the DE layer must be regenerated.

After the failure of the cartridge filtration system of the pilot study, Carus recommended an RDF unit manufactured by ALAR Engineering Corporation (Appendix A) for the full-scale operation. However, after discussions with ALAR, their RDF units may not be suitable for the full-scale system, regeneration of the DE layer will likely be necessary every 10 to 12 hours. Ideally, the filtration system should not require attention more frequently than $KMnO_4$ drum change-outs, i.e., every 3 to 4 days.

Disk filtration (DF) is another particle filtration process and is suitable for low strength process waters. Disk filters are assembled on candles, which are then stacked in a tower structure. Similar in principle to RDF, process water passes over the filters, which retain solids via a vacuum. As with RDF, disk filters require a DE coating to remove one-micron particles. Backwashing is required with DF, usually using pressurized air, and loss of DE may occur with removal of filtered solids. Thus, a DE precoat is required prior to restarting filtration. Disks are constructed of polypropylene, which may be Teflon-coated, and would not need replacement for the duration of the full-scale treatment system. The DF system may be automated to perform backwashing and precoat functions, however, periodic filter cleaning may be required (i.e., entire filter structure is taken apart and cleaned) and refilling of the DE reservoir will be required.

Microfiltration is a filtration process that commonly operates in a crossflow mode, as opposed to the "dead-end" type of filtration, decreasing, or totally removing the requirement to backwash the filter. Water flow scours the filter membrane, which allows filtrate to pass through and concentrates solids. Microfilters are tubular or spiral shaped, and are composed of ceramic or polymeric materials. Similar to "dead-end" filtration systems, a stream having a high solids concentration is generated and must be disposed of. Some flushing may be required to remove any accumulated solids from the filter and acid cleaning may be required to remove any scaling from dissolved metal precipitates (e.g., iron oxides or metal hydroxides). Microfiltration systems can be automated to perform all of these functions, decreasing the requirement for manual attendance.

Several considerations must be made in the final choice of the filtration system. Some systems may not be weather resistant, skid-mounted or may require peripheral equipment. Of the filtration systems reviewed, particle filtration processes are much cheaper than microfiltration systems. Filtration system estimates for the full-scale process stream range from \$3,000-\$4,000 (per filter) for pleated filters to \$30,000-\$70,000 for fully automated microfiltration systems. Operation and maintenance considerations should include frequency of manual attendance, frequency of gasket or valving replacements, automation

and instrumentation capabilities, cleaning requirements, and filter/material life and replacement. Health and safety considerations should also be made in choosing the appropriate filtration systems. DE handling and use raises concern due to health hazards associated with silica dust. Finally, some vendors have pilot systems available for rental or for free to test the applicability of their systems to site conditions. Most vendors will require a sample of the solution requiring filtration to allow sizing and costing of an appropriate filter. Points-of-contact for filtration system vendors are included in Appendix A.

Selection of an appropriate filtration system will be critical to full-scale operation. This portion of the treatment system must be carefully selected, and frequent coordination with Carus will likely be necessary to ensure an appropriate system is chosen and provided as part of the rental system.

The MnO₂ solids are non-hazardous and can be disposed of as a solid waste. MnO₂ particulates should settle quickly in backwash solutions. The water can be decanted off, leaving a layer of MnO₂ at the bottom of the backwash tank.

4.9 INSTRUMENTATION

Instrumentation requirements will be a function of the detailed design provided by Carus. The pilot study instrumentation was designed by Carus, based on performance requirements provided to them. A similar approach should be used for the full-scale system.

The pilot studied varied the speed of the Jabsco extraction pump to maintain a constant extraction rate based on a signal from a flow meter on the extraction piping. Because of the number of extraction pumps used by the full-scale system, variable speed operation of these pumps is not practical. Instead, the flow rate from each pump is manually set via valving and periodically checked and readjusted as necessary. A flow meter on the extraction piping would be used to provide a measure of total flow, and a system shutdown signal should there be a loss or significant reduction in flow.

Tank levels in Tanks 1 to 3 are maintained by gravity at the same elevation as Tank 4. Water levels in Tank 4 can be maintained by varying the speed of the pump transferring the solution to the filtration system and also the rate of injection. Level sensors used in the pilot study tanks were ultrasonic. These sensors worked very reliably, and eliminated the need for level sensors that needed to be immersed in the KMnO₄ solution.

5.0 PERMITTING REQUIREMENTS

The regulatory permitting requirements for implementation of the in-situ chemical oxidation system will be completed by the CLEAN and/or RAC contractor, and will include, but may not be limited to:

- an NTC, Orlando base excavation permit;
- a petition for variance from Underground Injection Control (UIC) requirements.

When NTC Orlando was an active facility, excavation permits were to be required for well installation and construction or any trenching. With the closure of the base, excavation and trenching requirements should be coordinated with the Navy and/or the current tenants at Area C. A copy of the excavation permit application required when the base was open is enclosed in Appendix D.

A petition for variance from UIC requirements (Chapter 62-522.300(2)(a) of the Florida Administrative Code [F.A.C.]) must be filed with the Florida Department of Environmental Protection (FDEP) Office of General Counsel. Injection of KMnO_4 solution will exceed secondary drinking water standards as set forth in Chapters 62-550.310 and 62-550.320 of the F.A.C. The petition for variance is company specific and must be filed by the RAC contractor prior to implementation of the in-situ chemical oxidation treatment system. An example of the petition for variance from UIC requirements is included in Appendix D. The example includes a request for a petition of variance filed by HLA for the in-situ chemical oxidation pilot study and the granted variance from FDEP.

The variance request for the full-scale system should be identical to the petition used by HLA, although the size of the area where secondary standards will be exceeded will likely be larger than the area stated in the HLA variance request.

6.0 SITE PLAN DESIGN BASIS

Design and performance criteria for the proposed treatment system associated with the site plan, which is shown in Figure 9, are described below.

- Loam and reseed areas disturbed by construction activities.
- Site access should be consistent with areas cleared for the previous investigations and pilot test, where possible.
- Aboveground completion of treatment systems should be surrounded with a chainlink fence with lockable gated entrance large enough for a forklift.
- It is assumed that power, as specified by the respective system vendors, exists at Building 1100 or the adjacent utility pole. The 3-phase power drop used for the pilot study is still present.
- Access issues associated with Building 1100 limit well installation and drilling techniques. Microwells will be installed using direct push technology (DPT) mounted on a van or similar-type vehicle. Monitoring, injection and recovery wells located beneath Building 1100 will be installed at an angle since either 1) drill rigs are unable to enter the building; or 2) if skid-mounted equipment for conventional drilling technology (e.g., hollow stem auger) is available, it is likely unable to achieve the desired depths at the desired well diameters.
- Water supply is available from a hydrant located west of Port Hueneme Ave.

7.0 CIVIL DESIGN BASIS

Civil design performance parameters include the requirements below.

- Injection and recovery wells used in the pilot test will be abandoned as they are screened through both the shallow and deep layers. Well construction, repair, abandonment, etc. are regulated by the St. John's River Water Management District, as delegated by the FDEP. Well abandonment procedures are outlined in the State of Florida Administrative Code, Chapter 40C-3.517(9).
- Concrete pads shall be finished at a slope to direct water away from wells.
- Microwells will be installed using DPT. DPT cannot penetrate the cemented sand layer, however, thus other drilling methods will be required for installation of deep zone groundwater monitoring wells.
- Monitoring, injection, and recovery wells will be installed using Rotosonic drilling. As indicated in Section 6.0, drill rig access within the building is limited. Therefore, Rotosonic drilling is necessary due to requirements for installation of angled wells beneath Building 1100. Conventional drilling methods, such as hollow-stem auger, are either unable to achieve the required angles or cannot penetrate the cemented sand layer and maintain a straight borehole. Prosonic Corporation (formerly Alliance Environmental) and Boart Longyear were contacted regarding Rotosonic drilling capabilities. Based upon conversations with individuals from each company, Boart Longyear appears to have the greatest expertise, experience and capability to complete the required angled wells using Rotosonic drilling. Contact information for Boart Longyear is provided in Appendix A.

8.0 MECHANICAL DESIGN BASIS

Mechanical design performance parameters include the requirements below.

- Treatment system piping shall be resistant to contaminants found at OU 4, compatible with the KMnO_4 solution, and properly supported and secured. A material compatibility table is included in the KMnO_4 pilot study work plan (HLA, 1999). Carus is also well-versed in materials selection. Polyethylene and PVC work well.
- Any valves and/or appurtenances associated with groundwater conveyance shall be resistant to contaminants found at OU 4 and the KMnO_4 solution.

9.0 ELECTRICAL AND INSTRUMENTATION DESIGN BASIS

The performance and design criteria for electrical and instrumentation components are listed below.

- Electrical service for the treatment system should be metered separately on-site.
- All electrical and instrumentation components should be suitable for outdoor installation. However, the drum inverter KMnO_4 feed system must be located indoors.
- NEMA 3R, or better, control panel for instruments and control push-buttons/switches.
- Hour meter(s) shall be installed on any pump(s), rotating mechanical equipment, etc.
- Telemetry instrumentation is optional, but is, however, recommended. The pilot study control system had the capability of providing system status via a phone line. However, a new dedicated phone line will be needed at OU 4 if the OU 4 IRA is using the existing circuit.

10.0 OPERATIONS AND MAINTENANCE

An operations and maintenance (O&M) plan will be developed by the CLEAN and/or RAC contractor and Carus. The O&M plan should include, but not be limited to, equipment manuals, startup and shutdown procedures, preventative maintenance schedules, a maintenance schedule for the filtration system, trouble-shooting guides, system operation failure procedures, and a reporting format for maintenance of the system. In addition, the O&M should include the activities below.

- System startup activities will continue until the system has met the performance criteria, as outlined in Section 5.0. The activities will include setting the treatment system operating parameters through adjustment of pumping and KMnO_4 dosage rates. Water samples should be collected periodically from each tank as the system fills during initial startup and analyzed onsite for VOCs. This is the only method available to confirm the predicted ex-situ VOC oxidation rates and ensure Florida MCLs will be met prior to injection.
- A maintenance record will be completed by the responsible personnel with copies maintained with the RAC contractor, the CLEAN contractor and the Navy.
- The injection wells should be monitored for MnO_2 precipitate fouling, although none should occur if the filtration system is operating properly. Evidence for fouling includes rising water levels in the wells. If necessary, MnO_2 can be removed from the inner wells screens using the 4-inch K-Packer (currently stored in Building 1100) from the pilot study. The procedure necessary for using the K-Packer is described in the final pilot study report (HLA, 2001d).

11.0 PERFORMANCE MONITORING AND SAMPLING

The performance monitoring and sampling plan (PM&SP) will be used to evaluate the performance of the in-situ chemical oxidation treatment system, measure the progress of source area remediation, and identify possible system adjustments to expedite cleanup. The PM&SP will be generated and performed by the RAC contractor. However, minimum requirements regarding the PM&SP for the final design of the treatment system include, but should not be limited to, the following:

- measure changes in source area VOC concentrations in groundwater,
- monitor the migration and in-situ consumption of KMnO_4 solution,
- evaluate changes in inorganic concentrations in groundwater due to KMnO_4 injection,
- ensure VOCs are adequately oxidized in the mixing tanks,
- evaluate MnO_2 precipitate formation and settling in the mixing tanks and solids concentrations before and after the filtration system, and
- ensure that the terms of the variance from UIC requirements are met.

An initial round of baseline data shall be collected prior to pilot system startup. Groundwater samples will be shipped to an off-site laboratory for analysis of VOCs by United States Environmental Protection Agency (USEPA) Method 8021, inorganics by USEPA Method 7000, total organic carbon, and total dissolved solids. Field methods will be used to collect conductivity, oxidation/reduction potential, temperature, pH, alkalinity, hardness, dissolved oxygen, chloride, total and ferrous iron, color and turbidity data. Groundwater samples for inorganic analysis should be field filtered.

Prior to use, KMnO_4 samples should be collected from each new lot of KMnO_4 purchased from Carus to confirm that inorganics are within permit limits. An initial 1.5 g/L solution will be prepared for each chemical batch number and analyzed for inorganics by an offsite laboratory to confirm inorganic concentrations will be within the limits specified in the UIC variance. As noted in the final pilot study report (HLA, 2001d), the high dissolved solids and manganese present in the KMnO_4 solution can affect the accuracy of the inorganic analyses. The laboratory must be made aware of these issues. Furnace (rather than flame) inorganic analytical techniques should be used.

During operation of the full-scale system, KMnO_4 migration will be monitored through visual color changes and specific conductance measurements. As the KMnO_4 solution migrates through the treatment zone, groundwater color will progress from pale yellow, to amber, to brown, and finally to purple when the zone is saturated with permanganate.

Water levels will be monitored in the injection wells as an indicator of the effectiveness of the filtration system to remove MnO_2 precipitate, which may clog injection well screens.

Shallow and deep zone monitoring wells will be placed to evaluate the migration of the KMnO_4 solution as well as VOC oxidation. A proposed monitoring well layout for the treatment system is shown in Figure 4. The sampling plan for monitoring wells will be developed by the CLEAN and/or RAC contractor.

Initial sampling after startup should focus solely on groundwater color changes. Significant changes in VOC concentrations will not occur until groundwater is a dark yellow or amber in color. Sampling for

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VOCs can be performed infrequently to minimize costs, as the pilot study demonstrated that the VOCs will readily oxidize if the KMnO_4 solution is present. Treatment is likely complete when groundwater color is dark brown or purple.

Sodium thiosulfate must be added to each groundwater sample to consume any excess KMnO_4 , and prevent further VOC oxidation within the sample vials after collection.

Additional details that may be useful when preparing the sampling plan are include in the pilot study work plan (HLA, 1999) and the final pilot study report (HLA, 2001d).

12.0 HEALTH AND SAFETY CONSIDERATIONS

Health and safety considerations pertaining to any work related to the installation, construction, and O&M of the in-situ chemical oxidation treatment system not already addressed in the existing generic Health and Safety Plan (HASP) for NTC, Orlando are outlined here. The RAC contractor shall complete an update to the NTC, Orlando HASP for the full-scale, in-situ chemical oxidation treatment system.

At a minimum, the work environment will be monitored for conditions that are “Immediately Dangerous to Life and Health” or other dangerous conditions. This monitoring will include evaluations for combustible gases, oxygen-deficient environments and hazardous concentrations of airborne contaminants. A combustible gas meter shall be used continuously. Direct reading instrumentation, including an organic vapor analyzer and lower explosive limit/oxygen meter, shall be used as the basis for upgrading or downgrading levels of personal protective equipment (PPE) in conformance with action levels provided in the updated HASP and at the direction of the Site Health and Safety Officer. Modified Level D PPE will be adequate for most activities related to installation and operation of the treatment system, except for KMnO_4 drum handling, unless air monitoring indicates PPE upgrades are required.

Operation of the KMnO_4 feed system will require change-out of empty drums of KMnO_4 . All handling of bulk KMnO_4 will be performed while wearing either a full-face respirator or a half-face respirator with a face shield. Personnel will work in pairs. An eyewash station will be available at the KMnO_4 handling area. Further handling considerations are provided in the Material Safety Data Sheets (HLA, 1999).

Groundwater sampling for VOCs must be conducted with gloves and safety glasses. Sodium thiosulfate will be used to quench the KMnO_4 oxidation reaction by adding several crystals to each 40-milliliter vial prior to adding groundwater. It must be strongly noted that when KMnO_4 is mixed with hydrochloric acid preservative from sample bottles, toxic chlorine gas is produced. Therefore, vials should not contain any hydrochloric acid and should be chilled at 4°C until they are analyzed.

REFERENCES

- ABB Environmental Services (ABB-ES), 1997a. *Interim Remedial Action Focused Field Investigation Report, Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (May).
- ABB-ES, 1997b. *Technical Memorandum, Interim Remedial Action, Focused Investigation/ Source Confirmation, Building 1100 Surge Tank, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (May).
- ABB-ES, 1997c. *Remedial Investigation and Feasibility Study Work Plan Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (October).
- ABB-ES, 1997d. *Project Operations Plan for Site Investigations and Remedial Investigations, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (August).
- Harding Lawson Associates (HLA), 1998. *Treatability Study, Technical Memorandum No. 1, Natural Attenuation Assessment, Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (July).
- HLA, 1999. *Treatability Study Work Plan No. 3, Data Collection Plan for Assessing In-Situ Chemical Oxidation using Potassium Permanganate, Operable Unit 4, Area C, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (December).
- HLA, 2000. *Interim Letter Report: In-Situ Chemical Oxidation Pilot Study, Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (July).
- HLA, 2001a. *Proposed Plan, Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (February).
- HLA, 2001b. *Remedial Investigation, Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (January).
- HLA, 2001c. *Feasibility Study, Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (February).
- HLA, 2001d. *Groundwater Treatability Studies, In-Situ Chemical Oxidation Pilot Study Using Potassium Permanganate, Operable Unit 4, Naval Training Center, Orlando, Florida*. Prepared for SOUTHNAVFACENGCOM, North Charleston, South Carolina (February).

REFERENCES

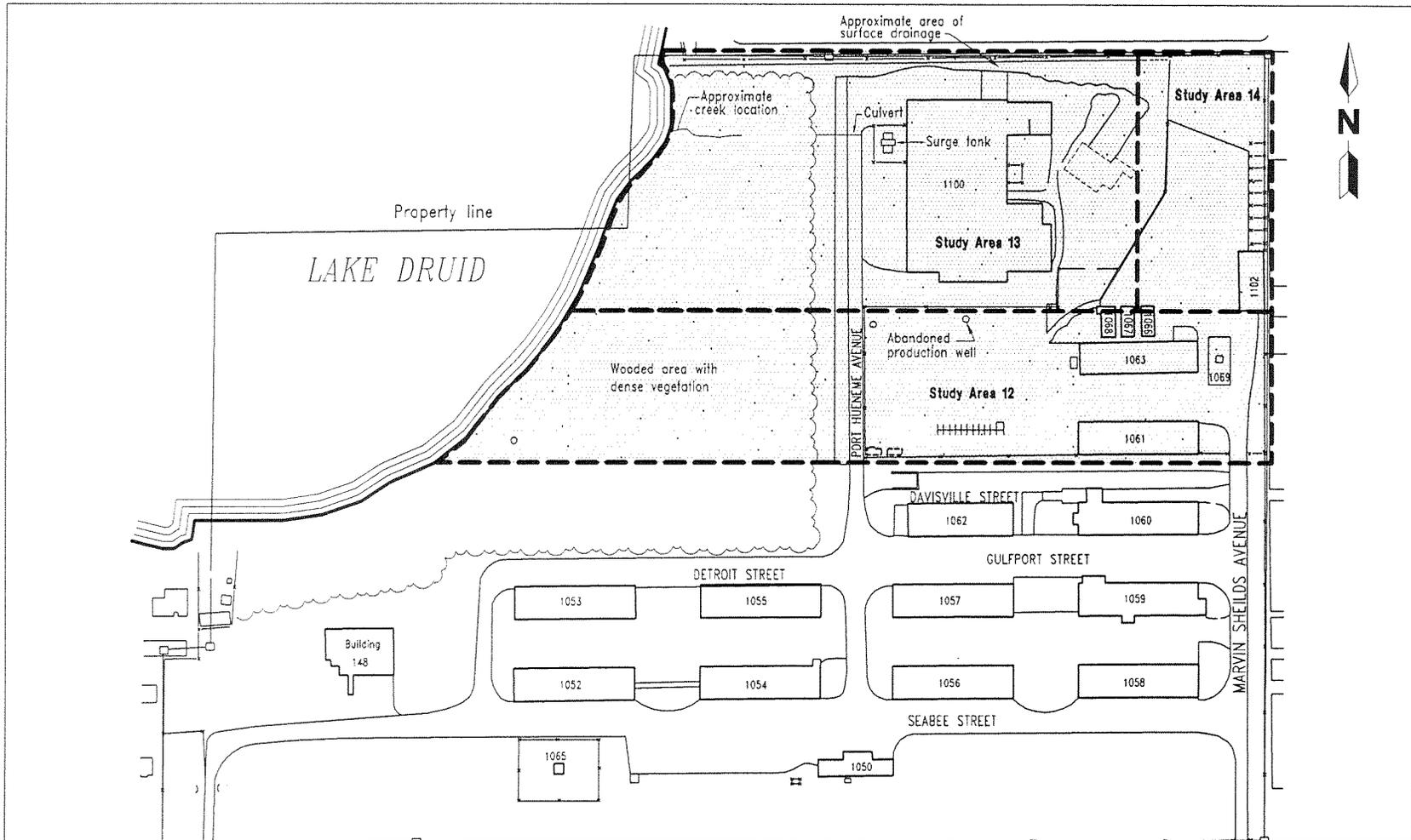
- Hood, E.D., N.R. Thomson, and G.J. Farquhar, 1998. *In Situ Oxidation: An Innovative Treatment Strategy to Remediate Trichloroethylene and Perchloroethylene DNAPLs in Porous Media*. Presented at the 6th Symposium on Groundwater and Soil Remediation, Montreal, Quebec (March).
- Huang, Kun-Chang, G.E. Hoag, and Pradeep Chheda. 2000. *Kinetics and Mechanism of Oxidation of Tetrachloroethylene with Permanganate*. Environmental Research Institute, University of Connecticut. Presented at the 17th Annual International Conference on Contaminated Soils, Sediments, and Water, October 16-19, 2000, University of Massachusetts, Amherst, MA.
- Schnarr, M., C. Truax, G. Farquhar, E. Hood, T. Gonullu, and B. Stickney, 1996. *Laboratory and Controlled Field Experiments Using Potassium Permanganate to Remediate Trichloroethylene and Perchloroethylene DNAPLs in Porous Media*. *Journal of Contaminant Hydrology* (December).
- U.S. Geological Survey, 1998. *Assessment of the Potential Effects of Phytoremediation on Groundwater Flow Around Area C at Orlando Naval Training Center, Florida*. Water-Resources Investigations Report 98-4110.
- West, O.R., S.R. Cline, W.L. Holden, F.G. Gardner, B.M. Schlosser, J.E. Thate, D.A. Pickering. 1997. *A Full-Scale Demonstration on In Situ Chemical Oxidation Through Recirculation at the X-701B Site, Field Operations and TCE Degradation*. Prepared for the U.S. Department of Energy. Oak Ridge National Laboratory, Environmental Sciences Division, Publication No. 4727 (December).



FIGURE 1
NAVAL TRAINING CENTER, ORLANDO
SITE LOCATION MAP



FULL-SCALE CONCEPTUAL DESIGN AND PERFORMANCE SPECIFICATION:
IN SITU CHEMICAL OXIDATION USING POTASSIUM PERMANGANATE, OPERABLE UNIT 4, NAVAL TRAINING CENTER ORLANDO, FLORIDA



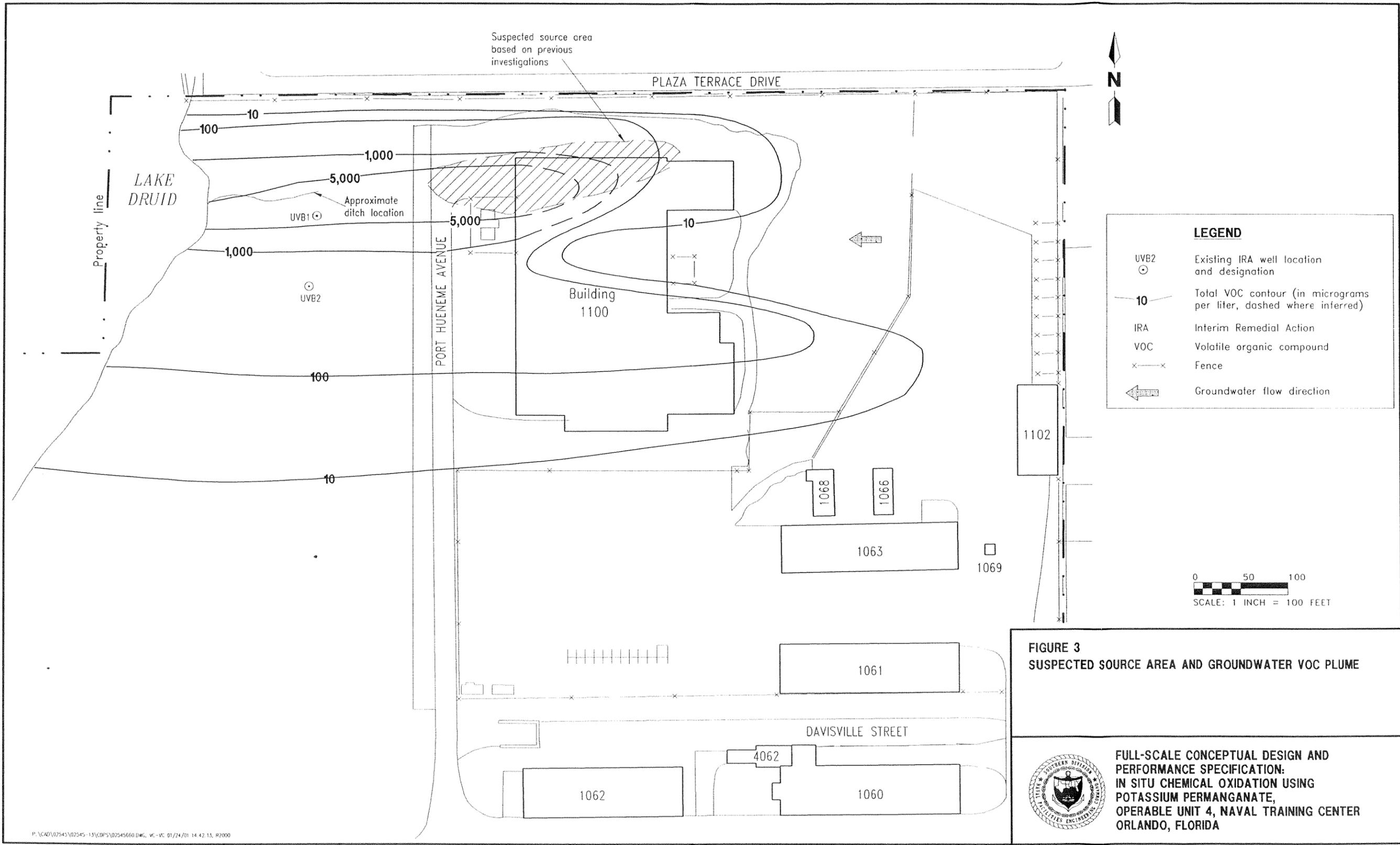
0 125 250
 SCALE: 1 INCH = 250 FEET

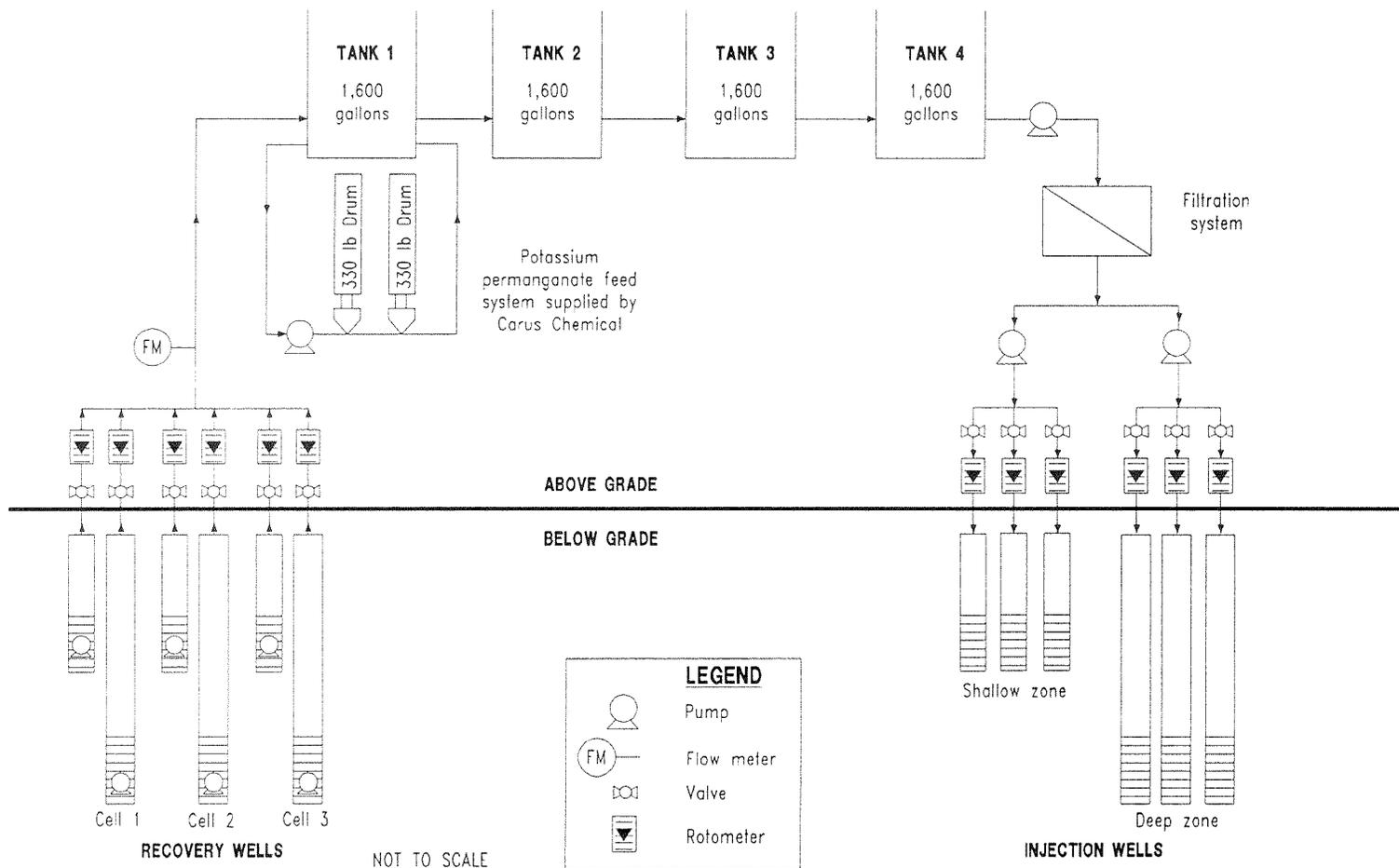
FIGURE 2
LOCATION OF OPERABLE UNIT 4
(STUDY AREAS 12, 13 AND 14)

P:\CAD\02545\02545-13\COPY\02545663.DWG, VC-VC 01/24/01 14:15:51, P2000



**FULL-SCALE CONCEPTUAL DESIGN AND PERFORMANCE SPECIFICATION:
 IN SITU CHEMICAL OXIDATION USING
 POTASSIUM PERMANGANATE,
 OPERABLE UNIT 4, NAVAL TRAINING CENTER
 ORLANDO, FLORIDA**





NOTES:

1. Tanks are not stirred.
2. Maximum total flow is 15 GPM.
3. All materials of construction to be compatible with 1% $KMnO_4$ solution at pH 10.

**FIGURE 5
PROCESS FLOW DIAGRAM**

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**FULL-SCALE CONCEPTUAL DESIGN AND PERFORMANCE SPECIFICATION:
IN SITU CHEMICAL OXIDATION USING POTASSIUM PERMANGANATE,
OPERABLE UNIT 4, NAVAL TRAINING CENTER ORLANDO, FLORIDA**

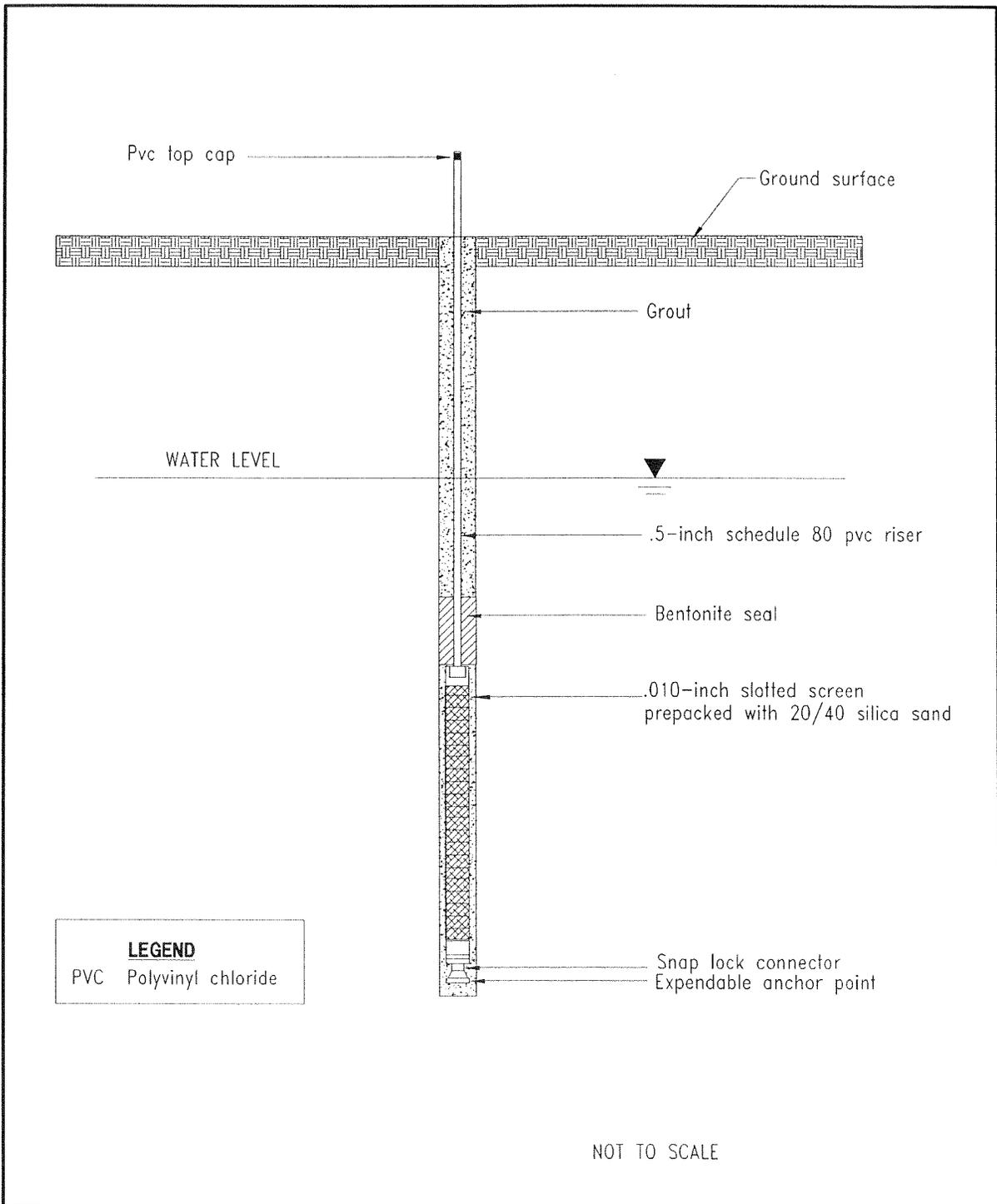


FIGURE 6
MICROWELL COMPLETION DIAGRAM



**FULL-SCALE CONCEPTUAL DESIGN AND PERFORMANCE SPECIFICATION:
IN SITU CHEMICAL OXIDATION USING POTASSIUM PERMANGANATE,
OPERABLE UNIT 4, NAVAL TRAINING CENTER ORLANDO, FLORIDA**

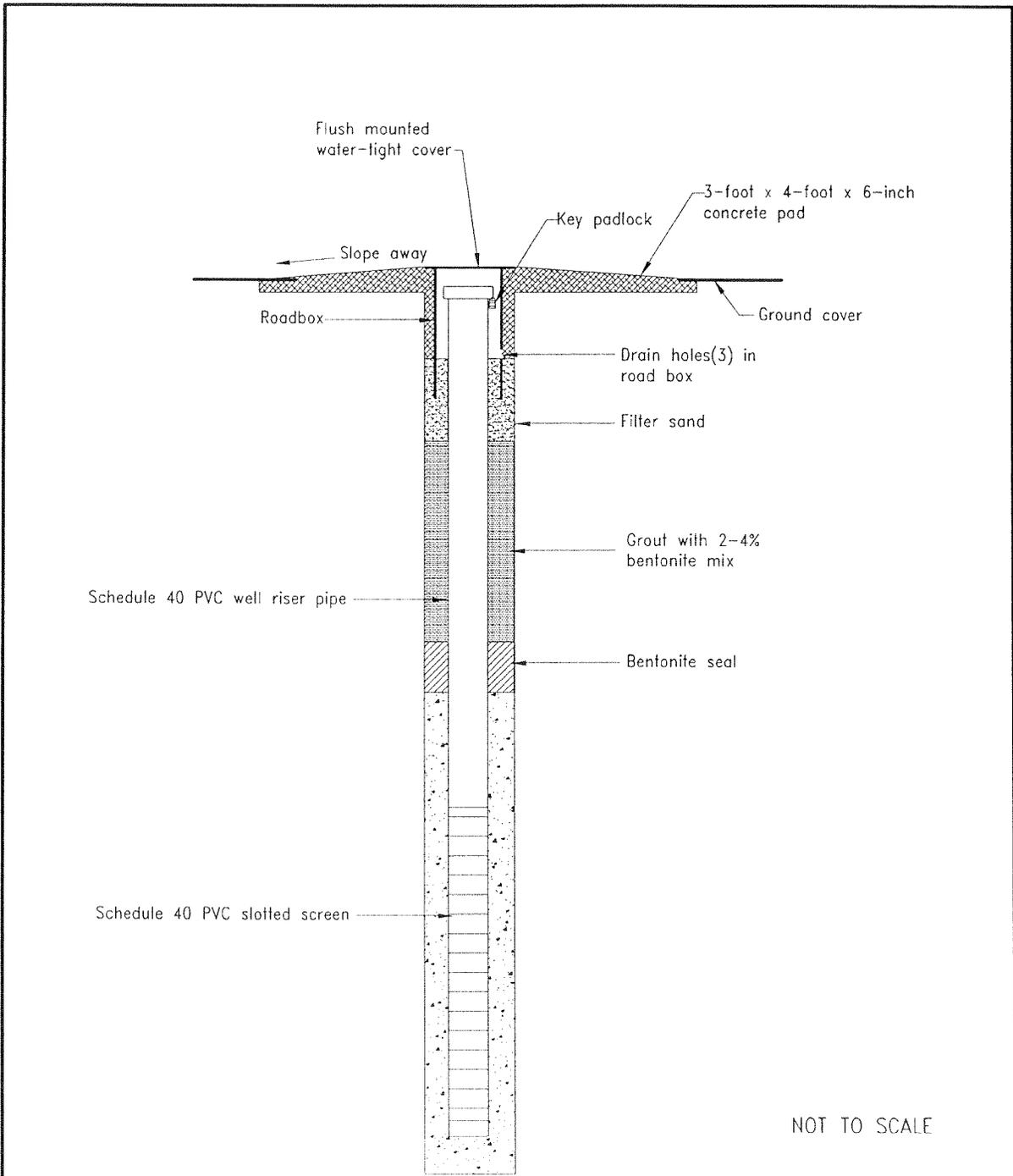
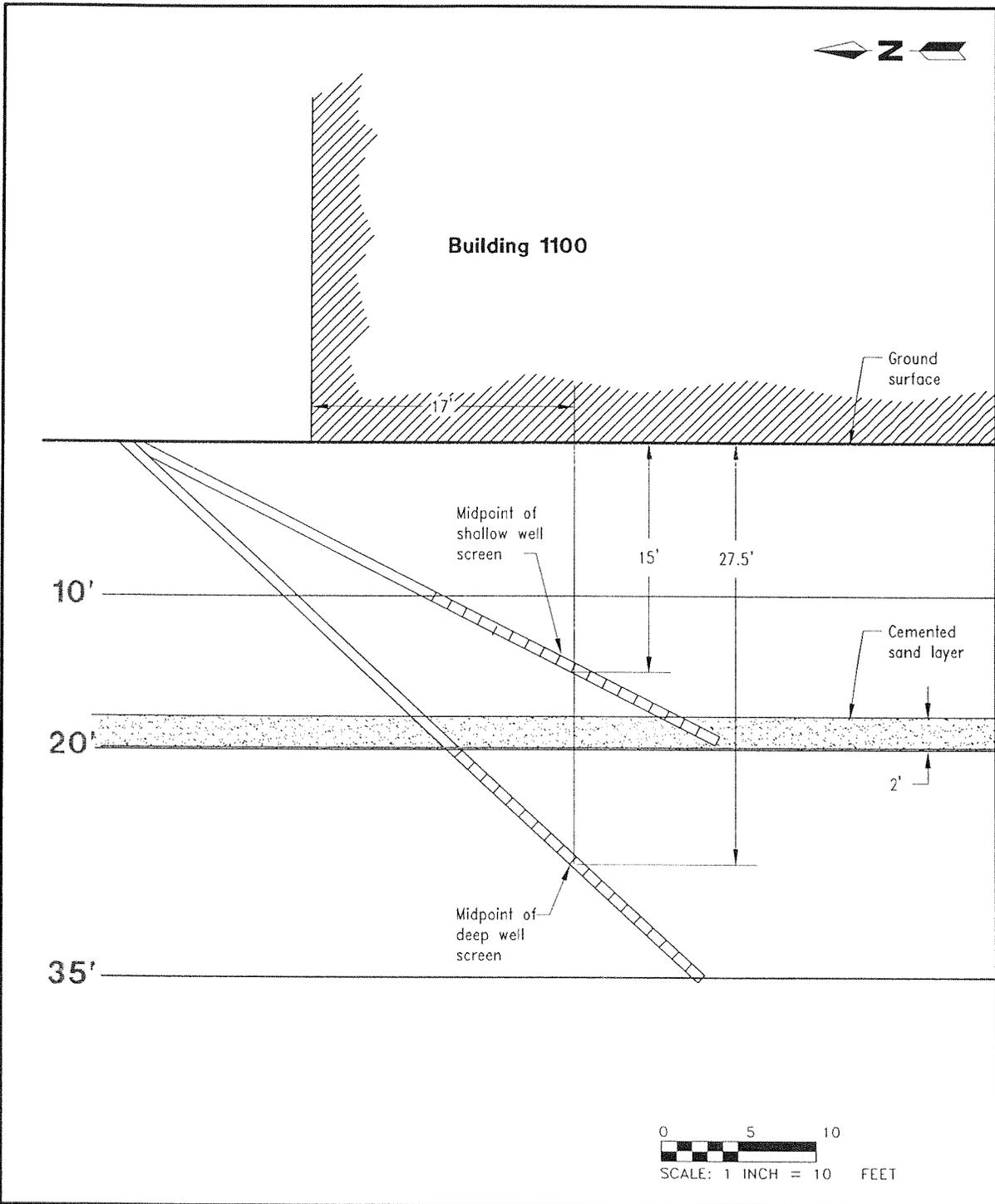


FIGURE 7
TYPICAL MONITORING, RECOVERY,
AND INJECTION WELL COMPLETION
DIAGRAM



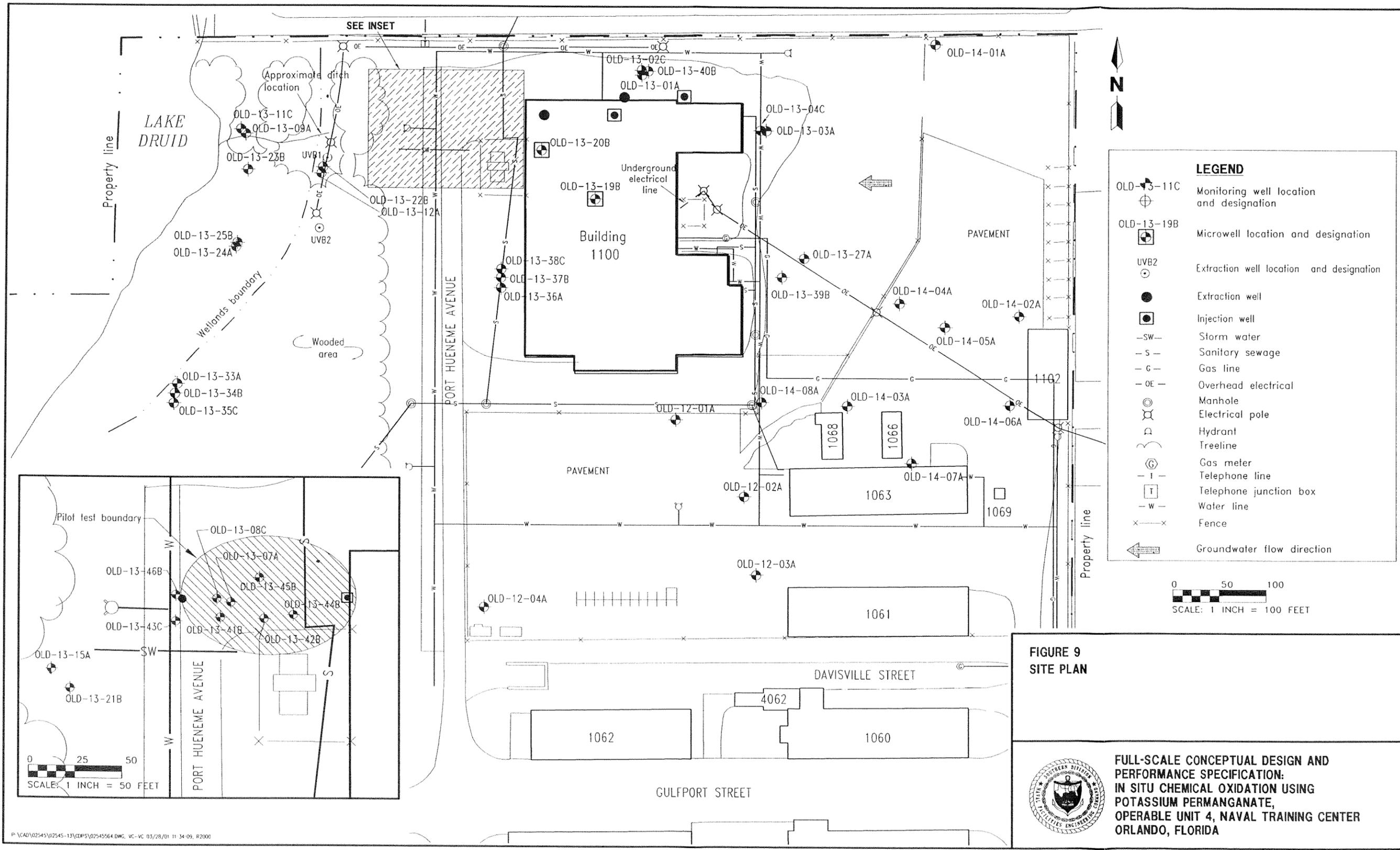
FULL-SCALE CONCEPTUAL DESIGN AND
PERFORMANCE SPECIFICATION:
IN SITU CHEMICAL OXIDATION USING
POTASSIUM PERMANGANATE,
OPERABLE UNIT 4, NAVAL TRAINING CENTER
ORLANDO, FLORIDA



**FIGURE 8
CROSS SECTIONAL VIEW OF ANGLED
INJECTION AND RECOVERY WELLS**

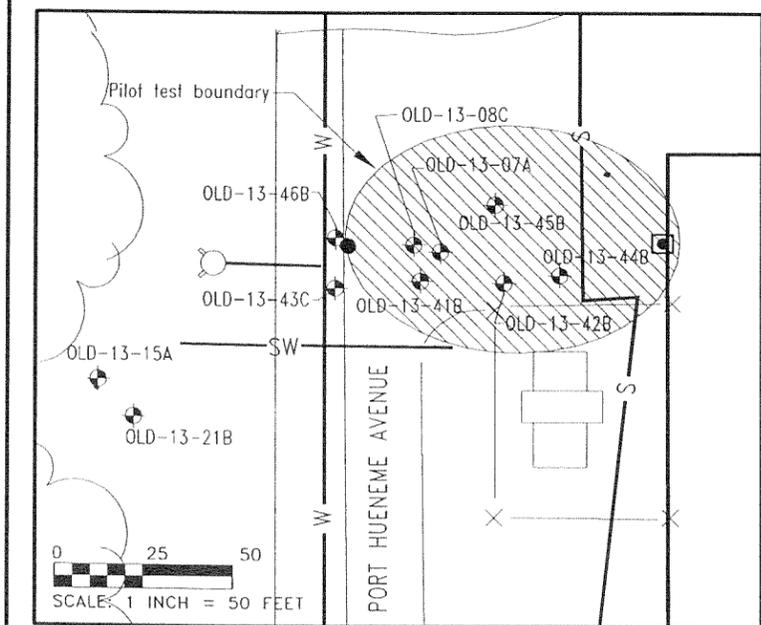


**FULL-SCALE CONCEPTUAL DESIGN AND
PERFORMANCE SPECIFICATION:
IN SITU CHEMICAL OXIDATION USING
POTASSIUM PERMANGANATE,
OPERABLE UNIT 4, NAVAL TRAINING CENTER
ORLANDO, FLORIDA**



LEGEND

○ (with dot)	Monitoring well location and designation
□ (with dot)	Microwell location and designation
○ (with cross)	Extraction well location and designation
●	Extraction well
□ (with dot)	Injection well
-SW-	Storm water
-S-	Sanitary sewage
-G-	Gas line
-OE-	Overhead electrical
⊙	Manhole
⊕	Electrical pole
⊕	Hydrant
⌒	Treeline
⊙ (with G)	Gas meter
-T-	Telephone line
T	Telephone junction box
-W-	Water line
X-X	Fence
←	Groundwater flow direction



**FIGURE 9
SITE PLAN**



**FULL-SCALE CONCEPTUAL DESIGN AND PERFORMANCE SPECIFICATION:
IN SITU CHEMICAL OXIDATION USING POTASSIUM PERMANGANATE,
OPERABLE UNIT 4, NAVAL TRAINING CENTER
ORLANDO, FLORIDA**

Table 1
Source Area Hydrogeological Parameters

In Situ Chemical Oxidation Treatment System
 Conceptual Design and Performance Specification
 Operable Unit 4
 NTC, Orlando, Florida

Hydrogeological Parameter	Shallow Zone (0 to 20 feet bls)	Deep Zone (20 to 50 feet bls)
Horizontal Hydraulic Conductivity (ft/day)	10	40
Vertical Hydraulic Conductivity (ft/day)	3.3	13.3
Hydraulic Gradient	0.005	0.005
Effective Porosity	0.30	0.30

NOTE: Shallow zone includes the cemented sand layer.

Table 2
Baseline Groundwater Chemistry Data within Source Area

In Situ Chemical Oxidation Treatment System
 Conceptual Design and Performance Specification
 Operable Unit 4
 NTC, Orlando, Florida

		Shallow Zone	Deep Zone
Volatile Organic Compounds (µg/L)			
Tetrachloroethene		6,000	1,500
Trichloroethene		1,400	2,600
1,2 Dichloroethene		700	1,100
Inorganics (µg/L)			
Aluminum		ND	73
Calcium		37,000	6,200
Iron		230	1,800
Magnesium		3,000	1,400
Manganese		12	23
Potassium		1,200	1,100
Sodium		4,700	12,000
Vanadium		15	ND
Water Quality Parameters			
Total Alkalinity	mg/L	8.2	2.7
Fe ²⁺	µg/L	300	1,200
Hardness	mg/L	130.3	47.0
TDS	mg/L	139	83
TOC	mg/L	6.8	7.0
pH		6.03	5.46

ND - not detected

Note: Values are an average of wells having detectable concentrations.

Source: Baseline data from pilot test conducted in February, 2000 (see HLA, 2001d).

Table 3
Target Treatment Levels for VOCs in Groundwater

In Situ Chemical Oxidation Treatment System
Conceptual Design and Performance Specification
Operable Unit 4
NTC, Orlando, Florida

COPC	Maximum Concentration ¹ (µg/L)	Expected Concentration ² (µg/L)	Target Concentration ³ (µg/L)
Tetrachloroethene	23,000	3,000	
Trichloroethene	8,700	900	
Total 1,2-Dichloroethene	2,000	400	
Total VOCs			80

COPC - Contaminant of Potential Concern

¹ Maximum concentrations are those detected in baseline groundwater sampling for the pilot test (see HLA, 2001d).

² Expected concentrations are those expected in the full-scale treatment system influent and are based on those observed in the pilot system influent (see HLA, 2001d). Note that influent PCE concentration was conservatively assumed as 5,000 mg/L for PCE oxidation kinetics calculations.

³ Target VOC concentration is the target in-situ level for the treatment system (see FS; HLA, 2001c). Biodegradation processes, such as natural attenuation or phytoremediation, will be used to attain groundwater MCLs once the treatment system has achieved the target treatment level.

APPENDIX A
VENDOR POINTS OF CONTACT

Carus Chemical Company
315 Fifth Street
Peru, IL 61354
815-223-1500 (P)
815-224-6697 (F)

Paul Hoffmann (Engineering), PHOFFMAN.POPeru.Peru@caruschem.com
Robert Myers (Sales), bob.myers@caruschem.com
Bill Reaska (Engineering), bill.reaska@caruschem.com
Russ Landsly (Engineering), russ.landsly@caruschem.com

Rotosonic Drilling Companies

Boart Longyear
P.O. Box 355
Little Falls, MN 56345
Mark Prueher
800-422-6552 (P)
320-632-2915 (F)

Prosonic Corporation (formerly Alliance Environmental and Gulf Atlantic Drilling, Inc.)
5785 Southwest 6th Place
Suite 101
Ocala, FL 34474
Tim Miller
800-476-3653 (P)
352-237-6551 (F)

Filtration System Vendors

ALAR Engineering Corporation
9651 W. 196th Street
Mokena, IL 60448
Andy Schamber
(813) 479-6100
rotary drum filters

Filters Water and Instrumentation (a distributor of Osmonics, Inc.)
Mike Tomicelli
603-434-9577 (P)
603-320-3226 (C)
pleated filters, microfiltration systems

ProChemTech
R.D. #2, Box 282
Brockway, PA 15824
Tim Kiester
814-265-0959 (P)
814-265-1263 (F)
microfiltration systems

World Water Works (a distributor of Pure Water Corporation)
Mark Fosshage
201-417-3417 (P)
disk filtration systems

APPENDIX B

RESULTS OF FLOW PATH MODELING USING VISUAL MODFLOW

CHEMICAL OXIDATION FLOW PATH MODELING USING VISUAL MODFLOW

In order to derive influent and effluent flow rates for the full-scale treatment system, groundwater modeling was conducted to determine flow rates for injection and recovery wells. Injection and recovery well flow rates were determined based on two criteria – the flow rates must adequately spread the flood front in both the shallow and deep hydrogeological zones and the travel time of the flood front must be reasonable (ideally, less than one year).

A conceptual model of the system was set up and was localized in the area of Building 1100. Two distinct hydrogeological layers were identified. Due to the high hydraulic conductivity of both the shallow and deep hydrogeological zones, flow rates from injection and recovery wells located in the localized model area did not have a significant effect on the groundwater contours on a larger scale. Thus, the assumption to constrain the boundaries within the area of Building 1100 was valid. Also, two distinct hydrogeological zones were defined based on field investigations and USGS modeling of groundwater at OU4.

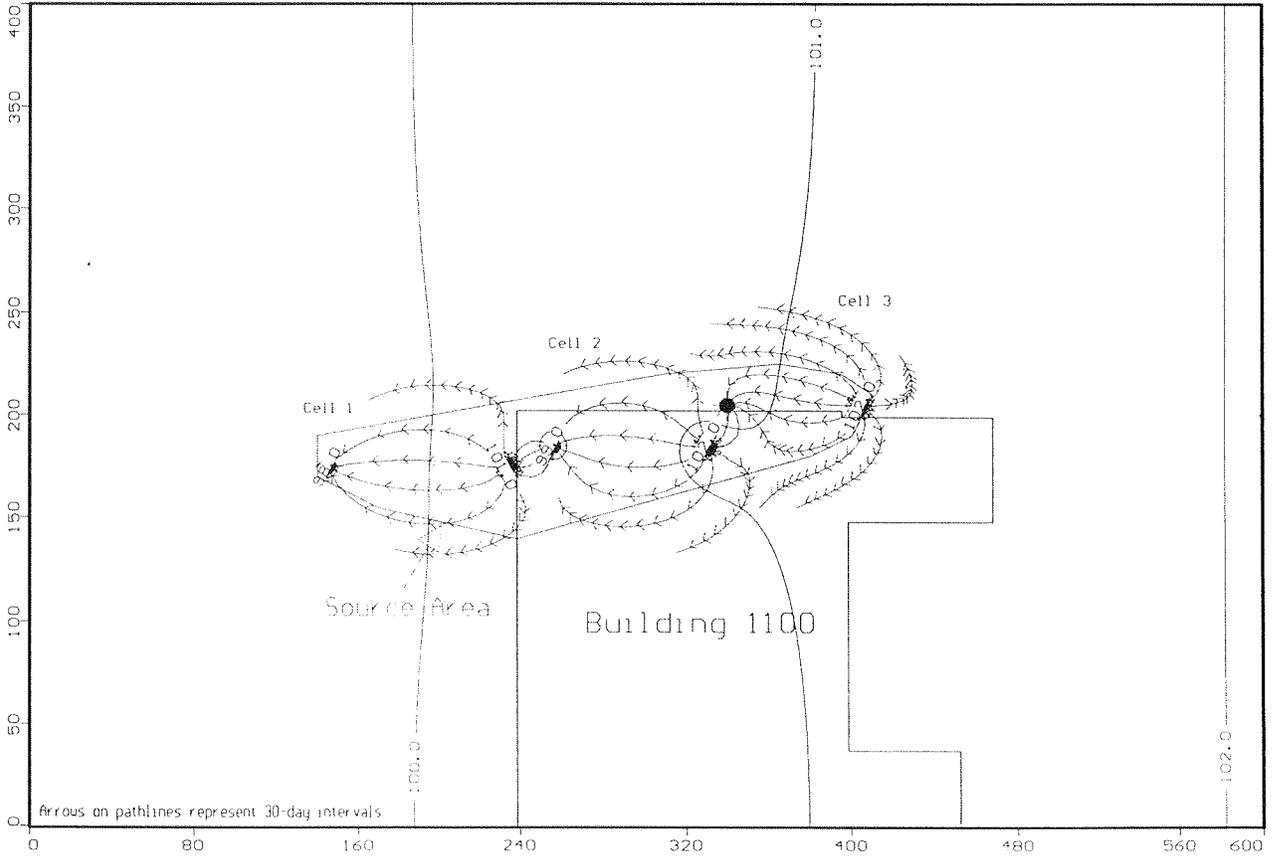
The model grid was rectangular – 600 feet in the X direction and 400 feet in the Y direction. The grid was divided vertically into twelve 5-foot layers resulting in a total depth of 60 feet. Constant head boundaries were placed along the east and west borders of the grid to impose a hydraulic gradient of 0.005 ft/ft. The north and south borders were assumed to be no-flow boundaries.

The shallow hydrogeological zone was assumed to encompass the upper 20 feet of the model grid and included the cemented sand layer and had a hydraulic conductivity of 10 ft/day. The deep layer was assumed to extend from 20 to 60 feet below ground surface (bgs) and had a hydraulic conductivity of 40 ft/day. Other hydrogeological properties are given in the following table.

Shallow injection and recovery wells were screened through the entire shallow layer. Deep injection and recovery wells were screened from 20 to 30 feet bgs. Well location and flow rates were determined based on the two criteria previously mentioned. Particle tracking was used in both the shallow and deep layers to determine flow paths and the position of the flood front at any time interval.

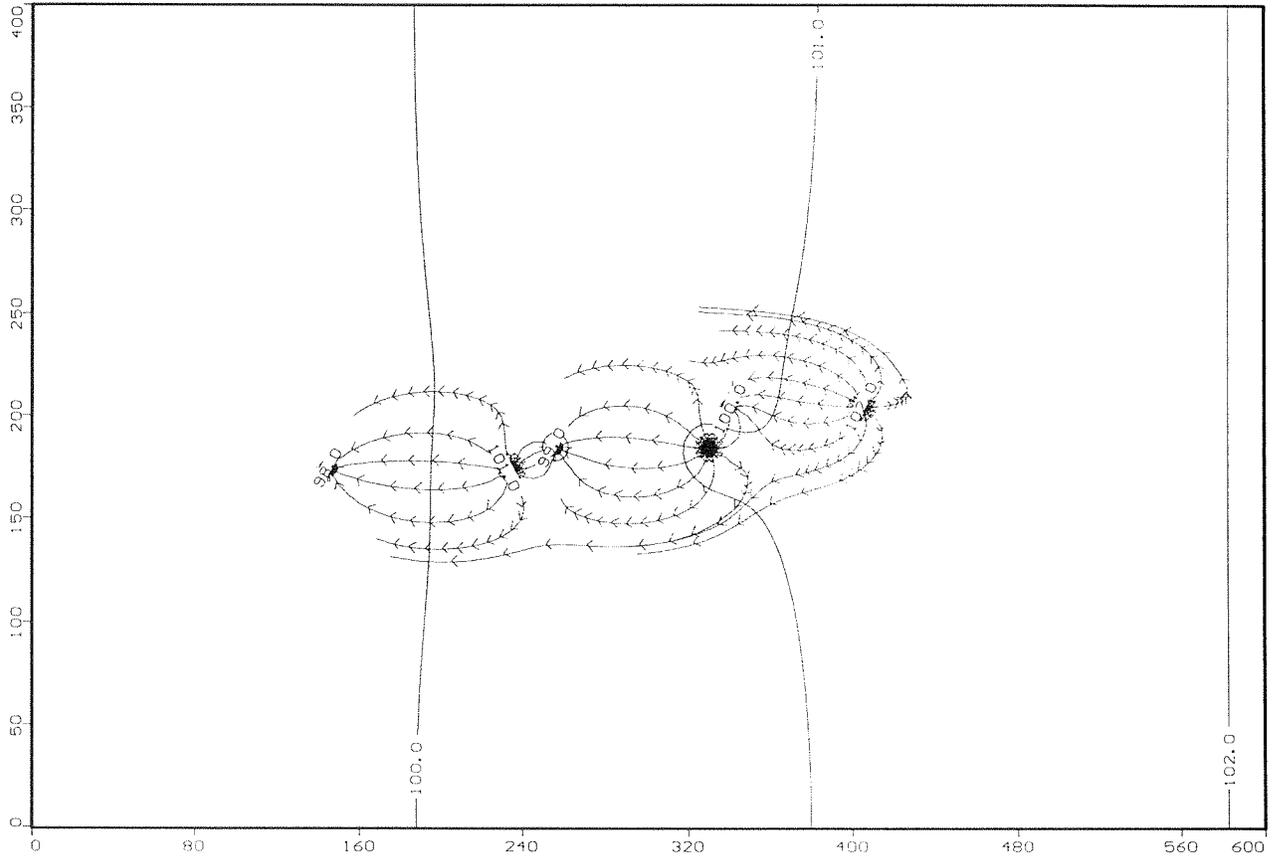
The model was calibrated using existing hydrogeological information and verified against modeling completed for the pilot test. The groundwater model for the full-scale system was able to accurately reproduce model results from the pilot test system (*n.b.* the full-scale model was not verified against pilot test data as injected flow was not distributed evenly across the injection well screens, which extended from the shallow layer to the deep layer). Model runs were conducted at steady state with an initial hydraulic gradient of 0.005 ft/ft. The attached figures show injected solution pathlines in the shallow and deep layers as well as vertical pathline profiles for each injection and extraction well cluster over a one-year period.

Hydrogeological Parameter	Shallow Zone (0 to 20 ft bgs, Layers 1-4)	Deep Zone (20 to 60 ft bgs, Layers 5-12)
Hydraulic Conductivity, K_x	10 ft/day	40 ft/day
Hydraulic Conductivity, K_y	10 ft/day	40 ft/day
Vertical Conductivity, K_z	3.3 ft/day	13.3 ft/day
Effective Porosity	0.30	0.30
Total Porosity	0.33	0.33
Specific Storage	0.0005 1/ft	0.0005 1/ft
Specific Yield	0.25	0.25



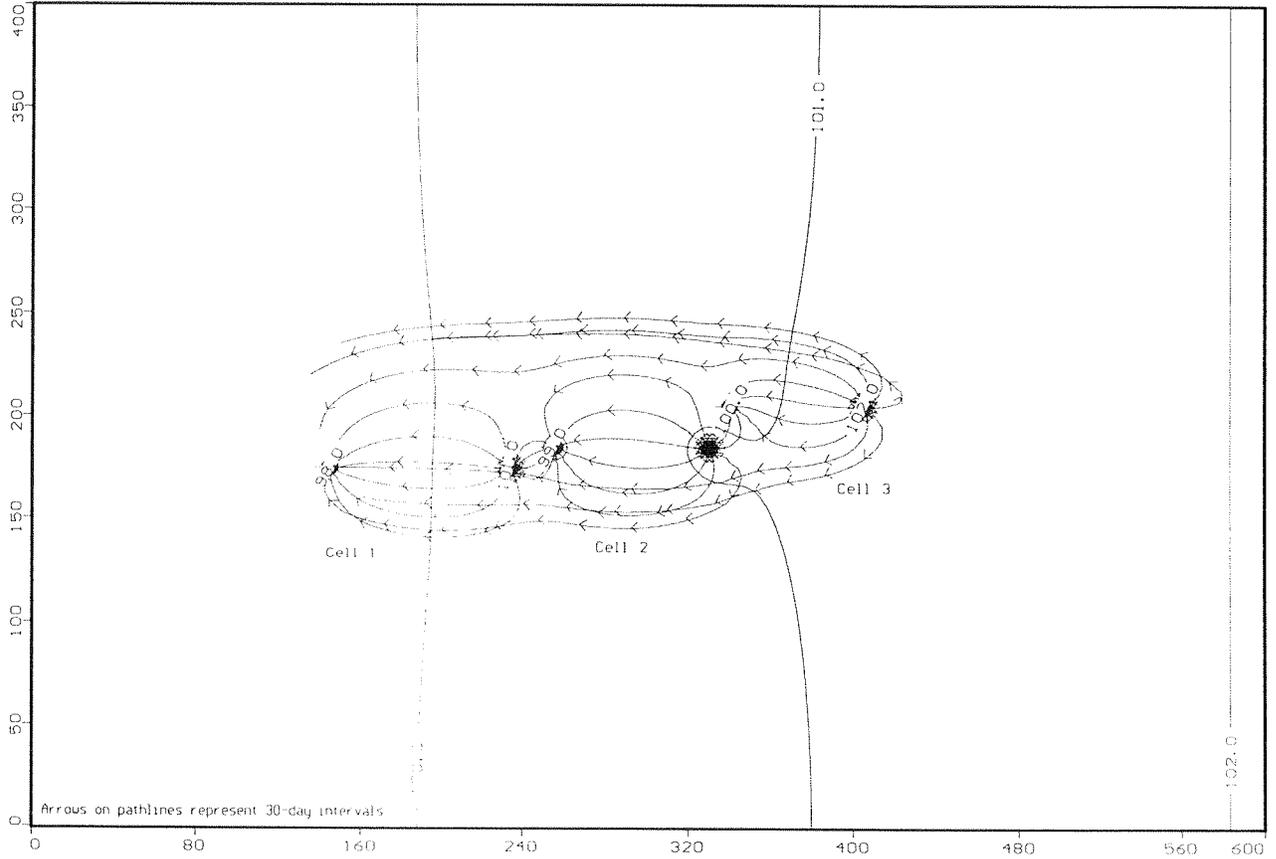
Harding ESE
 Project: NTC Orlando OU4
 Description: KMnO4 Injection Pathlines
 Modeller: Steven Giese
 18 Jan 01

Visual MODFLOW v.2.7.1, (C) 1995-1997
 Waterloo Hydrogeologic, Inc.
 NC: 92 NR: 48 NL: 12
 Current Layer: 1



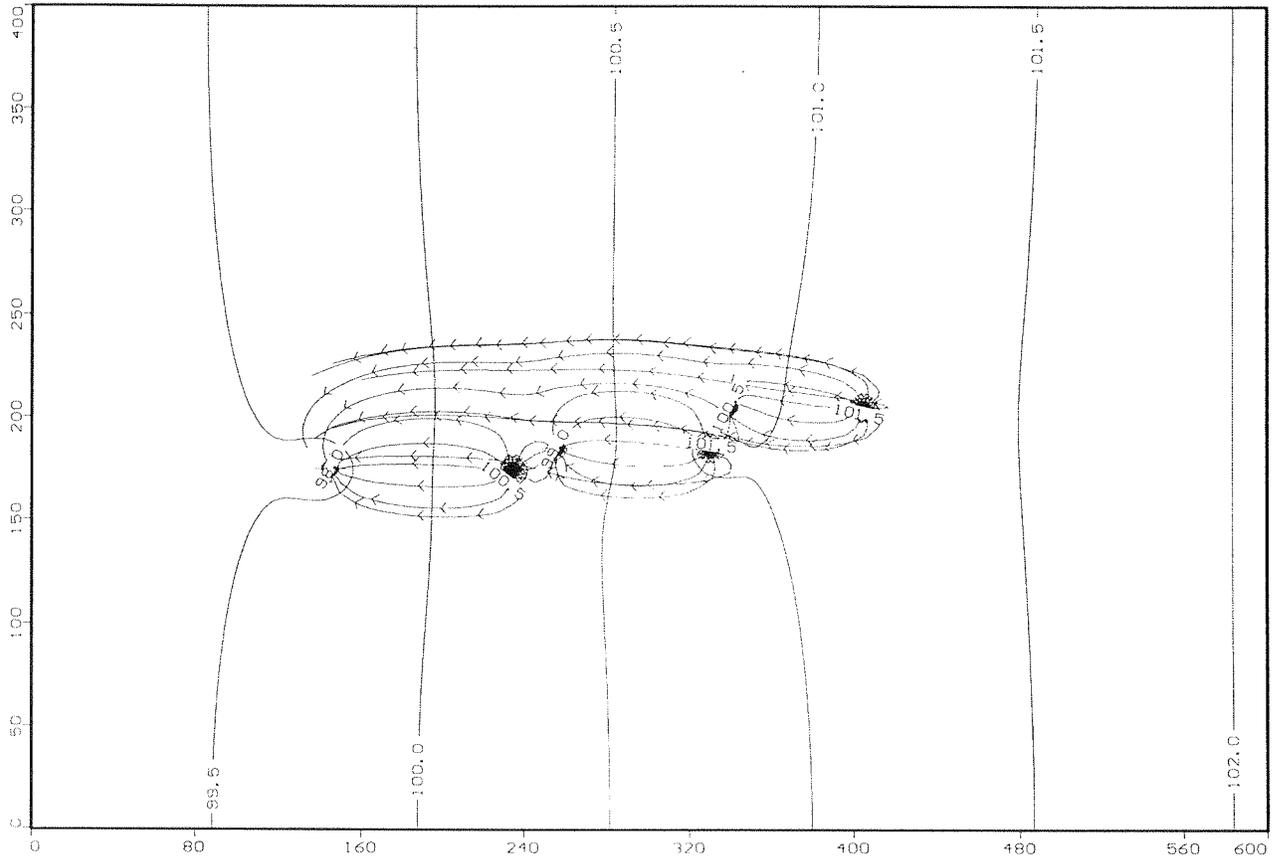
Harding ESE
Project: NTC Orlando OU4
Description: KMnO4 Injection Pathlines
Modeller: Steven Giese
18 Jan 01

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Waterloo Hydrogeologic, Inc.
NC: 92 NR: 48 NL: 12
Current Layer: 3



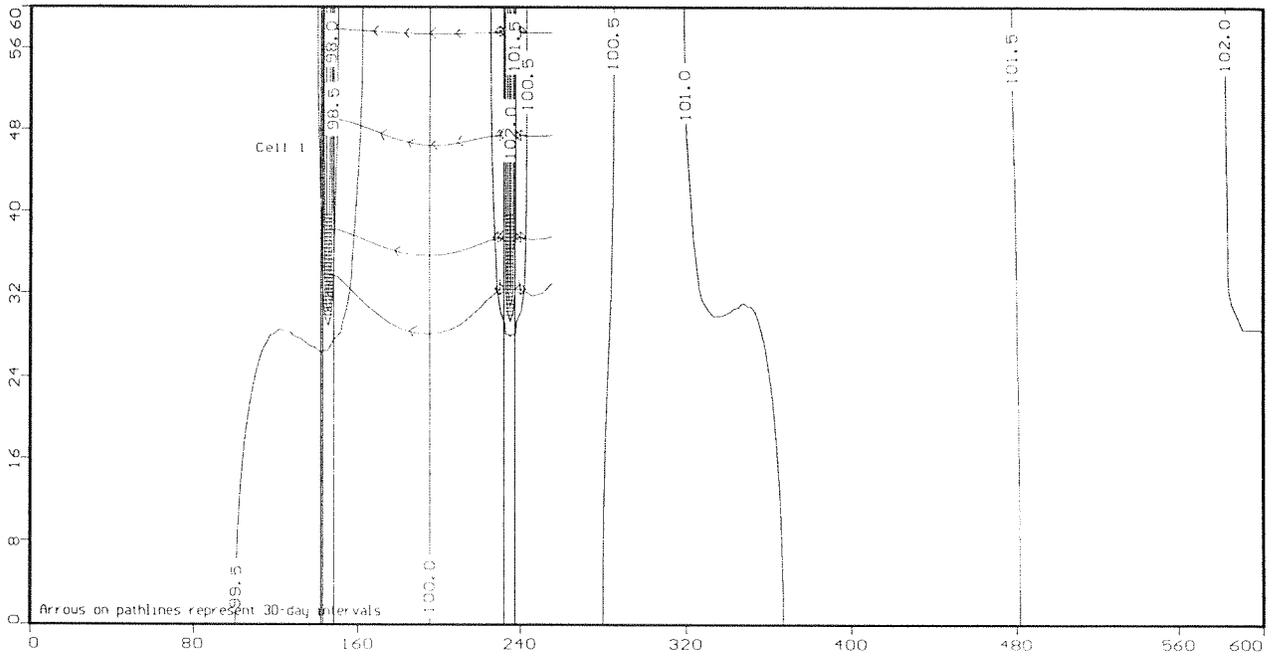
Harding ESE
 Project: NTC Orlando OU4
 Description: KMnO4 Injection Pathlines
 Modeller: Steven Giese
 18 Jan 01

Visual MODFLOW v.2.7.1, (C) 1995-1997
 Waterloo Hydrogeologic, Inc.
 NC: 92 NR: 48 NL: 12
 Current Layer: 5



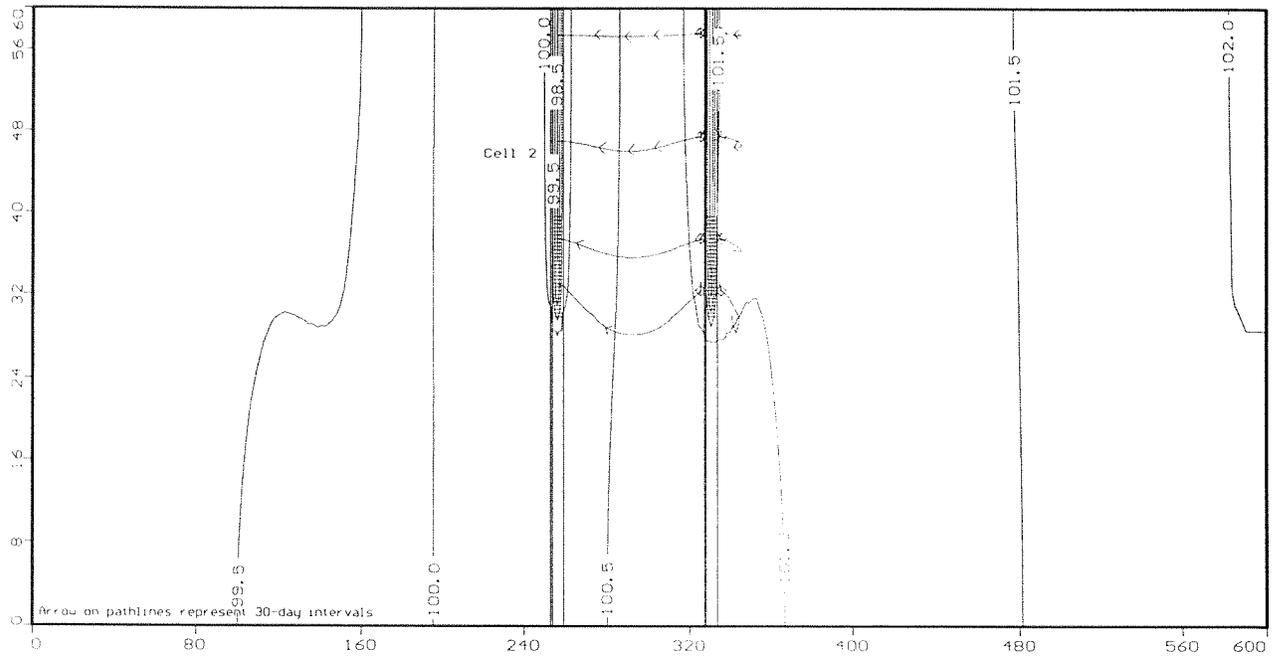
Harding ESE
 Project: NTC Orlando OU4
 Description: KMnO4 Injection Pathlines
 Modeller: Steven Giese
 18 Jan 01

Visual MODFLOW v.2.7.1, (C) 1995-1997
 Waterloo Hydrogeologic, Inc.
 NC: 92 NR: 48 NL: 12
 Current Layer: 6



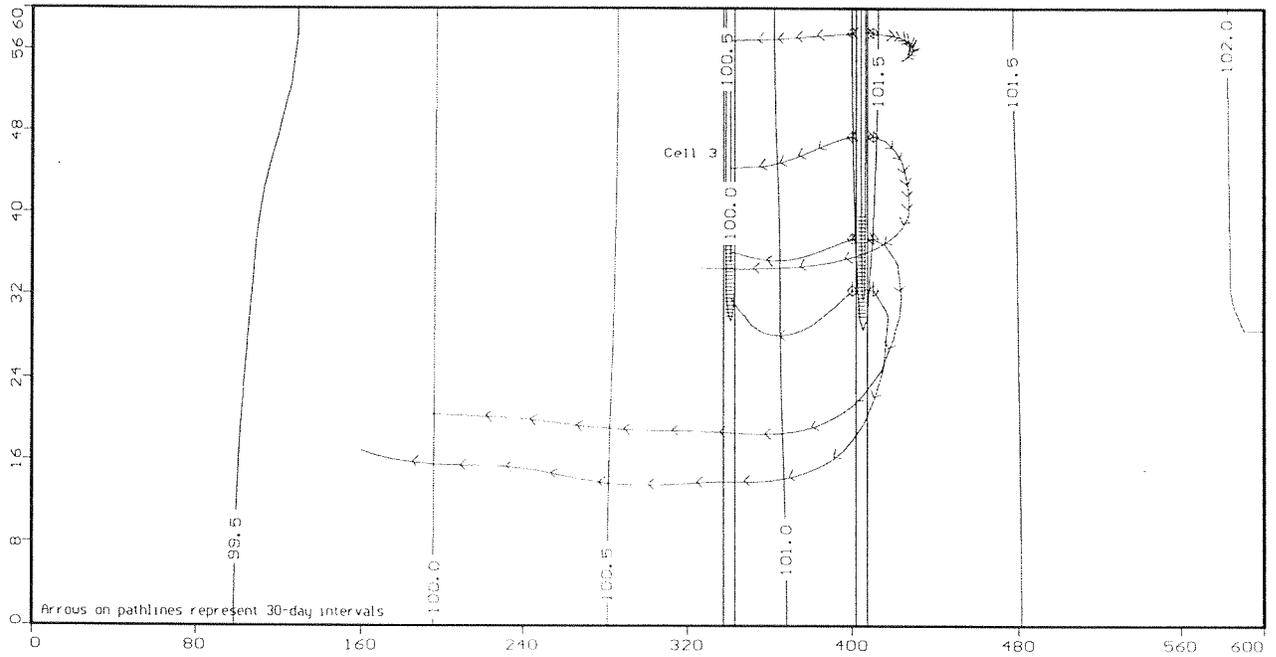
Harding ESE
 Project: NTC Orlando OU4
 Description: KMnO4 Injection Pathlines
 Modeller: Steven Giese
 18 Jan 01

Visual MODFLOW v.2.7.1, (C) 1995-1997
 Waterloo Hydrogeologic, Inc.
 NC: 92 NR: 48 NL: 12
 Current Row: 28



Harding ESE
 Project: NTC Orlando OU4
 Description: KMnO4 Injection Pathlines
 Modeller: Steven Giese
 18 Jan 01

Visual MODFLOW v.2.7.1, (C) 1995-1997
 Waterloo Hydrogeologic, Inc.
 NC: 92 NR: 48 NL: 12
 Current Row: 25



Harding ESE
 Project: NTC Orlando OU4
 Description: KMnO4 Injection Pathlines
 Modeller: Steven Giese
 18 Jan 01

Visual MODFLOW v.2.7.1, (C) 1995-1997
 Waterloo Hydrogeologic, Inc.
 NC: 92 NR: 48 NL: 12
 Current Row: 20

APPENDIX C
PCE OXIDATION CALCULATIONS



OBJECTIVE: Calculate the number of tanks required to meet the treatment system effluent requirement for PCE (3 ug/L).

ASSUME : • Treatment system influent is 5000 ug/L

based upon pilot test operation, this is a good assumption.

• Total flow to treatment system is 15 gpm.

based upon Visual Modflow results.

• Tanks hold 1500 gallons

based upon use during pilot test.

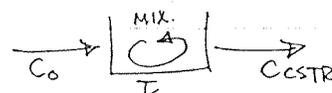
• Reaction rate constants are as given in the included figures, and are based on Carus laboratory testing data, which is also included.

• First tank can be represented as a CSTR, since water is pumped from it, dosed with $KMnO_4$, then pumped back in the first tank, creating a mixing effect. This effect is assumed to be similar to mixing with an agitator.

• Tanks are in series.

CALC'S : residence time, $\tau = 1500 \text{ gal.} / 15 \text{ gpm} = 1.67 \text{ hr.}$

for the first tank (CSTR), $\frac{C_{CSTR}}{C_0} = \frac{1}{1+k\tau}$



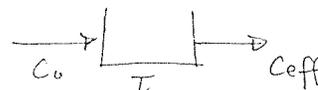
Assume $C_0 = 5000 \text{ ug/L}$, $\tau = 1.67 \text{ hr}$, $k = 0.91/\text{hr}$ ($KMnO_4$ dose of 1 g/L)

then: $\frac{C_{CSTR}}{C_0} = \frac{1}{1+k\tau}$

$$C_{CSTR} = \frac{C_0}{(1+k\tau)} = \frac{5000}{[1+(0.91)(1.67)]} = 1987 \text{ ug/L. } \checkmark$$

The rest of the tanks are unstirred, or plug-flow.

for PFRs, $\frac{C_{eff}}{C_0} = e^{-k\tau}$



for n PFRs in series, $\frac{C_{eff}}{C_0} = (e^{-k\tau})^n$

The objective is to achieve $C_{eff} \leq 3 \text{ ug/L}$.



Assume $C_0 = C_{CSTR} = 1987 \text{ } \mu\text{g/L}$, $\tau = 1.67 \text{ hr}$, $k = 0.91/\text{hr}$, $C_{eff} = 3 \text{ } \mu\text{g/L}$.
then the number of tanks (PFRs) required to achieve $3 \text{ } \mu\text{g/L}$ is:

$$\frac{C_{eff}}{C_{CSTR}} = (e^{-k\tau})^n$$

$$\frac{3}{1987} = (e^{-(0.91)(1.67)})^n$$

$$\ln\left(\frac{3}{1987}\right) = -(0.91)(1.67)n$$

$$n = 4.27 \sim 5 \text{ PFRs required to achieve } 3 \text{ } \mu\text{g/L}$$

(6 tanks total, including CSTR) ✓

This is too many tanks. Try a higher KMnO_4 dose of 1.5 g/L , thus $k = 1.365/\text{hr}$. (see "PCE KMnO_4 Oxidation Kinetics" figure)

Assume $C_0 = 5000 \text{ } \mu\text{g/L}$, $\tau = 1.67 \text{ hr}$, $k = 1.365/\text{hr}$

then for CSTR: $C_{CSTR} = \frac{C_0}{1+k\tau}$

$$C_{CSTR} = \frac{5000}{[1 + (1.365)(1.67)]} = 1527 \text{ } \mu\text{g/L}$$

for PFRs: $\frac{C_{eff}}{C_{CSTR}} = (e^{-k\tau})^n$

$$\frac{3}{1527} = (e^{-(1.365)(1.67)})^n$$

$$\ln\left(\frac{3}{1527}\right) = -(1.365)(1.67)n$$

$$n = 2.74 \sim 3 \text{ PFRs required (4 total, incl CSTR)} \checkmark$$

This number is more reasonable. Note that C_0 will decrease with time and system flow will decrease as well since deeper zone will be treated more quickly than the shallow zone (because hydraulic conductivity is 4X greater), thus KMnO_4 dose will be decreased accordingly.



Harding Lawson Associates
Engineering
and
Environmental Services

PROJECT NTC ORLANDO OUY
SUBJECT REACTOR KINETICS

SHEET 3 OF 3
JOB NO. 44241/0254550
DATE DEC 1, 2000
COMPUTED BY SWG.
CHECKED BY WAM

Therefore, the PCE effluent concentration with 1 CSTR, 3 PFRs is:

$$\frac{C_{eff}}{C_{CSTR}} = (e^{-k\tau})^n$$

$$C_{eff} = C_{CSTR} (e^{-k\tau})^n$$

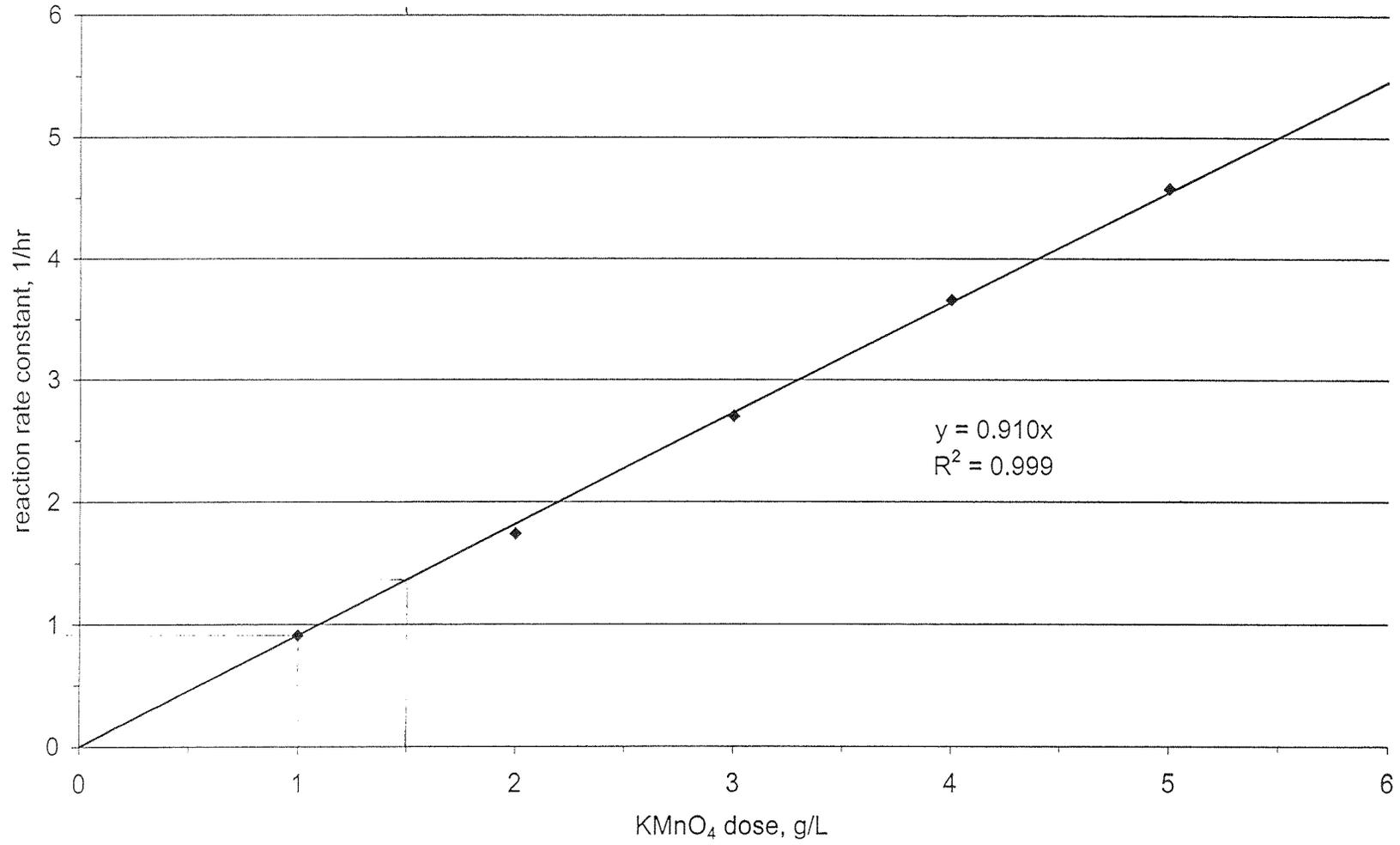
$$C_{eff} = (1527)(e^{-(1.365)(1.67)})^3$$

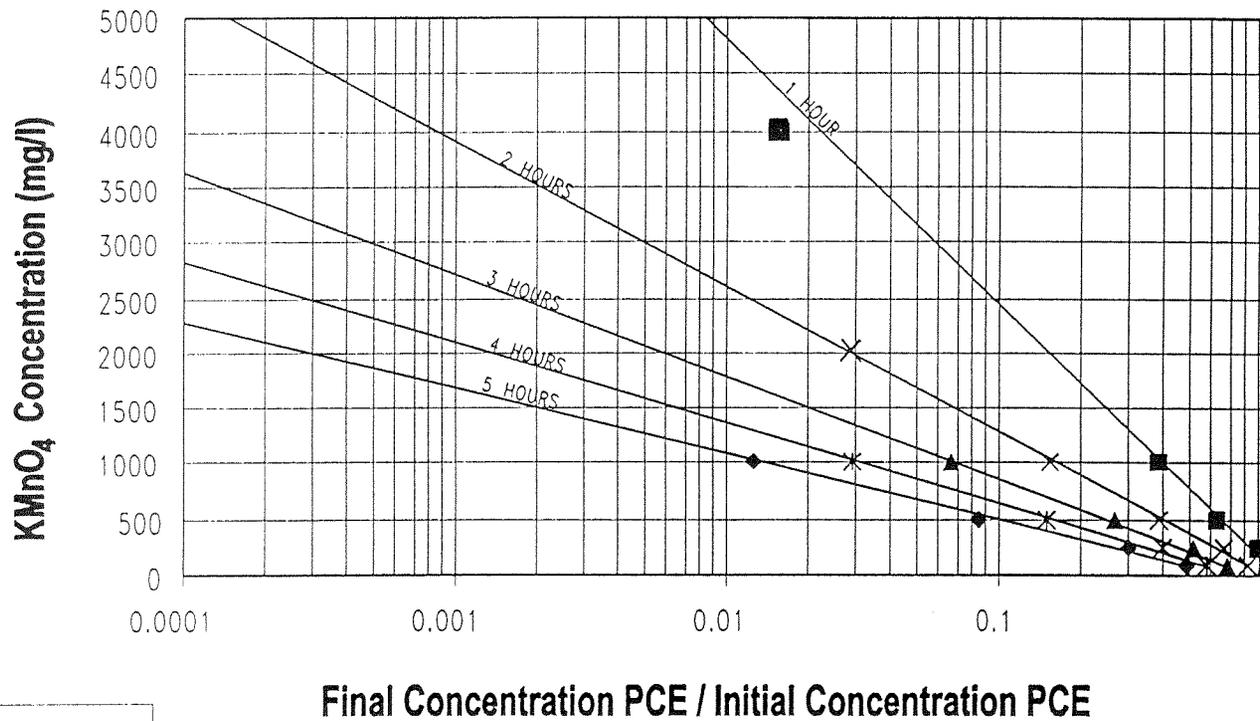
$$C_{eff} = 1.66 \mu\text{g/L}$$

The objective of $\leq 3 \mu\text{g/L}$ of PCE in the effluent will be met with 1 CSTR, 3 PFRs at a KMnO_4 dose of 1.5 g/L.

X
WAM

PCE KMnO_4 Oxidation Kinetics





LEGEND

- ◆ 5 Hours
 - ✱ 4 Hours
 - ▲ 3 Hours
 - ✕ 2 Hours
 - 1 Hour
- mg/l Milligrams per liter
 KMnO₄ Potassium permanganate
 PCE Tetrachloroethene

**FIGURE 2-1
 PCE OXIDATION RATES**



**TREATABILITY STUDY WORK PLAN NO. 3
 DATA COLLECTION PLAN FOR ASSESSING
 IN SITU CHEMICAL OXIDATION USING
 POTASSIUM PERMANGANATE, OPERABLE UNIT 4
 NAVAL TRAINING CENTER
 ORLANDO, FLORIDA**



PROJECT NTC Orlando OUA
SUBJECT CSTR Reactions

Objective: Look at $KMnO_4$ / PCE reaction rates and calculate CSTR performance.

Calculate Reaction Rate Constants

Literature indicates reaction is First Order:

$$-\ln \frac{C_A}{C_{A0}} = k\tau$$

For 1000 mg/L $KMnO_4$ (Data from bench-scale tests)

$T = 1 \text{ hr}$; $-\ln \frac{C_A}{C_{A0}} = -\ln \left(\frac{1.225}{3.170} \right) = 0.951$

$$0.951 = k(1 \text{ hr})$$

$$k = 0.951 \text{ hr}^{-1}$$

$T = 2 \text{ hr}$ (Data From App. B)

$$\left(\ln \frac{0.886}{3.147} \right) = 1.868$$

$$1.868 = k(2 \text{ hr})$$

$$k = 0.934 \text{ hr}^{-1}$$

$T = 3 \text{ hr}$ (Data From Fig 2-1)

$$-\ln(0.067) = 2.70$$

$$2.70 = 3k$$

$$k = 0.90 \text{ hr}^{-1}$$

$T = 4 \text{ hr}$ (Data From Fig 2-1)

$$-\ln(0.029) = 4k$$

$$k = 0.89 \text{ hr}^{-1}$$

$T = 5$ (Data From App. B)

$$-\ln(0.0127) = 5k$$

$$k = 0.873 \text{ hr}^{-1}$$

Ave = 0.91



Harding Lawson Associates
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and
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SHEET 2 OF 5

JOB NO. 44241/0254550

DATE December 8, 1999

COMPUTED BY WJM

CHECKED BY WJM

PROJECT UTC Orinda O&A

SUBJECT CSTR Reactions

For 2000 mg/l (Pull data off Figure 2-1)

$$T = 1 \text{ hr}; \quad \frac{C_A}{C_0} = 0.161$$

$$-\ln(0.161) = k$$

$$k = 1.83$$

$$T = 2 \text{ hr}$$

$$-\ln 0.029 = 2k$$

$$k = 1.77$$

$$T = 5 \text{ hr}$$

$$-\ln(0.0003) = 5k$$

$$k = 1.62$$

Ave = 1.74

For 3000 mg/l (Pull Data off Fig 2-1)

$$T = 1 \text{ hr}$$

$$-\ln(0.052) = k$$

$$k = 2.85$$

$$T = 3 \text{ hr}$$

$$-\ln(0.00048) = 3k$$

$$k = 2.55$$

Ave = 2.70

For 4000 mg/l (Pull Data off Fig 2-1)

$$T = 1 \text{ hr}$$

$$-\ln(0.0225) = k$$

$$k = 3.79$$

$$T = 2 \text{ hr}$$

$$-\ln(0.00087) = 2k$$

$$k = 3.53$$

k = 3.66



PROJECT NTC Orlando OU4
SUBJECT CSTR Reactions

For 5000 mg/l (Pull Data off Fig 2-1)

$T = 1 \text{ hr}$

$\ln(0.0085) = -kt$

$k = 4.77$

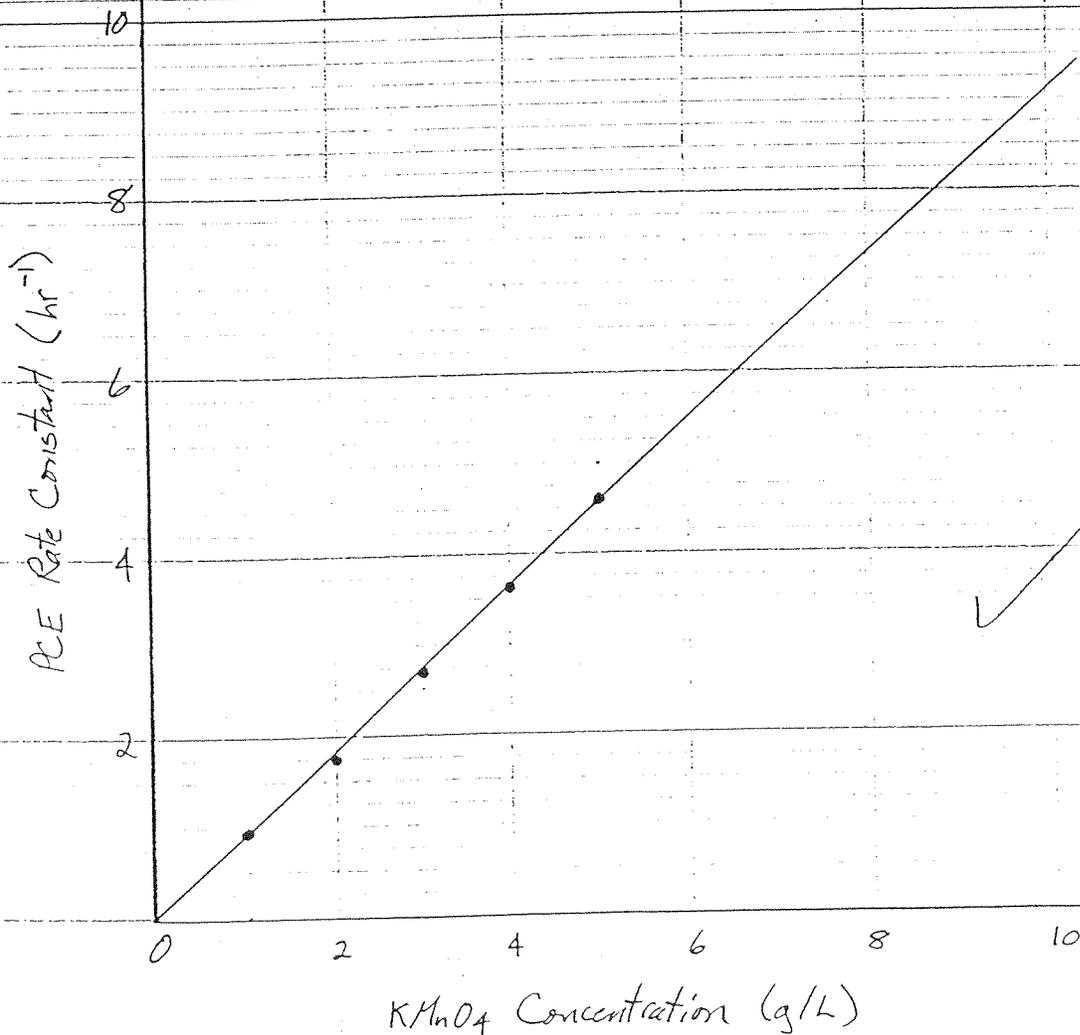
$T = 2 \text{ hr}$

$-\ln(0.0015) = 2k$

$k = 4.39$

Ave = 4.58

(PCE 10^{-3}) Rate Constant



APPENDIX D
PERMITTING

EXCAVATION PERMIT

PUBLIC WORKS DEPARTMENT
NAVAL TRAINING STATION, ORLANDO

REQUESTOR	ACTIVITY AND PHONE NO.
REASON FOR EXCAVATION	LOCATION
	DIMENSIONS OF EXCAVATION
PROPOSED EXCAVATION DATE	METHOD OF EXCAVATION

SKETCH OF EXCAVATION SITE

DEPARTMENT	SIGNATURE	YES
PWD ENGINEERING DIVISION		<input type="checkbox"/>
PWD ELECTRICAL TRADES BRANCH		<input type="checkbox"/>
PWD METAL TRADES BRANCH		<input type="checkbox"/>
PWD TELEPHONE BRANCH		<input type="checkbox"/>
PWD IRRIGATION CONTRACTOR		<input type="checkbox"/>

APPROVING OFFICIALS' COMMENTS:

DIRECTOR, MAINTENANCE / UTILITIES DIVISION

APPROVED

DISSAPPROVED

DATE

BEFORE THE STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

In re: Harding Lawson Associates
Petition for Variance

OGC File No. 99-0943

FINAL ORDER GRANTING PETITION FOR
VARIANCE FROM RULE 62-522.300(2)(a)

On June 8, 1999, Harding Lawson Associates (HLA), filed a petition for variance from requirements in rule 62-522.300(2)(a) of the Florida Administrative Code, under section 120.542 of the Florida Statutes and rule 28-104.002 of the Florida Administrative Code. The petition was for a variance from rule 62-522.300(2)(a), which prohibits a zone of discharge for discharges through wells, in order to use a product for in-situ remediation of sites contaminated with certain compounds susceptible to oxidation by potassium permanganate. This process involves the use of wells or borings which is considered installation of one or more temporary Class V underground injection control wells at the site of contamination. A notice of receipt of the petition was published in the Florida Administrative Weekly on July 9, 1999.

1. Petitioner is located at 1080 Woodcock Road, Suite 100, Orlando, Florida 32803.

2. HLA wants to perform in-situ chemical oxidation using potassium permanganate at sites with contaminated soils and ground water.

3. Under rule 62-520.420 of the Florida Administrative Code, the standards for Class G-II ground waters include the primary and secondary drinking water standards of rules 62-550.310 and 62-550.320 of the Florida Administrative Code.

4. Concentrations of potassium permanganate at 7.6 grams per liter (Free Flow grade) or 11.6 grams per liter (Pharmaceutical Grade) will be injected through wells or borings into soil and ground water. When the potassium permanganate solution contacts the contaminant molecules, the molecular bonds are broken (oxidized). The by-products of this reaction are potassium, carbon dioxide, chloride ions, and manganese dioxide. Laboratory and field tests of in-situ chemical oxidation with potassium permanganate have demonstrated the compound's effectiveness for reducing contaminant concentrations.

5. When potassium permanganate is added to the ground water, the secondary drinking water standard for color (15 color units) may temporarily be exceeded. It is also possible that the secondary drinking water standards for total dissolved solids (500 mg/L), aluminum (0.2 mg/L), manganese (0.05 mg/L), silver (0.1 mg/L), and chloride (250 mg/L) could be temporarily exceeded. None of these parameters will be exceeded beyond a 100-foot radius from each point of injection, and any exceedance will not occur for more than 365 days.

6. The injection of this product through temporary wells or borings is considered a type of underground injection control well, Class V, Group 4, "injection wells associated with an aquifer remediation project," as described in rule 62-

528.300(1)(e)4 of the Florida Administrative Code. Under rule 62-528.630(2)(c), "Class V wells associated with aquifer remediation projects shall be authorized under the provisions of a remedial action plan . . . provided the construction, operation, and monitoring of this Chapter are met."

7. Rule 62-522.300(2)(a) from which this petition seeks a variance, prohibits the Department from granting a zone of discharge for a discharge through an injection well to Class G-II ground water. Strict adherence to this rule would preclude the Department from granting approval for the use of the in-situ chemical oxidation with potassium permanganate for remediation of contaminated ground water.

8. The applicable rules state in pertinent part:

62-522.300(1) . . . [N]o installation shall directly or indirectly discharge into any ground water any contaminant that causes a violation in the ground water quality standards and criteria for the receiving ground water as established in Chapter 62-520, F.A.C., except within a zone of discharge established by permit or rule pursuant to this chapter.

62-522.300(2) No zone of discharge shall be allowed under any of the following circumstances:

(a) Discharges through wells or sinkholes that allow direct contact with Class G-I and Class G-II ground water

9. HLA has stated in its petition that to apply the zone of discharge prohibition to its use of this remediation process at contaminated sites would create a substantial hardship. The petition also states that other methods of remediation not using chemical oxidation are not as effective, are more costly, and take longer. Remediation would improve the water quality, and to

prohibit any exceedance of the specified drinking water standards in such a small area of already contaminated ground water and for such short duration would cause a substantial hardship. This small and temporary exceedance is not the usual occurrence, nor are most dischargers involved in the remediation of contaminated ground water. By allowing the use of the in-situ potassium permanganate, the clean up of the contaminated ground water and soils will be accelerated and returned to a usable condition. In addition, the use of the in-situ potassium permanganate has been tentatively approved by the Department's Division of Waste Management as being a sound environmental solution to the contamination, so long as HLA is able to obtain a variance.

10. Zones of discharge for the use of the in-situ potassium permanganate are necessary because of the temporary (not to exceed 365 days) exceedance of the color, total dissolved solids, aluminum, manganese, silver, and chloride standards in the ground water immediately surrounding the injection. Because this ground water is already contaminated and does not meet all applicable standards, allowing a zone of discharge as part of a ground water cleanup for remediation of organic contaminants meets the purpose of the underlying statute, which is to improve the quality of the waters of the state for beneficial uses. Such contaminated ground water is not presently used for drinking purposes, nor is it ever reasonably expected to be so used, thus posing no threat to human health.

11. The Department received no comments about the petition for variance.

12. For the foregoing reasons, HLA has demonstrated that it is entitled to a variance from the prohibition of zones of discharge in rule 62-522.300(2)(a) for its remedial product, with the conditions below.

a. Use of the in-situ potassium permanganate at contaminated sites must be through a Department-approved remediation plan, or other Department-enforceable document.

b. The discharge to the ground water must be through a Class V, Group 4 underground injection control well which meets all of the applicable construction, operating, and monitoring requirements of chapter 62-528 of the Florida Administrative Code.

c. The extent of the zone of discharge for color, total dissolved solids, manganese, aluminum, silver, and chloride shall be a 100-foot radius from the point of injection and the duration of the zone of discharge shall be 365 days from the time of injection. This will allow ample time for the temporarily exceeded parameters to return to their secondary drinking water standards set forth in chapter 62-550 of the Florida Administrative Code, or their naturally occurring background levels at the site, whichever is less stringent.

d. The injection of the product shall be at such a rate and volume that no undesirable migration occurs of either the product, its by-products, or the contaminants already present in the aquifer.

e. The Department-approved remediation plan shall address appropriate ground water monitoring requirements associated with

the use of the in-situ potassium permanganate for remediation based on site-specific hydrogeology and conditions. These shall include the sampling of ground water at monitoring wells located outside the contamination plume, before use of the in-situ potassium permanganate, to determine the naturally occurring background levels of color, total dissolved solids, manganese, aluminum, silver, and chloride which are the parameters pertinent to this variance, as well as pH to be sure that it is not exceeded. They should also include monitoring of these parameters in ground water downgradient from the injection points for at least one year after active remediation.

This order will become final unless a timely petition for an administrative hearing is filed under sections 120.569 and 120.57 of the Florida Statutes before the deadline for a filing a petition. The procedures for petitioning for a hearing are set forth below.

A person whose substantial interests are affected by the Department's action may file for an administrative proceeding (hearing) under sections 120.569 and 120.57 of the Florida Statutes. The petition must contain the information set forth below and must be filed (received) in the Office of General Counsel of the Department at 3900 Commonwealth Boulevard, Mail Station 35, Tallahassee, Florida 32399-3000.

Petitions filed by HLA or any of the parties listed below must be filed within 21 days of receipt of this written notice. Petitions filed by any other persons other than those entitled to written notice under section 120.60(3) of the Florida Statutes

must be filed within 21 days of publication of the public notice receipt of the written notice, whichever occurs first. Under section 120.60(3), however, any person who asked the Department for notice of agency action may file a petition within 21 days of receipt of such notice, regardless of the date of publication. The petitioner shall mail a copy of the petition to Harding Lawson Associates, 1080 Woodcock Road, Suite 100, Orlando, Florida 32803 at the time of filing. The failure of any person to file a petition within the appropriate time period shall constitute a waiver of that person's right to request an administrative determination (hearing) under sections 120.569 and 120.57 of the Florida Statutes, or to intervene in this proceeding and participate as a party to it. Any subsequent intervention (in a proceeding initiated by another party) will be only at the discretion of the presiding officer upon the filing of a motion in compliance with rule 28-106.205 of the Florida Administrative Code.

A petition that disputes the material facts on which the Department's action is based must contain the following information:

(a) The name, address, and telephone number of each petitioner; the Department case identification number and the county in which the subject matter or activity is located;

(b) A statement of how and when each petitioner received notice of the Department action;

(c) A statement of how each petitioner's substantial interests are affected by the Department action;

(d) A statement of the material facts disputed by the petitioner, if any;

(e) A statement of facts that the petitioner contends warrant reversal or modification of the Department action;

(f) A statement of which rules or statutes the petitioner contends require reversal or modification of the Department action; and

(g) A statement of the relief sought by the petitioner, stating precisely the action that the petitioner wants the Department to take.

A petition that does not dispute the material facts on which the Department's action is based shall state that no such facts are in dispute and otherwise shall contain the same information as set forth above, as required by rule 28-106.301.

Because the administrative hearing process is designed to formulate final agency action, the filing of a petition means that the Department's final action may be different from the position taken by it in this notice. Persons whose substantial interests will be affected by any such final decision of the Department have the right to petition to become a party to the proceeding, in accordance with the requirements set forth above.

Mediation under section 120.573 of the Florida Statutes is not available for this proceeding.

This action is final and effective on the date filed with the Clerk of the Department unless a petition is filed in accordance with the above.

Any party to this order has the right to seek judicial review of it under section 120.68 of the Florida Statutes, by filing a notice of appeal under rule 9.110 of the Florida Rules of Appellate Procedure with the clerk of the Department in the Office of General Counsel, Mail Station 35, 3900 Commonwealth Boulevard, Tallahassee, Florida 32399-3000, and by filing a copy of the notice of appeal accompanied by the applicable filing fees with the appropriate district court of appeal. The notice must be filed within thirty days after this order is filed with the clerk of the Department.

DONE AND ORDERED this 3 day of September 1999 in Tallahassee, Florida.

Mimi Drew

Mimi A. Drew
Director,
Division of Water Resource
Management

2600 Blair Stone Road
Mail Station 3500
Tallahassee, Florida 32399-2400
Telephone: (850) 487-1855

FILING AND ACKNOWLEDGMENT FILED, on this date, pursuant to s. 120.52, Florida Statutes, with the designated Department Clerk, receipt of which is hereby acknowledged.

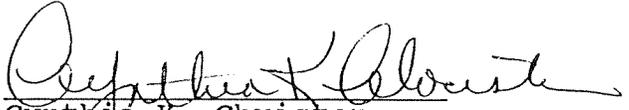
Shirley Shields
Clerk

Sept 3, 1999
Date

Copies furnished to:
George Heuler, UIC Section Rick Ruscito, Petroleum Cleanup
Bill Neimes, Bur. Waste Cleanup Cynthia Christen, OGC
Brent Hartsfield, Bur. Waste Cleanup

CERTIFICATE OF SERVICE

I certify that a copy of the foregoing Final Order has been furnished to Mark J. Salvetti, P.E., by facsimile at 781/246-5060, and by U.S. Mail at Harding Lawson Associates, 107 Audubon Road, Suite 25, Wakefield, MA 01880, on this 3rd day of September 1999.


Cynthia K. Christen
Sr. Assistant General Counsel

Department of
Environmental Protection
3900 Commonwealth Blvd.
MS 35
Tallahassee, FL 32399-3000
Telephone 850/921-9610

Harding Lawson Associates



June 7, 1999

02545.027

Kathy Carter, Agency Clerk
Florida Department of Environmental Protection
Office of General Counsel
Mail Station 35
3900 Commonwealth Blvd.
Tallahassee, FL 32399-3000

Subject: Petition for Variance

Dear Ms. Carter:

Enclosed you will find a petition for Variance from Rule 52-522.300(2)(a), Florida Administrative Code. Harding Lawson Associates requests this variance for the use of In-Situ Chemical Oxidation with Potassium Permanganate in an aquifer remediation design document. By granting this petition, many remediation projects throughout Florida will benefit through the use of this promising technology.

Please feel free to contact me at (781)245-6606 should you have any questions regarding this technology or this petition.

Sincerely,

Harding Lawson Associates

A handwritten signature in cursive script that reads "Mark J. Salvetti".

Mark J. Salvetti, P.E.
Project Manager

cc: D. Grabka, Waste Cleanup
 W. Neimes, Waste Cleanup
 G. Brown, Waste Cleanup

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BEFORE THE STATE OF FLORIDA
DEPARTMENT OF ENVIRONMENTAL PROTECTION

IN RE: HARDING LAWSON ASSOCIATES
PETITION FOR VARIANCE

PETITION FOR VARIANCE
FROM RULE 62-522.300(2)(a), FLORIDA ADMINISTRATIVE CODE

Petitioner, Harding Lawson Associates, pursuant to Section 120.542, Florida Statutes, and Rule 28-104, Florida Administrative Code, hereby petitions for a variance from Rule 62-522.300(2)(a), Florida Administrative Code, because the strict application of this rule will create a substantial hardship and will violate principles of fairness. In support thereof Petitioner states:

Background Facts

1. Petitioner is Harding Lawson Associates, (HLA) located at 1080 Woodcock Road, Suite 100, Orlando, Florida 32803, telephone (407) 895-8845, facsimile (407) 896-6150.
2. Research conducted by the University of Waterloo, Canada, and Oak Ridge National Laboratory, has led to the finding that In-Situ Chemical Oxidation using Potassium Permanganate can be an effective remediation technology at sites contaminated with compounds susceptible to oxidation by Potassium Permanganate, including chlorinated solvents. When the Potassium Permanganate solution contacts the contaminant molecules, the molecular bonds are broken (i.e., the contaminant is oxidized). The by-products of this reaction are potassium, carbon dioxide, manganese dioxide, and chloride ions.
3. Laboratory and field tests of In-Situ Chemical Oxidation with Potassium Permanganate have demonstrated remarkable success in quickly reducing contaminant concentrations.
4. When Potassium Permanganate is added to groundwater, the secondary groundwater standard for color may be temporarily exceeded. It is also possible that the secondary standards for Total Dissolved Solids, aluminum, manganese, silver, and perhaps chloride (when high concentrations of chlorinated compounds are oxidized) could be temporarily exceeded. Injection of Potassium Permanganate violates no primary groundwater standards.

The Rule

5. Rule 62-522.300(1) provides that:
No installation shall directly or indirectly discharge into groundwater any contaminant that causes a violation in the water quality standards and criteria for the receiving groundwater as established in Chapter 62-520 except within a zone of discharge established by permit or rule pursuant to this chapter.
6. Furthermore, Rule 62-522.300(2)(a) provides that:
(2) No zone of discharge shall be allowed under any of the following circumstances:

(a) Discharges through wells or sink holes that allow direct contact with Class G-I or Class G-II groundwater, except projects designed to recharge aquifers with surface water of comparable quality, or projects designed to transfer water across or between aquifers of comparable quality for the purpose of storage or conservation.

7. Pursuant to Rule 62-520.420, the water quality standards for Class G-I and G-II groundwater are the primary and secondary drinking water quality standards as set forth in Rules 62-550.310 and 320, and the minimum criteria provided in Rule 62-520.400, F.A.C.
8. The relevant water quality standards as provided in Rules 62-550.320 and 62-520.400 are:

Parameter	Standard
pH	6.5 to 8.5
Color	15 color units
Total Dissolved Solids	500 mg/l
Aluminum	200 µg/l
Manganese	50 µg/l
Molybdenum	35 µg/l (Rule 62-520.400)
Silver	100 µg/l
Chloride	250 mg/l

9. Rule 62-522.300(2)(a) implements Sections 403.021, 403.061, and 403.088, Florida Statutes, and has as its specific authority in Section 403.061, Florida Statutes.

Type of Action Requested

10. HLA is requesting a variance from the restrictions imposed by Rule 62-522(2)(a) that would prohibit the Department from granting a zone of discharge in conjunction with the approval of Remedial Action Plans proposing the use of In-Situ Chemical Oxidation with Potassium Permanganate.

Specific Facts Which Demonstrate a Substantial Hardship
Or Violation of Principles of Fairness

11. The concentration of Potassium Permanganate in the injected fluid is a maximum 7.6 g/l (Free Flow grade) or 11.6 g/l (Pharmaceutical Grade), based on the concentration of inorganics with primary standards in the Potassium Permanganate solution. The actual grade and concentration used will be dependent on the effectiveness of the oxidation reaction observed in the field. The compositions of the potential Potassium Permanganate solutions are shown in Attachment A.

These concentrations exceed the secondary standard for Total Dissolved Solids. During the reaction, Manganese Dioxide is generated. In unfiltered samples, this precipitate has the potential to exceed the secondary standard for Manganese. Dissolved concentrations of aluminum (Free Flow grade) or aluminum and silver (Pharmaceutical Grade) may also exceed secondary standards. Depending on the contaminant oxidized, there is also the potential to generate acids and/or bases which may temporarily alter the pH of the groundwater. The buffering capacity of Florida's aquifers will quickly neutralize this condition. Upon injection of the Potassium Permanganate into the contaminant plume, it is expected that the color of the groundwater will turn purple. As the oxidation process proceeds, the groundwater will turn pink

and then clear again depending on the site stratigraphy, contaminant distribution, and the injection scenario. It is expected that through oxidation, dilution, diffusion, and advection, the groundwater color will be reduced to less than 15 color units or to background levels.

The above exceedances are possible in an area extending up to 100 feet from the point of injection. Conditions in the aquifer are expected to return to background within 365 days. Active remedial measures can be implemented if secondary standards continue to be exceeded beyond this period.

12. Pursuant to Rule 62-528.300(1)(e)4, the type of injection well to be utilized in the Potassium Permanganate In Situ Oxidation Process is a Class V, Group 4 well – "injection wells associated with an aquifer remediation project shall be authorized under the provision of a remedial action plan...provided the construction, operation, and monitoring requirements of the Chapter are met." There is no dispute that the subject injection wells will meet the construction, operation, and monitoring requirements of Chapter 62-528.
13. The staff of the Department's Bureau of Waste Cleanup and Bureau of Petroleum Storage Systems are familiar with In-Situ Chemical Oxidation with Potassium Permanganate and are prepared to approve its use at sites contaminated with petroleum compounds and chlorinated solvents. However, the provisions of Rule 62-522.300(1) would appear to prohibit the injection of Potassium Permanganate except within a Zone of Discharge. Rule 62-522.300(2)(a) prohibits the Department from granting a zone of discharge through an injection well to Class G-I and G-II groundwater.
14. Strict adherence to the prohibition of Rule 62-522.300(2)(a) would preclude the Department from granting approval for the use of In-Situ Chemical Oxidation with Potassium Permanganate.
15. Rule 62-522.300 is designed to protect the underground sources of drinking water of clean aquifers. However, the prohibition of a zone of discharge for an injection well to Class G-I and G-II groundwater is a hindrance to a reasonable, common sense remediation process that may cause only a temporary exceedence of a secondary drinking water standard in what is already a highly contaminated aquifer.
16. In-Situ Chemical Oxidation can accomplish the remediation of contaminated aquifers more effectively, more quickly, and potentially, at much lower cost than traditional remediation technologies. Therefore, a strict adherence to the zone of discharge prohibition will prevent the use of a safe, effective, and cost efficient remediation technology.

The Requested Variance Will Serve the Purposes of the Underlying Statute

17. As set forth in Section 403.021(2), Florida Statutes:
It is declared to be the public policy of this state to conserve the waters of the state and to protect, maintain, and improve the quality thereof for public water supplies, for the propagation of wildlife and fish and other aquatic life, and for the domestic, agricultural, industrial, recreational, and other beneficial uses and to provide that no wastes be discharged into any waters of the state without first being given the degree of treatment necessary to protect the beneficial uses of such waters.
18. There are no adverse impacts on human health or the environment that result from colored water. Temporary exceedance of the secondary standards for chloride, aluminum, manganese, silver, and total dissolved solids are also not expected to present any adverse impacts. The buffering capacity of Florida's aquifers is expected to prevent violations of the secondary standard for pH. The temporary exceedence of the secondary drinking water standards in connection with the

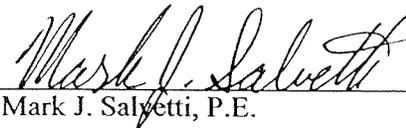
remediation of contaminated groundwater will not only allow for the protection and conservation of public water supplies, but will have the net effect of improving those public water supplies. Granting the variance will allow for the more effective cleanup of contaminated public water supplies. Therefore, the variance requested herein will serve the purpose of the underlying statute.

Conclusion

19. Rule 62-522.300(2)(a) precludes the Department from approving the use of an innovative site remediation technology that can more quickly and effectively clean up groundwater at sites contaminated with petroleum compounds and chlorinated solvents. The use of this technology will not cause any adverse impacts to the potential underground drinking water sources, but, in fact, will contribute significantly to improving the quality of those sources.

WHEREFORE, HLA requests that the Department grant a variance from Rule 62-522.300(2)(a) and allow the Department to approve a temporary zone of discharge for any Pilot Study Plan, Remedial Action Plan, or any other plan proposing the use of In-Situ Chemical Oxidation utilizing Potassium Permanganate with the condition that no Site Rehabilitation Completion Order will be granted unless the site meets all applicable, or approved cleanup target levels including color, aluminum, silver, manganese, chloride, total dissolved solids, and pH or their respective site-specific background concentration, whichever is less stringent. The approval document generated by the Department shall detail the physical limits of the permitted zone of discharge.

Respectfully submitted this 7th day of June, 1999.



Mark J. Salvetti, P.E.
Senior Engineer
Harding Lawson Associates

ATTACHMENT A

KMnO4 INORGANIC CONSTITUENTS		
Analyte (µg/l)	Free Flow Solution Concentrations at Maximum 7.6 g/l	Pharmaceutical Grade Concentrations at Maximum 11.6 g/l
Aluminum	600	660
Antimony	0.8	0.8
Arsenic	41	9.7
Barium	23	315
Beryllium	<0.5	<0.8
Boron	35	62
Cadmium	<2.5	<3.9
Chloride	<0.1	73
Calcium	646	27
Chromium	99	96
Cobalt	27	44
Copper	127	12
Iron	176	23
Lead	<0.5	3.1
Magnesium	34	39
Manganese	2,640,100	4,029,600
Mercury	0.30	1.1
Molybdenum	70	<21
Nickel	<5.0	<7.7
Potassium	1,880,300	2,869,900
Selenium	0.38	1.5
Silica	11,080	205
Silver	18	160
Sodium	3,740	1,140
Sulfate	0.1	615
Strontium	8	<0.4
Thallium	<0.5	<0.8
Zinc	37	16
pH	8.5 to 9.5	8.5 to 9.5