Corrective Measures Design Report

Prepared for:

Camp Stanley Storage Activity
Boerne, Texas

November 2015

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ACRONYMS AND ABBREVIATIONS

AOC	Area of Concern
BS	Bexar Shale
CAO	Corrective Action Objective
CC	Cow Creek
cis-1,2-DCE	*cis*-1,2-dichloroethene
CMD	Corrective Measures Design
CMS	Corrective Measures Study
COC	Contaminant of Concern
CSSA	Camp Stanley Storage Activity
CQA	Construction Quality Assurance
DQO	Data Quality Objective
DVR	Data Verification Report
ERPIMS	Environmental Resource Program Information Management System
GAC	Granular-Activated Charcoal
ISCO	*in situ* Chemical Oxidation
LGR	Lower Glen Rose
LTM	Long-Term Monitoring
LTMO	Long-Term Monitoring Optimization
MCL	Maximum Contaminant Limit
OB/OD	Open Burn/Open Detonation
Order, the	Administrative Order on Consent
PCE	tetrachloroethene
PWS	public water supply
QAPP	Quality Assurance Program Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RMU	Range Management Unit
SAP	Sampling and Analysis Plan
SCADA	Supervisory Control and Data Acquisition
SIW	Substrate Injection Wells
SVE	Soil Vapor Extraction
SWMU	Solid Waste Management Unit
TCE	trichloroethene
TCEQ	Texas Commission on Environmental Quality
UGR	Upper Glen Rose
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound
WB	West Bay

SECTION 1
INTRODUCTION

1.1 BACKGROUND

Camp Stanley Storage Activity (CSSA) is located in northwestern Bexar County, Texas about 19 miles northwest of downtown San Antonio and 11 miles southeast of Boerne (**Figure 1.1**). In 1991, routine water well testing by the Texas Department of Health detected the presence of dissolved tetrachloroethene (PCE), trichloroethene (TCE), and *cis*-1,2-dichloroethene (*cis*-1,2-DCE) in a CSSA water supply well (Well 16) above maximum contaminant levels (MCLs) and the well was taken out of service. Subsequent sampling showed volatile organic compound (VOC) contamination levels above MCLs in several other wells. Sources of the waste constituents were found to be the former oxidation pond (SWMU O-1) and Burn Area 3 (later renamed SWMU B-3). Later, AOC-65 was also identified as another source of groundwater contamination.

As a result of the groundwater contamination and the U.S. Environmental Protection Agency's (USEPA) findings on an open burn/open detonation (OB/OD) area in CSSA's North Pasture (SWMU B-20), USEPA issued CSSA an Administrative Order on Consent (the Order) under Section 3008(h) of the Resource Conservation and Recovery Act (RCRA) on May 5, 1999. With the Order, USEPA is the lead agency for investigation and remediation of groundwater. The Texas Commission on Environmental Quality (TCEQ) is the lead agency for investigation and closure of waste disposal sites, although USEPA provides input.

Since the Order was issued in 1999, CSSA has closed sites under State of Texas regulations, with both TCEQ and USEPA oversight. A total of 85 sites, including 39 solid waste management units (SWMUs), 41 areas of concern (AOCs), and 5 range management units (RMUs), were identified at CSSA, and investigations and interim removal actions (if warranted) were conducted at 83 of those sites. As of July 2014, 77 waste disposal sites were either delisted or closed to unrestricted use/unrestricted exposure in accordance with TCEQ requirements. A summary of past investigations and findings is provided in the RCRA Facility Investigation (RFI) Report (Parsons, 2014).

Five of the seven remaining sites are part of the active firing range. These sites will be closed when the range is no longer active. The two remaining open sites at CSSA, SWMU B-3 and AOC-65, are the remaining sources of groundwater contamination, and are the focus of groundwater remediation efforts going forward. Treatability studies to address SWMU B-3 were initiated in 1996 and to address AOC-65 in 2002. Remediation efforts are ongoing. Throughout the site closure and treatability study process, USEPA and TCEQ actively participated in site investigation and treatability study planning, as well as provided extensive document review.

USEPA (2015) issued its Final Remedy for CSSA in a Decision Document on July 28, 2015. The Decision Document approved the Preferred Alternative described in the Statement of Basis issued on March 24, 2015 as the Final Remedy. The remedy utilizes source area treatment, point-of use treatment, land use controls (LUCs), and long-term monitoring (LTM) to achieve the Corrective Action Objectives (CAOs) for groundwater remediation. The CAOs are as follows:

1. Prevent or minimize migration of contaminants of concern (COCs) in groundwater within the source area at concentrations exceeding the MCLs and restore groundwater to its most beneficial use in a reasonable timeframe.
2. Prevent human exposure to groundwater containing COCs at concentrations that exceed MCLs in water supply wells.
3. Prevent on-site worker dermal contact and/or ingestion of COCs in shallow groundwater at concentrations exceeding acceptable human health risk values.

Continued use of bioremediation (bioreactor) will treat the source area at SWMU B-3; and continued use of *in sit*u chemical oxidation (ISCO) will treat source area contamination at AOC-65. Institutional and engineering LUCs will be implemented to prevent contact with contaminated media. Current off-post granular activated carbon (GAC) units installed on private drinking water wells will continue to be operated and monitored. New GAC units will be installed at additional off-post drinking water wells if COC concentrations exceeding the MCLs are detected during the LTM program. This approach is consistent with USEPA guidance on final cleanup goals for RCRA corrective action (USEPA, 2004).

1.2 CORRECTIVE MEASURES DESIGN REPORT PURPOSE AND OBJECTIVES

The purpose of the Corrective Measures Design (CMD) report is to address the requirements necessary to implement the selected corrective measures at CSSA, as defined in the Statement of Basis (USEPA, 2015).

Corrective measures have been in place to monitor and treat groundwater contamination for several years. Groundwater sampling has been conducted at CSSA since 1991 to identify, delineate, and monitor groundwater plumes. A bioreactor has been treating groundwater contamination via monitored bioremediation at SWMU B-3 since 2007. Groundwater contamination at AOC-65 was treated using soil vapor extraction (SVE) from 2002 through 2012, and since then has been addressed using ISCO applications. Because the corrective measures in place at CSSA are part of USEPA's selected remedy for groundwater, this report describes and references the original design documents for those corrective measures.

1.3 CMD REPORT ORGANIZATION

The CMD is presented in the following sections and addresses the content requirements of the Order:

- Section 2 outlines the design plans and specifications for the SWMU B-3 bioreactor, AOC-65 ISCO application, and groundwater monitoring program;
- Section 3 describes the operation and maintenance of the groundwater monitoring program and treatment systems at CSSA;
- Section 4 provides a cost estimate for the groundwater corrective actions;
- Section 5 presents the project schedule;
- Section 6 outlines the construction quality assurance objectives;
- Section 7 references the project health and safety program;
- Section 8 summarizes the design phases of the groundwater corrective actions; and
- Section 9 presents the references used in this CMD.

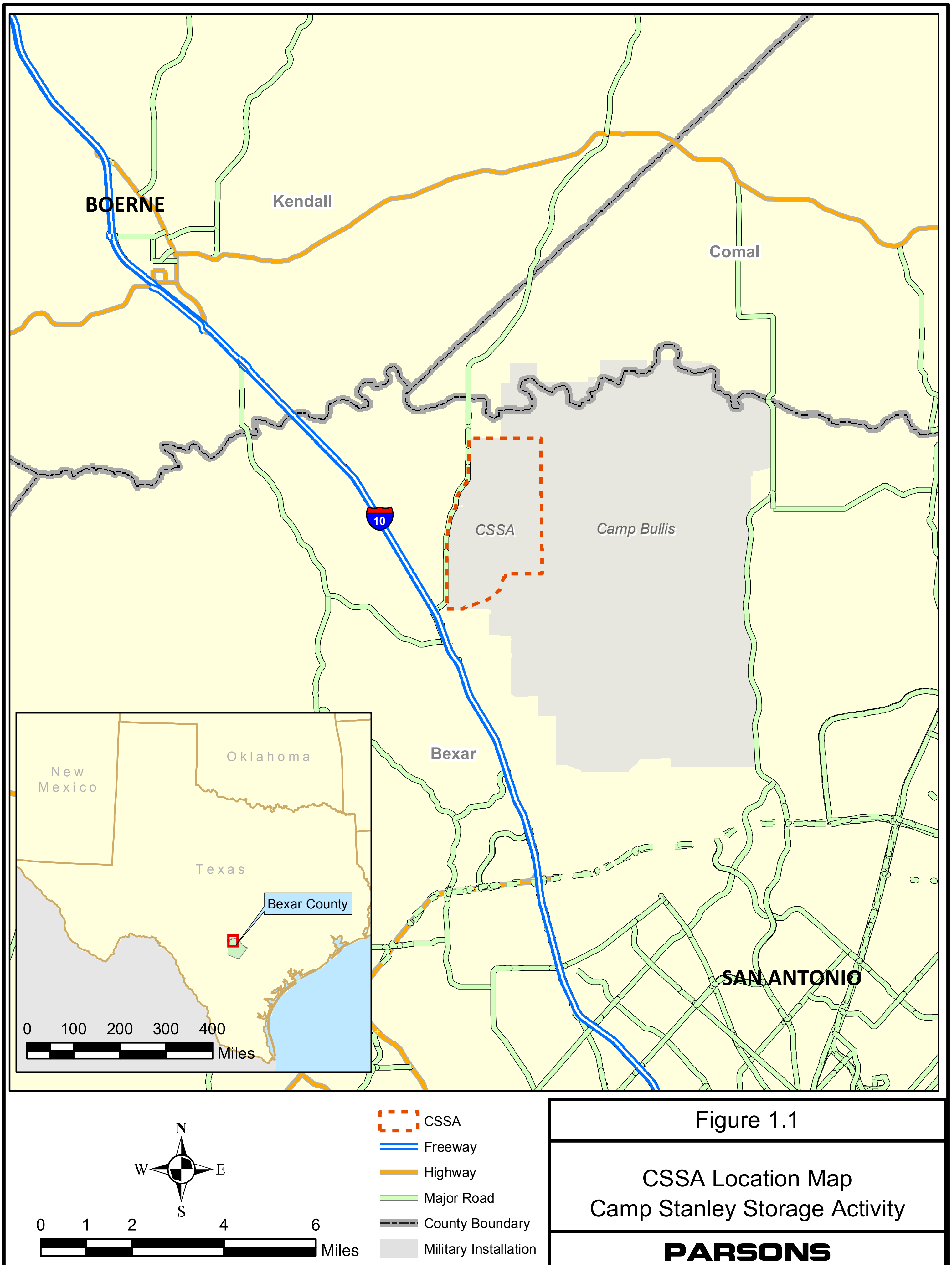

Figure 1.1

CSSA Location Map
Camp Stanley Storage Activity

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SECTION 2
DESIGN PLANS AND SPECIFICATIONS

2.1 SWMU B-3 BIOREACTOR

To remediate contaminated groundwater, an *in situ* "bioreactor" was created in 2007 by removing the waste in the disposal trenches, backfilling with a gravel/mulch mixture, and infiltrating contaminated groundwater (**Figure 2.1**). Microbial activity was augmented with addition of the KB-1 commercial culture of *dehalococcoides*. The general design criteria for the bioreactor included placement of a 1:1 mixture by volume of gravel to deciduous tree mulch into the six excavated trenches at SWMU B-3. A water irrigation system was installed near the gravel/tree mulch in which water could be pumped from nearby wells and delivered into each trench (**Figure 2.2**).

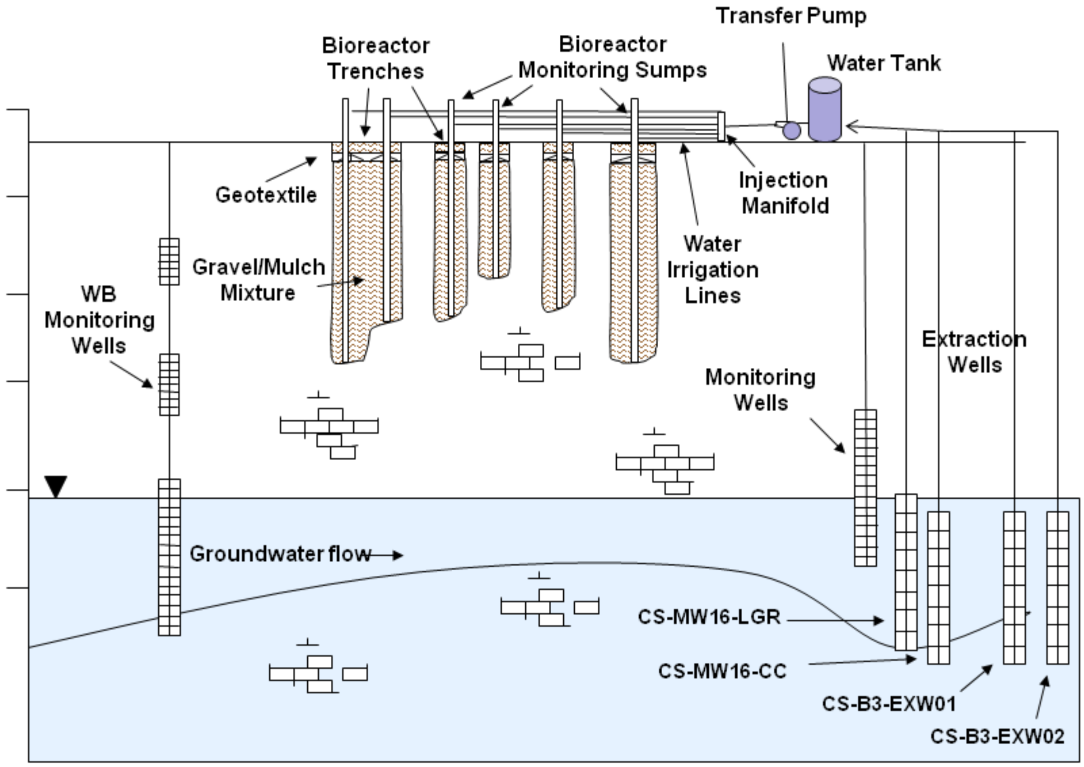

Figure 2.1 Conceptual Drawing of SWMU B-3 Bioreactor

In 2011-2012, several system updates were incorporated at the SWMU B-3 bioreactor. Three new extraction wells were installed between May 2011 and June 2012. The current system distributes contaminated groundwater collected from seven extraction wells located around the perimeter of the site into the bioreactor trenches where the water encounters microbial activity which degrades the organic contaminants.

Groundwater contaminant concentrations are monitored at surrounding monitoring wells including four Westbay multi-port wells, nine UGR wells, and four LGR wells, as shown on Figure 2.2

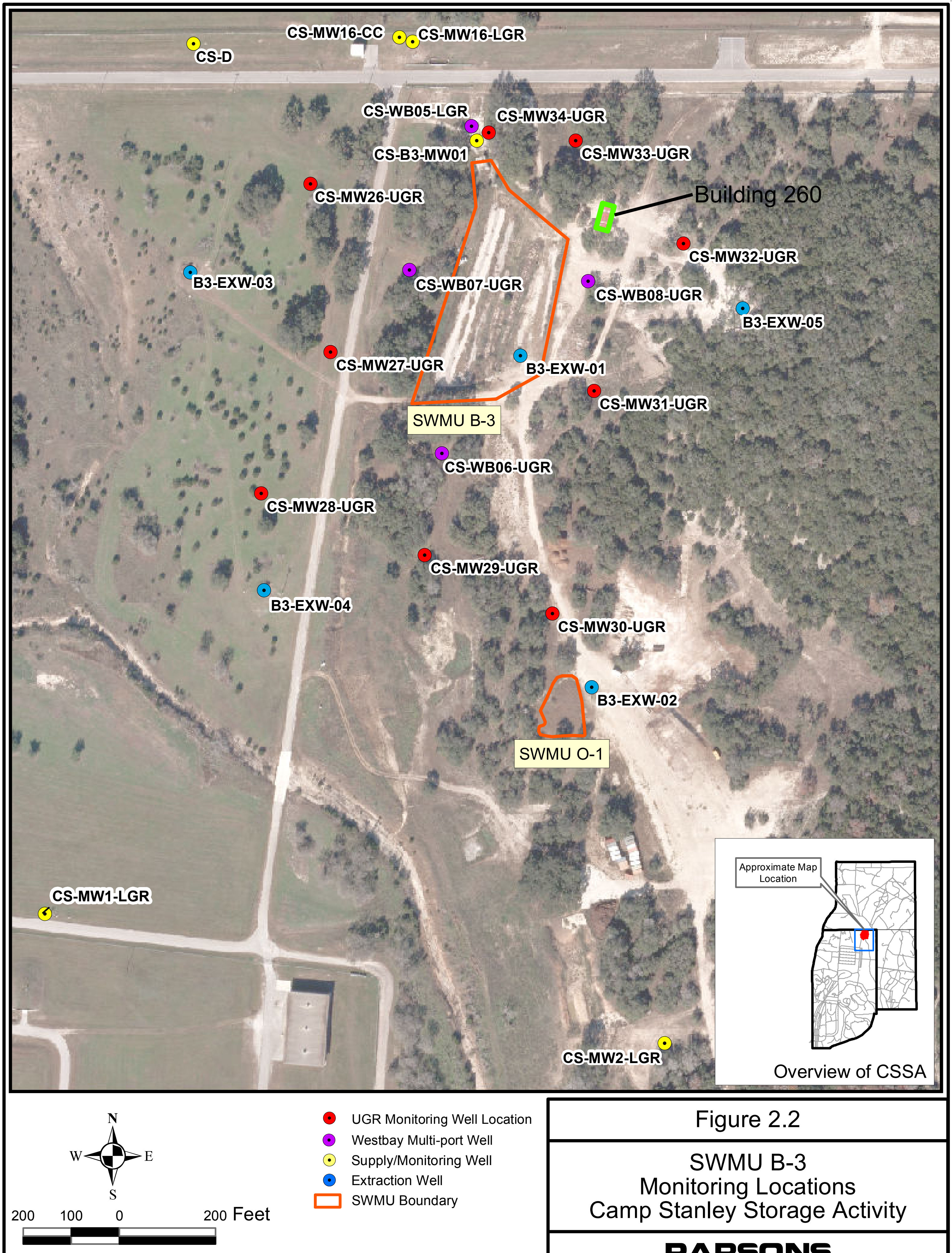

Figure 2.2

SWMU B-3
Monitoring Locations
Camp Stanley Storage Activity

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Aerial Photo Date: Feb. 2013

In 2011-2012, Building 260 was constructed on the northeast side of the bioreactor to house system controls, storage tanks, the transfer pump, and bag filter. The repositioning of the injection equipment in this new building required the rerouting of water lines from extraction wells and utilities, and moving supervisory control and data acquisition (SCADA) controls. Two 10,000-gallon polyethylene storage tanks were installed in the new building, and they replace the 6,000-gallon trailer-mounted tank previously used. Design drawings for Building 260 and a typical extraction wellhead completion design are included as **Figures 2.3 and 2.4**, respectively. Following the addition of Building 260, bioreactor trenches were recharged with deciduous tree mulch and gravel. New injection piping was installed approximately 18 inches below the surface within each trench and covered with new geotextile fabric.

Complete construction and completion details for the bioreactor and associated extraction wells are included in the following documents:

- *SWMU B-3 Bioreactor Construction Report* (Parsons, 2007)
- *CSSA B-3 Extraction Well Construction Summary* (Parsons, 2010a)
- *Construction Summary for SWMU B-3 Extraction Well 02 (B3-EXW02) and Shallow Monitoring Wells (B3-MW26 through B3-MW34)* (Parsons, 2010b)
- *Final Well Installation Report [for B3-EXW03 and B3-EXW04]* (Parsons, 2011)
- *B3-EXW05 Well Installation Report* (Parsons, 2012b)

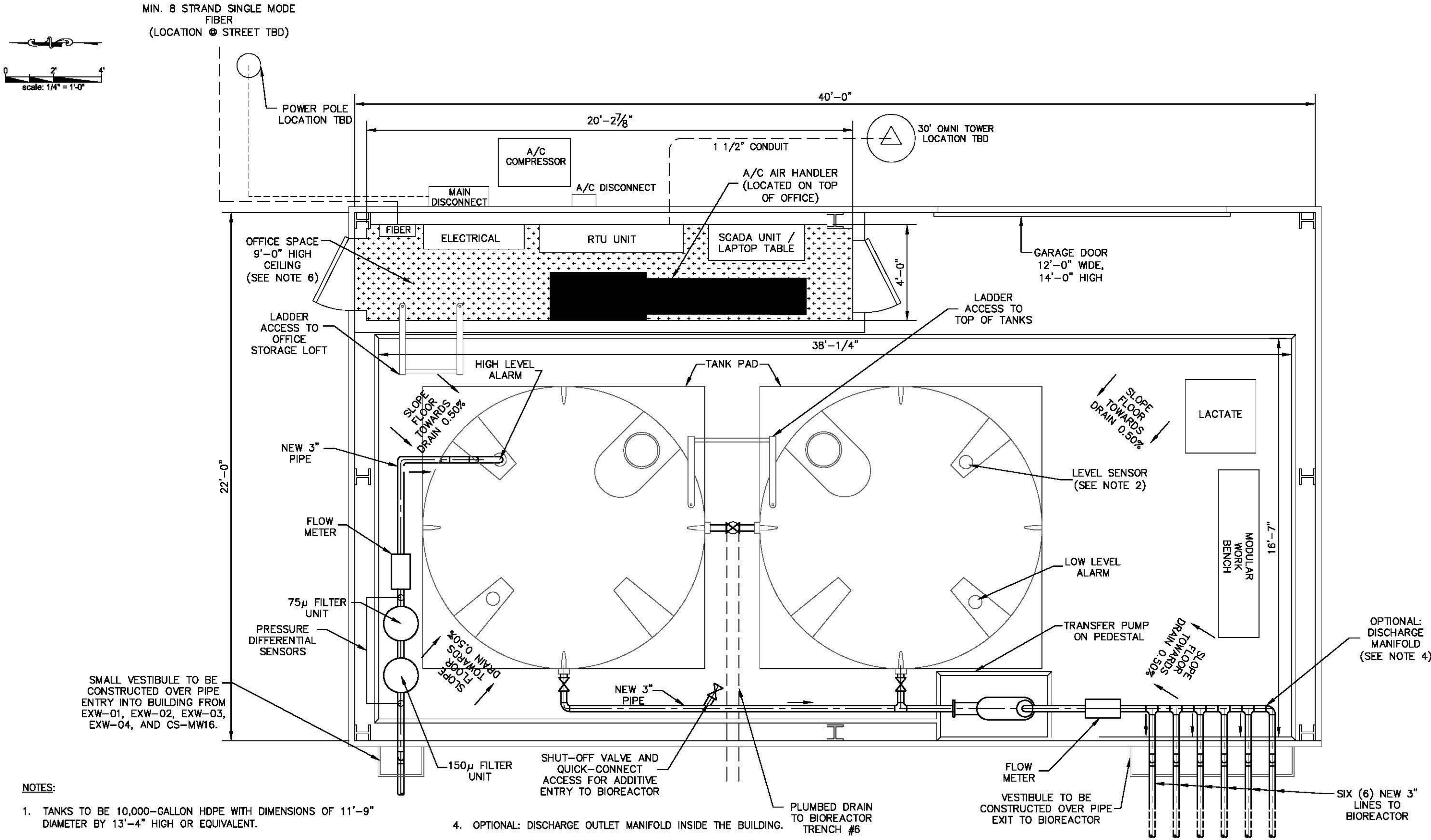
2.2 AOC-65

An SVE system was initially installed at AOC-65 to remediate VOC contamination in groundwater. The system proved ineffective after 10 years of operations due to large fluctuations in water levels within the aquifer. Extraction well screens and flow paths (fractures) were flooded during periods of higher groundwater elevations. Therefore, a new remedial approach was designed for utilizing ISCO at AOC-65.

Partial source area removal was accomplished by removing soil and rock west of Building 90. However, contamination sources underlying the building, immediately adjacent to the building, and in deep bedrock fractures remained to be addressed.

In 2012, the approach for injecting ISCO material at AOC-65 to treat this remaining source included the construction of a multi-zone infiltration gallery within a trench excavated along a suspected point of release. The trench was backfilled with alternating layers of gravel and compacted clay, and irrigation lines were installed within each of the gravel layers to create three separate treatment zones within the trench (**Figure 2.5**). The infiltration gallery zones were configured to target multiple fractures that had been identified on the exposed trench walls. ISCO solution can also be delivered to the subsurface using existing nearby former vapor extraction wells, piezometers, and steam injection wells (SIWs) modified for ISCO injection (**Figure 2.6**). Two 13-foot-long, 2-foot-wide, 2-foot-deep surficial excavations were later created within a concrete vault located inside Building 90 for additional ISCO applications within the suspected source area (**Figure 2.7**).

Sodium persulfate was selected for application within the discrete galleries due to reaction life-span, solution density, and oxidation potential. In 2013, four ISCO injection wells (IIWs) were installed along the post boundary in the upper portion of the bedrock vadose zone to create a reactive curtain for intercepting potential PCE migration off-post (Figure 2.4). In 2015, five



NOTES:

1. TANKS TO BE 10,000-GALLON HDPE WITH DIMENSIONS OF 11'-9" DIAMETER BY 13'-4" HIGH OR EQUIVALENT.
2. PROSONIC M-FMU40 ULTRASONIC LEVEL TO BE MOVED FROM EXISTING TANK.
3. METEOROLOGICAL MONITORING TOWER TO BE LOCATED 150'-200' WEST OF BUILDING 205. THE TOWER SHALL HAVE THE CAPABILITY TO BE TILTED DOWN FOR MAINTENANCE. POWER CABLE AND DATA TRANSMISSION CABLE TO BE BURIED AT A 2' DEPTH BETWEEN TOWER AND THE MW16 STANCHION.
4. OPTIONAL: DISCHARGE OUTLET MANIFOLD INSIDE THE BUILDING.
5. DESIGN EAVE (WHERE ROOF MEETS WALLS) HEIGHT OF BUILDING 18-FEET
6. HATCHED AREA TO BE CLIMATE CONTROLLED.

FIGURE 2.3

Conceptual Bioreactor Building

Camp Stanley Storage Activity

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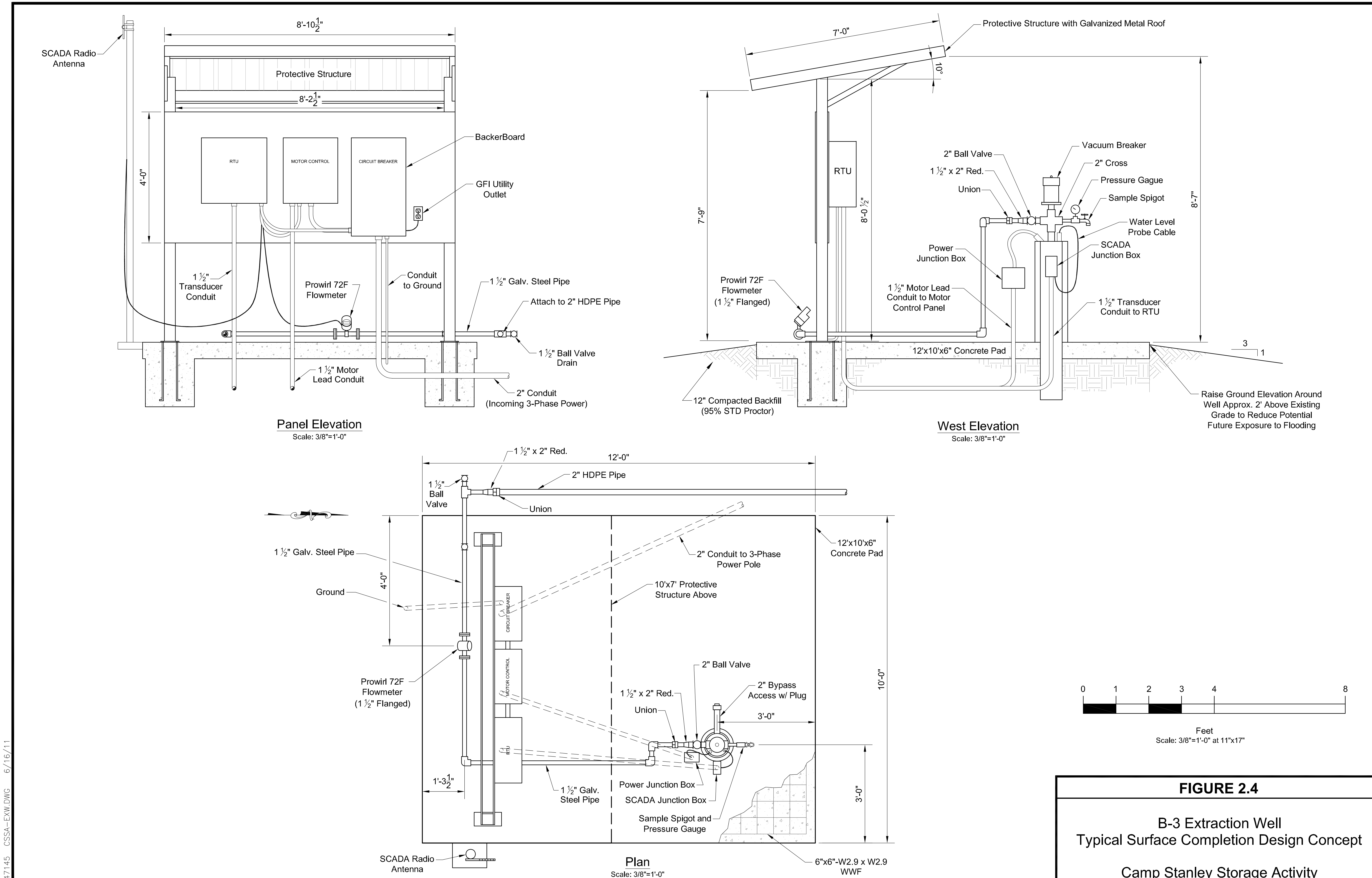

FIGURE 2.4

B-3 Extraction Well
Typical Surface Completion Design Concept

Camp Stanley Storage Activity

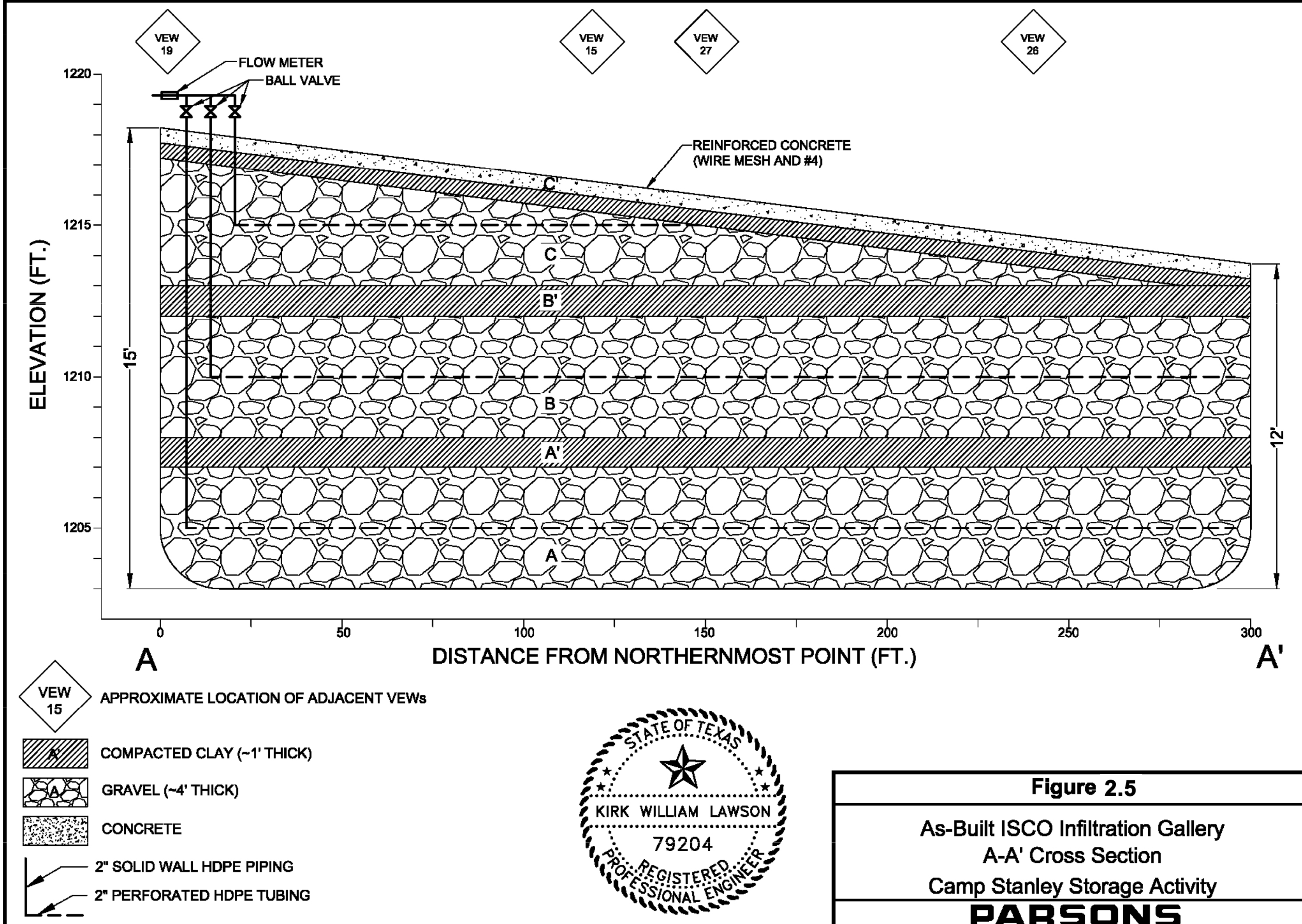

Figure 2.5

As-Built ISCO Infiltration Gallery
A-A' Cross Section
Camp Stanley Storage Activity

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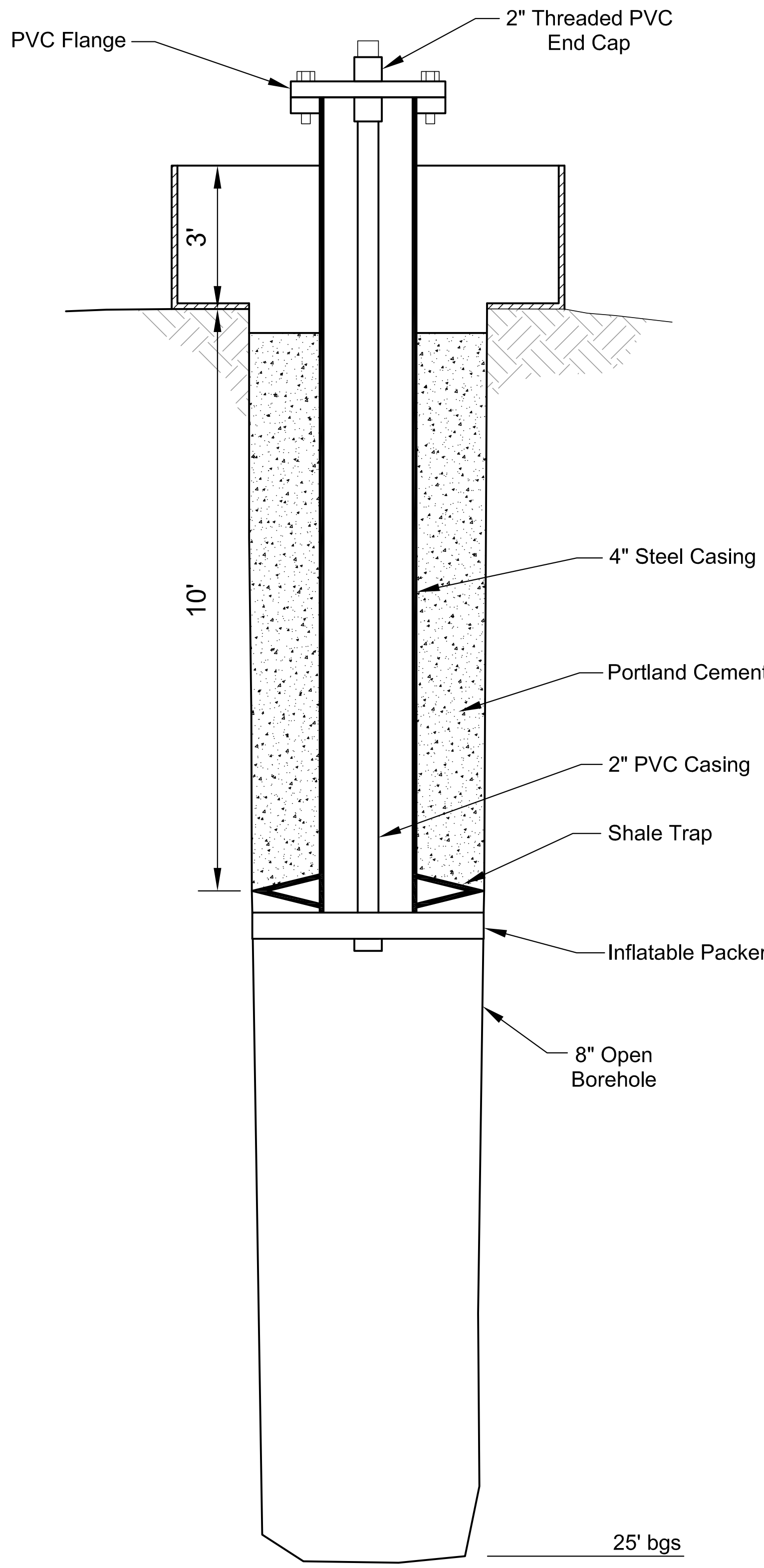

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Not to Scale

Figure 2.6

SIW-01 Modified for ISCO Injection

Camp Stanley Storage Activity

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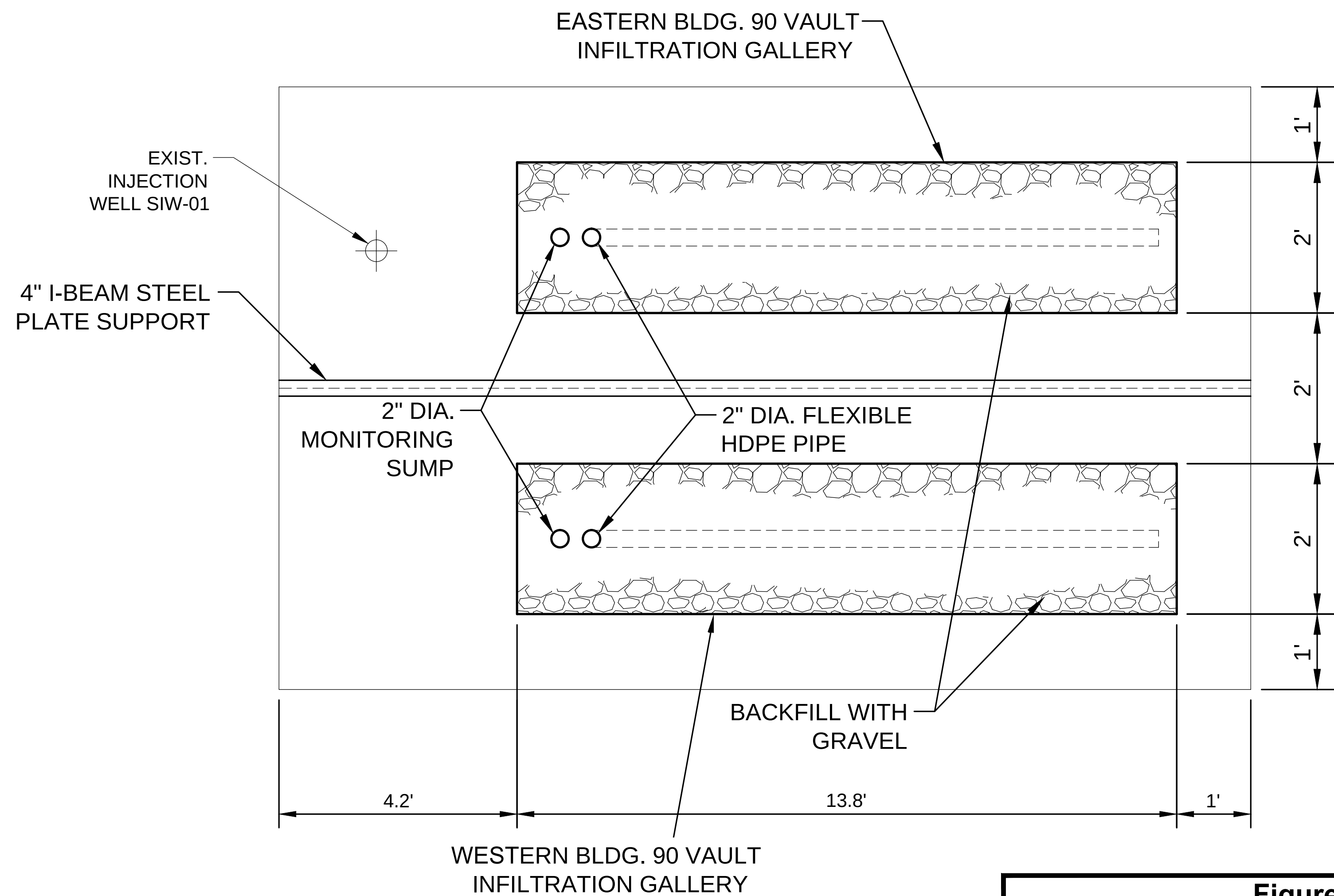


Figure 2.7

ISCO Building 90
Vault Infiltration Gallery Plan

Camp Stanley Storage Activity, Texas

PARSONS

additional infiltration galleries were installed. Four ISCO injections have been performed at AOC-65 as follows:

- 2012: 15,000 gallons of alkaline-activated 20% sodium persulfate solution;
- 2013: 33,000 gallons of alkaline-activated 20% sodium persulfate solution;
- 2014: 103,000 gallons of alkaline-activated 20% sodium persulfate solution; and
- 2015: 3,500 gallons of 0.45% sodium permanganate activated solution.

A fifth injection will be conducted in November 2015.

Groundwater samples collected at AOC-65 indicate the ISCO solution follows preferential flow paths. This was inferred by the positive field identification of persulfate (oxidant) and elevated pH (activator), and the presence of reaction by-products within the monitoring well network.

Complete construction and completion details for the ISCO injection system are included in the following documents:

- *Work Plan for AOC-65 ISCO Treatability Study* (Parsons, 2013)
- *2014 AOC-65 In-Situ Chemical Oxidation Assessment Report* (Parsons, 2015b)
- *Work Plan Addendum (Revised) for AOC-65 ISCO Injection* (Parsons, 2015a)

2.3 GROUNDWATER MONITORING

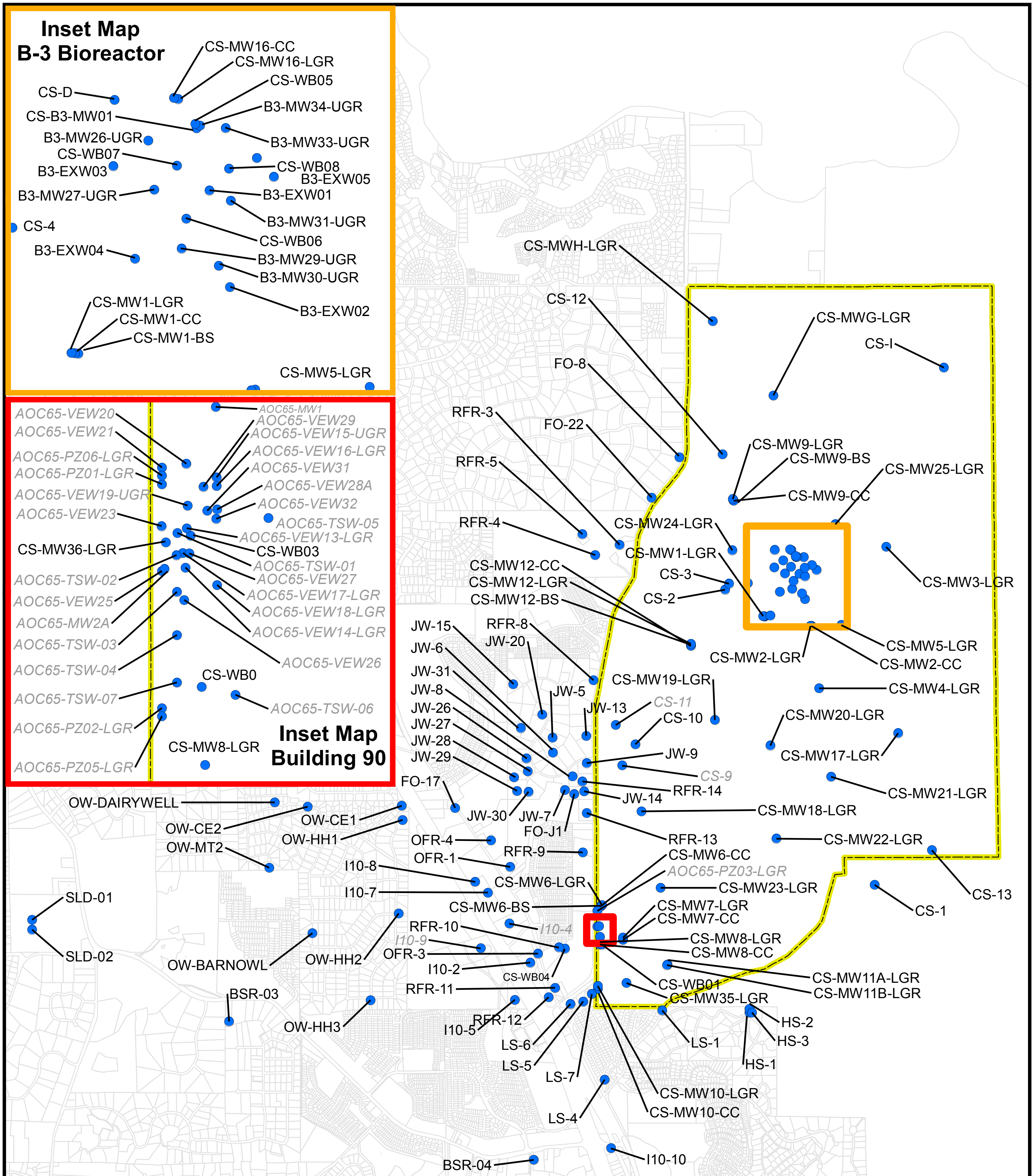
The CSSA groundwater monitoring program contains 196 sampling locations (**Figure 2.8**). The sampling locations include 64 on-post wells, 59 off-post wells, and eight Westbay wells totaling 73 distinct sampling locations throughout the eight wells. The following paragraphs describe typical well designs included in the monitoring networks.

2.3.1 Well Design

2.3.1.1 Monitoring Wells

The most common type of well construction at CSSA is the typical environmental monitoring well completion. In its simplest form, a single-cased monitoring well consists of a pre-manufactured well screen that is threaded to a casing of equivalent diameter, and installed within a straight-wall (single diameter) borehole. The typical monitoring well at CSSA consists of a wire-wrapped screen constructed of stainless steel, or to a lesser extent, PVC. The screen can vary in length between 15 and 50 feet depending on the intended use of the well. For example, most wells that monitor the Lower Glen Rose (LGR) segment of the aquifer consist of 25 feet of screen. But wells associated with remedial activities can have screen lengths up to 50 feet. The screened material is threaded to a PVC casing that extends from the ground surface to the screened interval. Stainless steel centralizers are affixed to the casing to keep the well centered within the borehole.

Most monitoring wells drilled at CSSA are typically four inches in diameter and are installed within an eight-inch drilled borehole. However, a handful of 2-inch diameter wells have been installed. After the well materials have been carefully lowered into a drilled borehole, the annular space around the screened interval is gravel packed with a sand-sized quartz material that is coarser than the slots on the screen. Above the gravel pack, a bentonite seal is emplaced, typically with a thickness of at least five feet. The remainder of the borehole around the PVC



Well

CSSA Boundary

Note: Wells shown in *italics* are not part of the current or proposed long-term monitoring program

0 0.5 1 Miles

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Figure 2.8

Groundwater Monitoring Well Locations
Camp Stanley Storage Activity

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casing is sealed with either Portland cement or a bentonite-based Volclay grout. Each well has been finished with a concrete surface completion and locking mechanism. Depending on the location and use of the well, the surface completion maybe either be above grade with a locking well protector and traffic bollards, flush-mounted within a traffic-rated vault.

Variants of this typical monitoring well installation include double-cased and triple-cased monitoring wells. These styles of wells are used to either hydraulically separate distinct water production zones, or to prevent the cross contamination of aquifer segments that have been either impacted by contamination (e.g, microbial or solvent contamination), or to prevent inferior water quality zones (e.g., Upper Glen Rose [UGR]) from co-mingling with superior water quality zones (e.g., LGR and Cow Creek [CC]).

As opposed to the straight-wall design of a single-cased well, a double- or triple-cased well has a telescoping design that includes successfully smaller borehole sizes to be drilled to accommodate protective surface casings. For example, a triple-cased well drilled into the CC segment would follow a completion such as this:

1. A 16-inch borehole drilled throughout the thickness of the LGR. A 12-inch diameter steel casing would be installed, and the annular space would be filled with Portland cement.
2. Once the 12-inch casing has been installed, the underlying Bexar Shale (BS) segment would be drilled with a 12-inch bit and then an 8-inch diameter casing would be installed and cemented.
3. Once the 8-inch casing has been installed, the underlying CC segment would be drilled with an 8-inch bit and then a 4-inch diameter casing and well screen would be installed. A gravel pack would be emplaced around the screened interval, followed by a 5-foot bentonite seal, and then topped with grout to the ground surface.

Similarly, a double-cased well would only utilize steps 2 and 3 in the above example. In general most UGR and LGR wells are single-cased, while BS wells are double-cased completions. Depending on their location and potential for solvent contamination, the CC wells are either double- or triple-cased monitoring well completions. Most monitoring wells are equipped with QED bladder pumps to obtain groundwater samples.

2.3.1.2 Westbay Wells

The Westbay wells (WB) have ports at multiple depths across the LGR, BS, and CC zones totaling 73 distinct sampling locations throughout the eight wells. Wells WB01 through WB04 are used to monitor Plume 2 in the southwest quadrant of CSSA. WB05 through WB08 are installed at the SWMU B-3 source area for Plume 1, and are used to support the bioreactor remediation activities. The wells are unique such that they can monitor multiple zones within a single borehole. As shown on **Figure 2.9** each zone within a Westbay well contains a packer (1), a measurement port (2), and a pumping port (3).

Open Borehole Wells

A common style of well completion that is used in the San Antonio vicinity is "open borehole" well completions. Because the underlying strata is competent limestone bedrock, well

Figure 2.9 Typical Westbay Monitoring Well

materials such as casing, screen, and annular seals are not required to maintain borehole stability, or to produce groundwater of acceptable quality with low suspended solids. These physical characteristics of the subsurface make it more economical to drill wells and allows for groundwater to be developed easily from multiple groundwater zones. A segment of surface casing is typically used to keep unconsolidated surface materials from sloughing into the wellbore, or to isolate less desirable groundwater strata from entering the borehole, such as the UGR groundwater. These types of wells have different uses, but generally include the public water supply wells and off-post privately owned wells.

Public Water Supply Wells

Public water supply (PWS) wells are typically drilled throughout the entire thickness of the Middle Trinity aquifer, which can be in excess of 450 feet of thickness. They are typically constructed as single-cased telescoping wells, with a final borehole diameter of eight inches or more. PWS wells typically have long segments of protective surface casing that isolate all the near-surface water zones above the production zones. This prevents the co-mingling of the highly mineralized, perched groundwater with the more desirable water production zones at depth in the LGR and CC. In the CSSA vicinity, PWS wells are equipped with high capacity electric submersible pumps that are capable of producing 50 to 100 gallons per minute, or more.

CSSA operates several on-post PWS wells for its water supply. Off-post independent water purveyors produce Middle Trinity aquifer groundwater from similar PWS wells to supply the surrounding residential and commercial developments.

Off-Post Wells (Privately Owned Wells)

Based on the design utilized for the PWS systems, many landowners surrounding CSSA have privately-owned wells to provide water for residential, agricultural, or commercial uses. These wells are similarly designed as open borehole completions to produce groundwater from the LGR and CC portions of the Middle Trinity aquifer. Privately owned wells are usually smaller in diameter (6 to 8 inches), and are equipped with lower yielding submersible pumping equipment (5 to 15 gallons per minute). Besides well diameter and groundwater yield, a significant difference is that the surface casings are generally short in length. The minimum requirement in the State of Texas is 10 feet of casing. The use of shorter lengths of casing drastically reduces the overall cost of the well to the owner, and is a common practice in the vicinity. The drawback is that allows the co-mingling of lower quality water intervals, or potentially contaminated waters that exist in shallower water zones (chemical or microbial). Typically, older wells have very minimal casing lengths. New wells are subject to newer regulations and typically have longer surface casing requirements.

2.3.2 Monitoring Program

The design of the groundwater monitoring program is based on the following three documents:

- *Data Quality Objectives for the Groundwater Monitoring Program* (Parsons, 2010; currently in revision);
- *Three-Tiered Long-Term Monitoring Network Optimization Evaluation* (Parsons, 2010; currently in revision); and
- *CSSA Off-Post Monitoring Program Response Plan* (Parsons, 2002).

The Data Quality Objectives (DQO) Report outlines the process for determining the frequency, locations, and methods of groundwater sample collection and analysis following USEPA's seven-step DQO process. In conjunction with the DQO Report, the Long-Term Monitoring Network Optimization Evaluation (LTMO Report) summarizes the effectiveness of the CSSA monitoring network, and develops a site-specific strategy for groundwater sampling and analysis to maximize the amount of relevant information that can be obtained while minimizing incremental costs. The DQO and LTMO Reports are described further in Section 3.3.

The purposes of the *CSSA Off-Post Monitoring Program Response Plan* are to (1) confirm area drinking water meets USEPA and TCEQ standards, (2) determine the lateral and vertical extent of VOC contamination, (3) determine if there are any potential off-post VOC source areas, (4) provide the framework to monitor off-post water wells that are located downgradient of known VOC source areas and within close proximity of CSSA, and (5) provide action levels and Army response guidance if additional off-post groundwater contamination is encountered.

2.4 POINT-OF-USE TREATMENT

CSSA has installed seven granular activated carbon (GAC) treatment systems at private off-post wells in which COC concentrations reached 90% or greater of the MCL for PCE and TCE (i.e., ≥ 4.5 milligrams per liter [mg/L]). Well locations that routinely exceed the MCL for PCE and/or TCE and are used for consumption include:

- Three private residences (LS-5, LS-7 and RFR-10 [2 GAC units]);
- Two businesses (OFR-3 and RFR-11); and
- One church (LS-6).

These wells are all located southwest of CSSA, within the extent of Plume 2 (**Figure 2.10**). Prior to 2008, two public supply wells (LS-2 and LS-3) for the Leon Springs Villas were also treated by a centralized hi-capacity GAC unit. However, this Public Water Supply (PWS) system no longer derives its groundwater from the Middle Trinity aquifer, and therefore the system was dismantled. This method of groundwater treatment employs activated carbon to remove organic contaminants from the groundwater. In general, contaminated groundwater produced from the well is pumped through two carbon vessels, each containing 90 pounds of granular activated carbon. The carbon vessels are placed in "series" in ensure all VOCs are removed. The treatment systems also include 5-micron cartridge filters to remove sediment and ultraviolet light treatment to destroy microbial contaminants. The entire system is self-contained within a small shed at each well location (**Figure 2.11**). There are multiple configurations of treatment dependent upon the well and water supply equipment that each well owner operates. Figure 2.11 shows the GAC system configuration for well RFR-10. Regular maintenance is performed both by Parsons and the carbon vendor (Carbonair, Inc) as described in Section 3.3.2.

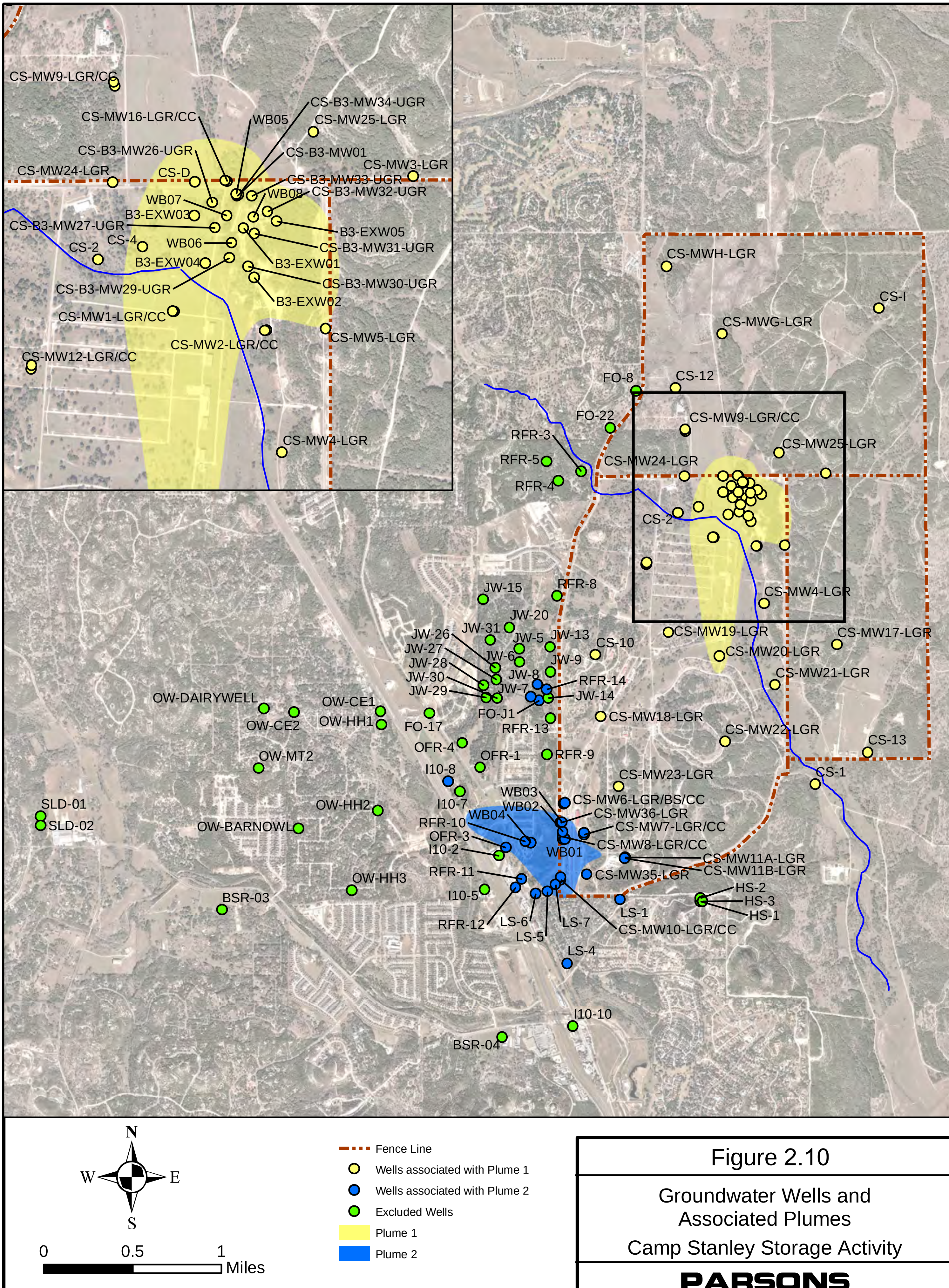

Figure 2.10

Groundwater Wells and Associated Plumes

Camp Stanley Storage Activity

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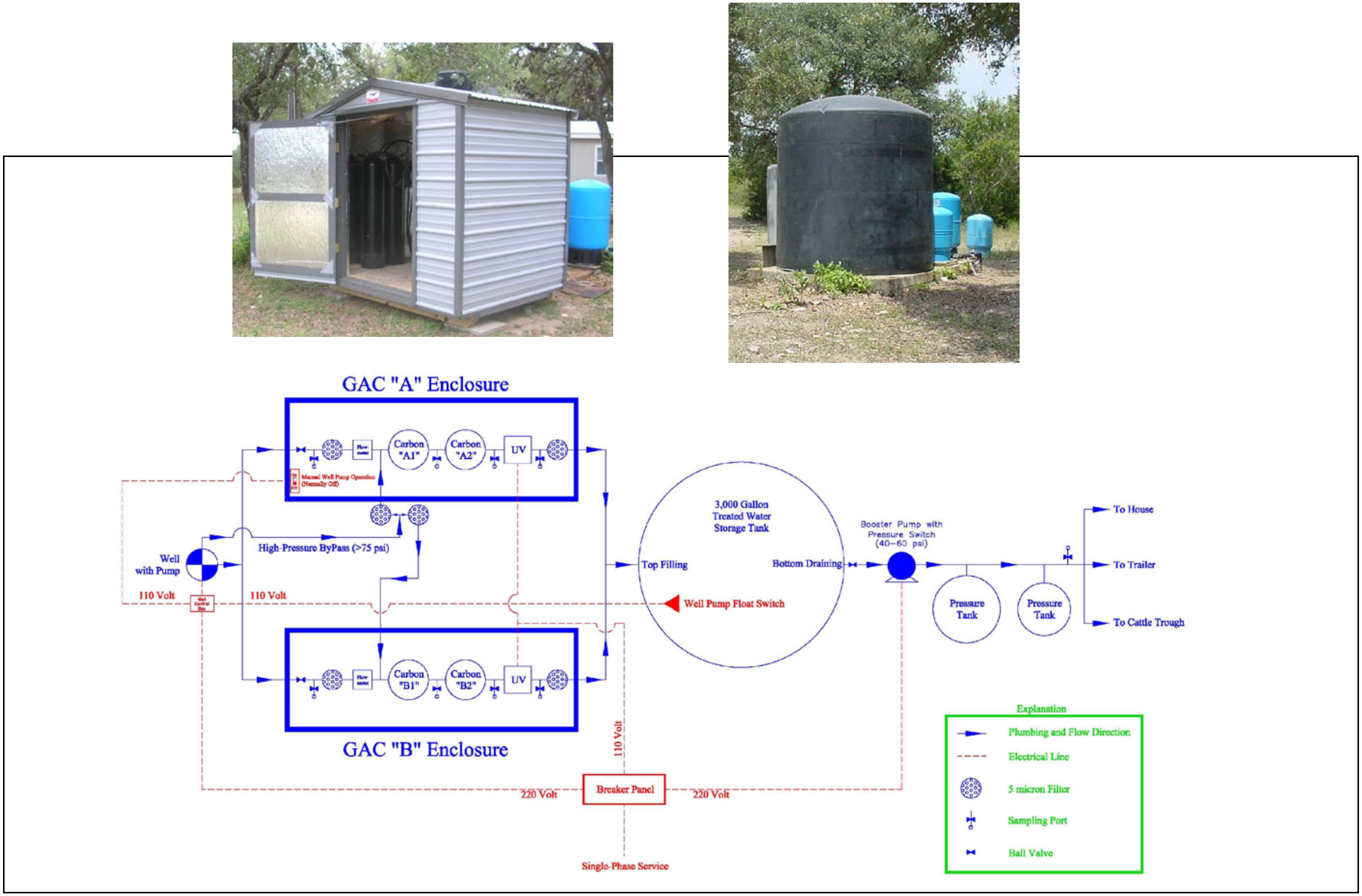

Figure 2.11 Example of GAC System Operational Schematic and Residential GAC Unit Housing (Well RFR-10)

SECTION 3
OPERATION AND MAINTENANCE PLAN

3.1 SWMU B-3

The bioreactor installed to treat VOCs in the vadose zone and underlying aquifer at SWMU B-3 utilizes contaminated groundwater pumped from seven extraction wells around the periphery of the site and injected into up to six mulch-filled trenches. The reintroduction of contaminated groundwater into bioreactor trenches requires a Class V Underground Injection Control (UIC) permit. The UIC permit requires the monitoring of injection volumes, pressures, and concentrations of contaminants (including pH and total dissolved solids) of the injected water which is sampled on a quarterly basis at the point of reinjection. Additionally, the contaminant concentrations within the bioreactor trench sumps and surrounding monitoring wells are sampled semi-annually, and results are reported to the UIC Permits Team on an annual basis. Typically, 50,000 gallons of contaminated groundwater is applied and treated within the trenches daily.

Semi-annual performance monitoring of microbial population and dissolved hydrogen concentrations within trench sumps is used to evaluate overall bioreactor “health,” and may be used to determine if and when addition of supplementary carbon or bioaugmentation (with *dehalococcoides*) is required. Supplementary carbon is added in the form of an injected carbon substrate or by renewing the bark mulch within the trenches. Anaerobic bacteria require anaerobic conditions (i.e., dissolved oxygen less than 0.5 mg/L) to function. Concentrations above 0.5 mg/L may require the addition of carbon to provide aerobic microorganisms with sufficient substrate to consume and ultimately deplete the aquifer of dissolved oxygen. Fermentation of carbon produces hydrogen, which is then consumed by anaerobic microorganisms including *dehalococcoides*. When dissolved hydrogen concentrations fall below the optimal range for anaerobic reductive dechlorination (2 – 11 nM/L) or dissolved oxygen concentrations rise above 0.5 mg/L, additional application of carbon should be considered. Similarly, bioaugmentation should be considered if *dehalococcoides* populations show signs of significant decline, and anaerobic conditions are achieved within the aquifer (DO less than 0.5 mg/L, and dissolved hydrogen greater than 1.0nM/L).

The *SWMU B-3 Bioreactor Operation and Maintenance Manual* (Parsons, 2012a) describes the procedures to be followed during normal operation of the system. The plan provides a detailed description of the injection system, including specifications of system components, data to be collected during normal system operations, system maintenance procedures, and general site maintenance to facilitate effective system operations. It also provides procedures for monitoring the equipment used for operating the SWMU B-3 bioreactor as well as monitoring the bioreactor effectiveness at reducing the concentrations of VOCs in the aquifer underlying SWMU B-3.

3.2 AOC-65

The ISCO solution used to treat VOCs in the vadose zone at AOC-65 is applied via infiltration galleries or injection wells within the site. The injection of oxidants at AOC-65 requires a Class V UIC permit, which stipulates construction standards, well plugging requirements, and semi-annual reporting of injection activities and site status. Six infiltration galleries are installed at AOC-65 and range in size from a 320-foot-long, 15-foot-deep, 3.5-foot-wide trench installed along a drainage ditch (Figure 2.5), to two 13-foot-long, 2-foot-wide, 2-foot-deep surficial excavations within a concrete vault located inside Building 90 (Figure 2.7). ISCO injections within the smaller infiltration galleries target suspected source areas at the site, while the larger gallery allows for a broader ISCO application.

Multiple monitoring locations are present at AOC-65, and monthly and quarterly monitoring following injection events monitor VOC concentrations as well as the breakdown products of both the ISCO solution and the contaminants. Significant reductions in contaminant concentrations are anticipated following ISCO injections, however, continued monitoring typically indicates some amount of rebound in contaminant concentrations. Future ISCO injections will likely occur in response to observed rebound trends, or as a finishing step to treat dissolved-phase VOCs within the aquifer. Prior to conducting each injection, a work plan describing the injection will be prepared and submitted to USEPA for approval.

The *AOC-65 In-Situ Chemical Oxidation Operations and Monitoring Plan* (Parsons, 2013) was created as a guide for operating the ISCO injection system equipment and the associated monitoring efforts following ISCO injections at AOC-65. The plan describes the ISCO injection system including layout drawings and schematics, system operation and monitoring, and reporting requirements.

3.3 GROUNDWATER

3.3.1 Monitoring

In April 2002, DQOs for CSSA's groundwater monitoring program were formally developed using U.S. Environmental Protection Agency's (USEPA's) *Guidance for the Data Quality Objectives Process* (EPA/600/R-96/055). The DQO process is a planning tool for data collection activities that provides a basis for balancing decision uncertainty with available resources. The format of these DQOs follows the seven-step process identified in the above-referenced USEPA guidance document. The April 2002 DQOs, and subsequent updates in 2003, 2006, 2009, and 2010, were approved by the USEPA and the TCEQ. A 2015 update for the DQOs is currently pending approval.

Four groundwater monitoring events will be performed each year at selected monitoring wells both on- and off-post. Specific schedules and requirements for periodic monitoring shall conform to the approved LTMO Report completed for CSSA (Parsons, 2015c).

The estimated number of samples to be collected and sampling frequency is based on the protocol provided in the 2015 LTMO Report. The sample count may also be adjusted in times of extreme weather to ensure adequate sample coverage. Parsons will confirm that right-of-entry agreements are in place for each of the off-post wells to be sampled, and will adjust their sampling schedule as necessary to meet the needs of the off-post residents.

Parsons will follow the methods approved in *CSSA Quality Assurance Program Plan (QAPP)* and the *Sampling and Analysis Plan* (SAP) for this contract. Quality Assurance/Quality Control (QA/QC) sampling and analysis will be performed to meet the requirements in the CSSA QAPP. The purge water from on-post wells will be containerized, transported and applied to the

SWMU B-3 Bioreactor for disposal. Further details on the groundwater sampling are included in the SAP.

3.3.2 Granular Activated Carbon Unit Installation and Maintenance

The GAC units are wholly operated and maintained by CSSA without cost or burden to the well owner. The GAC system maintenance includes effluent sampling and GAC carbon canister replacement as necessary for off-post GAC systems. Parsons performs two carbon changes per year (January and July) at each of the six off-post GACs. Pre- and post-GAC filters at each off-post GAC system are changed every three weeks, and each system is inspected at that time for proper operation.

Semi-annual post-GAC confirmation samples are collected from all wells equipped with GAC filtration systems. The samples confirm that the GAC filtration systems are working effectively and that VOCs are reduced to concentrations below the applicable drinking water MCLs. To date, no COCs have been detected above reporting limits in the post-GAC samples. The annual cost to maintain the seven GAC units is approximately $30,000. If future analytical results at off-post drinking water wells in the monitoring program indicate COC concentrations of 90% or greater of the MCL for PCE and TCE, a new GAC unit will be installed at the well, in accordance with the DQOs for the Groundwater Monitoring Program (Parsons, 2015d).

3.3.3 Data Validation and Verification

Analytical validation and verification includes issues related to analytical data, including oversight of sample collection and submittal efforts, interaction with the selected laboratory, data verification, data validation, and management of electronic analytical data. Groundwater results from the on- and off-post monitoring and drinking water will be validated in accordance with the CSSA QAPP (Parsons, 2003).

Parsons will oversee analysis for each sampling event, including reviewing each chain-of-custody for accuracy and completeness, verifying that the laboratory sample log-in sheets match the chain-of-custody forms, addressing any sample receipt issues (such as broken sample containers), and maintaining continuous contact with the laboratory regarding scheduling.

Laboratory data packages will be reviewed by Parsons chemists for completeness and adherence to the CSSA QAPP and the approved laboratory variances. All associated analytical QA/QC data will be examined, and all exceptions will be noted in both the case narrative and data verification report (DVR). Following verification of the laboratory data, the data usability as related to the project DQOs will be assessed. Validation will include examination of historical data (if available), laboratory data trends, and the reasons for data collection. Based on the overall assessment of the data, flags may be removed or changed to reflect usability of the data.

Electronic data submitted by the laboratories will be loaded into the CSSA GIS database, verified for accuracy, and updated to reflect all data qualifier changes incurred through the data verification and validation process. The data are in Environmental Resource Program Information Management System (ERPIMS) compliant format.

SECTION 4
COST ESTIMATE

Capital costs associated with this alternative include the cost to file a deed notice and update the Master Plan to restrict AOC-65 and SWMU B-3 to commercial/industrial land use. Also included in the capital cost estimate is one initial ISCO injection at AOC-65. Periodic costs include one additional or replacement GAC unit (i.e., the entire GAC system and not just the filters) every other year for a total of 15 additional or replacement units over a 30-year period. Periodic costs also include ISCO injections every 5 years on average for the next 30 years, and assume $450,000 every other year for new or replacement wells and general well maintenance. Operation and maintenance costs include maintenance and replacement of GAC filters; labor and laboratory costs related to sampling and project management of LTM for on- and off-post groundwater; and labor and laboratory costs related to LTM of the bioreactor (SWMU B-3) and the ISCO treatment area (AOC-65).

Table 4.1
Cost Estimate Breakdown for Corrective Measures at CSSA

Activity	Capital Costs	Periodic Costs	Annual Costs
Point of Use Treatment			
Maintenance and Replacement of GAC Filters			$24,498.00
Additional GAC Units (every 2 years)		$10,917.00	
On-Post Water Supply System Operations and Sampling			$144,048.00
Contingency (20% scope + 10% bid) - Alternatives 2 and 4		$3,275.10	$50,563.80
Contingency (20% scope + 10% bid) - Alternative 3		*$3,275.10*	*$43,214.40*
Total - Alternatives 2 and 4	**$0.00**	**$14,192.10**	**$219,109.80**
Total - Alternative 3	***$0.00***	***$0.00***	***$187,262.40***
Land Use Controls			
Administrative/Institutional Controls at SWMU B-3 and AOC-65	$1,000.00		
Contingency (20% scope + 10% bid)	$300.00		
Total	**$1,300.00**	**$0.00**	**$0.00**

Table 4.1
Cost Estimate Breakdown for Corrective Measures at CSSA
(*continued*)

Activity	Capital Costs	Periodic Costs	Annual Costs
On- and Off-Post Monitoring (Drinking Water and MNA)			
Groundwater Monitoring Plan Updates			$4,244.00
Quarterly Groundwater Monitoring			$131,414.00
Quarterly Groundwater Reports			$53,979.00
New/Replacement Wells and Maintenance		$450,000.00	
Other GW Monitoring			$40,449.00
Contingency (20% scope + 10% bid)		$135,000.00	$69,025.80
Project Management (10% of O&M + Contingency)		$58,500.00	$29,911.18
Total	**$0.00**	**$643,500.00**	**$329,022.98**
Source Area Treatment			
SWMU B-3 Bioreactor O&M			$370,000.00
AOC-65 ISCO O&M (initial, then every 5 years)	$11,500.00	$11,500.00	$140,000.00
AOC-65 ISCO Materials (initial, then every 5 years)	$472,597.00	$472,597.00	
Westbay Maintenance			$11,232.00
Project Management (10% of Total O&M)	$48,409.70	$48,409.70	$52,123.20
Contingency (20% scope + 10% bid)	$159,752.01	$159,752.01	$172,006.56
Total	**$692,258.71**	**$692,258.71**	**$745,361.76**
Total Capital Cost	**$693,500**		
30-Year O&M Cost	**$38.8M**		
30-Year Total Cost	**$52.8M**		
30- Year Total Present Value	**$23.5M**		

SECTION 5
PROJECT SCHEDULE

A project schedule detailing the implementation of the corrective measures described in this report is presented below.

Task Name	Frequency	Start	Finish
Administrative/Management			
Administrative Record Update	Quarterly	10/6/2014	10/2/2045
EPA Progress Reports	Semi-annual	1/12/2015	7/10/2045
Administrative Order Documents			
RCRA Facility Investigation Report	Once	8/4/2014	11/21/2014
CMS	Once	8/18/2014	1/22/2015
Statement of Basis	Once	10/6/2014	4/8/2015
EPA Issues Statement of Basis	Once	4/8/2015	4/8/2015
Public Comment Period	Once	4/9/2015	5/8/2015
EPA - Host Public Meeting	Once	4/23/2015	4/23/2015
Final Design Site Inspection	Once	6/8/2015	6/8/2015
CMI Program Plan	Once	2/5/2015	8/27/2015
CMD Report	Once	4/9/2015	1/25/2016
QA Program Plan	Once	11/2/2015	2/26/2016
CMI Report	Once	11/2/2015	2/26/2016
Decision Document	Once	7/10/2015	7/28/2015
Point of Use Treatment			
Maintenance and Replacement of GAC Filters	Ongoing	4/6/2015	12/31/2045
Additional GAC Units	Bi-annual	9/8/2016	9/8/2044
On-Post Water Supply System Operations and Sampling	Ongoing	4/6/2015	12/29/2045
Land Use Controls			
Implement Institutional Controls at SWMU B-3	Once	1/4/2016	1/4/2016
Implement Institutional Controls at AOC-65	Once	1/4/2016	1/4/2016
On- and Off-Post Groundwater Monitoring			
Groundwater Monitoring Plan Updates	Annual	3/9/2015	3/13/2045
Quarterly/Annual Groundwater Monitoring	Quarterly/Annual	3/14/2016	12/11/2045
Quarterly Reporting	Quarterly	8/8/2016	10/9/2045
Annual Groundwater Report	Annual	9/5/2016	9/4/2045
Annual Groundwater Fact Sheet	Annual	3/14/2016	3/13/2045
New/Replacement Wells and Maintenance	Bi-annual	9/11/2017	10/6/2045
Source Area Treatment			
SWMU B-3 - Bioreactor O&M			
SWMU B-3 O&M Plan	Once	6/18/2015	10/22/2015
O&M	Ongoing	4/6/2015	12/29/2045
Annual Performance Report/UIC Letter	Annual	6/13/2016	6/12/2045
AOC-65			
ISCO O&M	Initial, then every 5 yrs	9/8/2016	10/4/2041
Monitoring	Quarterly	11/16/2015	11/17/2045
Westbay Maintenance	Ongoing	4/6/2015	12/31/2045

SECTION 6
CONSTRUCTION QUALITY ASSURANCE OBJECTIVES

The *Construction Quality Assurance Plan for SWMU-B3 and AOC-65 Remedial Activities and Other Construction Activities* (Parsons, 2006) was prepared to provide guidelines for the implementation of construction quality assurance (CQA) during construction of remedial systems for effective and efficient operation at CSSA. The plan defines the roles, responsibilities, authorities, qualifications, and accountabilities for remedial actions at CSSA. Project personnel performing duties affecting costs, schedule, quality, safety, and environmental compliance are responsible for meeting the requirements established in the CQA Plan. The CQA Plan also outlines inspection activities, testing requirements, and documentation.

General guidelines for the implementation of CQA, described in detail in the CQAP (Parsons, 2006), are as follows:

- Periodic meetings held during the life of the project will clarify responsibility and authority associated with construction of the new or modified systems.
- Competent qualified personnel possessing appropriate experience and educational credentials (other than those who prepared the design documents being verified) shall perform the verification of all construction designs. Design verification shall include review of all disciplines to ensure design outputs have met the design inputs, and to evaluate the ability of the design and development to meet requirements.
- Design documentation and records, which provide evidence that the design and development verification, validation and interface reviews were performed, shall be collected, stored, and maintained.
- Records will be kept on all aspects of construction and operation including payment of contractor services, warranty documentation, as well as safety and health information backup. Most importantly, records, including As-Built Drawings are required to assure the systems have been constructed in conformance with the plans and specifications. Additionally, well-organized and complete records will allow proper operation and maintenance.
- Permitting support of the selected remedial action, data validation, as well as preparation of appropriate documentation necessary to optimize the performance of the bioreactor at SWMU B-3.

SECTION 7
HEALTH & SAFETY PLAN

The health and safety program for environmental remediation activities at CSSA has been in place for nearly 20 years. The initial HASP, prepared by Parsons in 1996, has been revised or rewritten throughout the remediation process to address changes in project requirements, and/or to implement any federal, state, or CSSA-specific safety requirements. The HASP and its addenda/revisions establish personnel protection standards and mandatory safety practices and procedures for all work conducted in association with environmental closure and compliance activities at CSSA. The HASP and its addenda/revisions are available in Volume 1.5 of the Environmental Encyclopedia (http://www.stanley.army.mil/Volume1-5/TOC.htm).

SECTION 8
DESIGN PHASES

8.1 SWMU B-3

Drawings and technical specifications for the bioreactor and associated extraction wells are included in the following documents:

- *SWMU B-3 Bioreactor Construction Report* (Parsons, 2007)
- *CSSA B-3 Extraction Well Construction Summary* (Parsons, 2010a)
- *Construction Summary for SWMU B-3 Extraction Well 02 (B3-EXW02) and Shallow Monitoring Wells (B3-MW26 through B3-MW34)* (Parsons, 2010b)
- *Final Well Installation Report [for B3-EXW03 and B3-EXW04]* (Parsons, 2011)
- *B3-EXW05 Well Installation Report* (Parsons, 2012b)

Equipment start-up and operator training are conducted on an as-needed basis if bioreactor components are updated or replaced, or if new employees are brought on to operate and maintain the system.

8.2 AOC-65

Drawings and technical specifications details for the ISCO injection system are included in the following documents:

- *Work Plan for AOC-65 ISCO Treatability Study* (Parsons, 2013)
- *2014 AOC-65 In-Situ Chemical Oxidation Assessment Report* (Parsons, 2015b)
- *Revised Work Plan Addendum for AOC-65 ISCO Injection* (Parsons, 2015a)

Equipment start-up and operator training are conducted prior to ISCO injection events.

SECTION 9
REFERENCES

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