100% FINAL DESIGN REPORT
OFF-SITE GROUNDWATER
BIOSPARGE PHASE I TREATMENT SYSTEM

HOOKER CHEMICAL/RUCO POLYMERS SUPERFUND SITE
HICKSVILLE, NEW YORK

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1.0 INTRODUCTION

1.1 PURPOSE AND ORGANIZATION OF REPORT

This report has been prepared on behalf of Miller Springs Remediation Management, Inc. (MSRMI) and presents the 100% Final Design submittal for the in situ bioremediation at the Hooker Chemical/Ruco Polymers Superfund Site (Hooker/Ruco Site) located in Hicksville, New York. The Hooker/Ruco Site is a 14-acre former polymer manufacturing facility. The Site location is shown on Figure 1.1.

The Site operated between 1945 and 2002 during which time some chemical releases into the hydrogeologic environment occurred. While the impacts to soils at the Site have been addressed through remedial activities, some impacts due to the historic chemical releases persist in the groundwater. The groundwater impact has migrated off-site and is now commingled within the regional groundwater. The studies that have been performed over the years have defined the horizontal and vertical extent of the chemical plume emanating from the Hooker/Ruco Site which is primarily characterized as a vinyl chloride monomer (VCM) plume. The Record of Decision (ROD) that was issued for the Site in 2000 determined that the appropriate remedy for the off-site groundwater plume of VCM (identified as Operable Unit-3) would incorporate the use of in situ biosparging. The ROD also included a contingency remedy involving pump and treat technologies if the biosparging was not able to achieve the remedial action objectives in a reasonable time frame.

In 2002, MSRMI submitted the "Off-Site Groundwater Predesign Information Report" to the USEPA which presented a conceptual design for the biosparging remedy. Since that time, through discussions with USEPA, NYSDEC, and Northrop Grumman Corporation (an adjacent industry), and the fact the VCM has migrated to well GP-3, the remedy has evolved into a dual remediation program involving both biosparge and pump/treat technologies. MSRMI has joined efforts with Northrop Grumman Corporation to address the leading (southernmost) portion of the VCM plume using Northrop Grumman's existing GP-1/GP-3 pump and treat facility. Northrop Grumman's facility is being operated to address Northrop Grumman's groundwater plume of VOCs. With some modification of the Northrop Grumman treatment facility, it can capably address the commingled Hooker/Ruco Site VCM plume and the Northrop Grumman VOC plume. These modifications are complete. Due to the relative size difference between the regional VOC plume and the VCM plume and the fact that the VCM plume is entirely encompassed within the lateral limits of the regional VOC plume, the VCM is often referred to as a subplume.

While the pump and treat technology will capture and remove the leading portion of the VCM subplume, the primary remedial technology for the VCM subplume remains in situ bioremediation. In situ bioremediation will involve the installation of two fence lines (middle and north) of air injection wells into the north/central portion of the VCM subplume and, potentially, individual air injection wells at select locations into the southern portion of the VCM subplume. The injection of air into the middle of the VCM subplume will increase the rate of natural degradation of the VCM into inert compounds as the subplume continues to migrate south toward the Northrop Grumman GP-1/GP-3 pumping system. The air injection in the two fence lines may promote sufficient degradation to eliminate the need for any additional injection wells in the southern portion of the subplume. In conjunction with the continued operation of Northrop Grumman's pump and treat system, the biosparge system should eliminate the need for any additional groundwater treatment of VCM downgradient of the Northrop Grumman system.

This 100% Final Design Report presents the planned remedial components associated with the two fence lines of biosparge injection wells. The design details for wells in the south portion of the subplume will be provided in a future document, if determined to be required based on the monitoring results of the two fence lines.

The report is organized as follows:

- Section 1 - Introduction: Discusses the purpose of the report and outlines the components of this final design submittal;
- Section 2 - Regulations: Lists the regulatory documents utilized in the design of the in situ bioremediation system;
- Section 3 - Design Basis: Discusses the design basis for the in situ bioremediation system;
- Section 4 – Biosparge Treatment System Design: Discusses the design of the components of the in situ bioremediation system;
- Section 5 - Specifications: Lists the specifications for construction;
- Section 6 - Permits: Discusses the permits required for the construction and operation of the system;
- Section 7 - Implementation: Presents the plan for implementation of the final design;
- Section 8 - Operation and Maintenance: Discusses the operation and maintenance of the system;
- Section 9 - Performance Monitoring: Discusses the Monitoring Program that will assess the effectiveness of the remediation; and

- Section 10 - Schedule: Presents the implementation, construction, and startup schedule.

1.2 FINAL DESIGN SUBMITTAL

The components of this 100% Final Design Submittal include:

i) Process engineering calculations;
ii) Specifications;
iii) Plans;
iv) Permit applications;
v) Construction Quality Assurance Project Plan;
vi) Construction Health and Safety/Contingency Plan;
vii) Draft Operation and Maintenance Plan; and
viii) Draft Implementation, Construction, and Startup Schedule.

2.0 REGULATIONS

2.1 FEDERAL REGULATIONS/GUIDELINES

The following Federal Applicable or Relevant and Appropriate Requirements (ARARs) were utilized or referenced during the design phase of the OU-3 biosparge treatment system:

i) 40 Code of Federal Regulations (CFR) 141: National Primary Drinking Water Standards - Maximum Contaminant Levels; and

ii) 40 CFR 141.50: National Primary Drinking Water Standards - Maximum Contaminant Level Goals.

iii) 40 CFR 144 (Subpart G): Underground Injection Control Program;

iv) 40 CFR 146 (Subpart F): Underground Injection Control Program Criteria and Standards;

v) 40 CFR 147 (Subpart HH): State Underground Injection Systems, New York; and

vi) "Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils" November, 2000 (EPA 530-F-02-052).

Under §144.84(14), the injection wells are Class V wells. It is noted that pursuant to §144.83 and §147.1651, the underground injection program for Class V wells in New York State is administrated by the EPA.

2.2 STATE REGULATIONS

The following State of New York ARARs were utilized or referenced during the design phase of the OU-3 biosparge treatment system:

i) 6 New York Code of Rules and Regulations (NYCRR) Parts 609, 700-704: New York Water Classification and Quality Standards;

ii) 10 NYCRR Part 5: New York Public Water Supply Regulations; and

iii) New York State Division of Air Resources 1 (DAR 1) AGCs and SGCs.

3.0 DESIGN BASIS

3.1 GENERAL

In accordance with the ROD, the objective of the remediation for Operable Unit-3 at the Hooker/Ruco Site is to reduce contaminant levels in the groundwater within a period of approximately 12 years after startup of the entire system to achieve State drinking water standards or Federal MCLs; to prevent the need for supplemental treatment at the Northrop Grumman Treatment System; and to protect human health and the environment from risks associated with the contaminated groundwater. This will be accomplished using in situ bioremediation treatment of the VCM subplume using biosparging (with supplemental nutrient addition, if necessary). The contingency of relying solely on a pump and treat system (as is being used for the southernmost portion of the VCM subplume) can be implemented if biosparging is shown not to be able to achieve the remedial action objectives in a reasonable time frame for the VCM subplume.

The VCM subplume is a small component of the regional VOC plume. The groundwater in the regional VOC plume is generally aerobic and conditions amenable for the natural attenuation of VCM in the regional groundwater are present. Thus throughout most of the regional VOC plume area, VCM degradation could be occurring. However, in the middle of the VCM subplume, the available oxygen has been depleted and needs to be replenished. Once replenished, natural attenuation of VCM by the oxidation pathway will be enhanced. The replenishment is intended to be provided by the addition of dissolved oxygen through air injection. Carbon sources may also be needed to be injected into the VCM subplume to stimulate and maximize VCM degradation.

The current estimated areal limit of the VCM subplume is shown on Figure 3.1. A cross-section of the VCM subplume from the Site through to the vicinity of GP-1/GP-3 is shown on Figure 3.2.

3.2 SUMMARY OF PREDESIGN ACTIVITIES

To obtain the information needed to assist in the design of the OU-3 biosparge remedy, OxyChem aggressively undertook a number of predesign activities. These predesign activities included:

i) groundwater sample collection from 26 wells in May and June 2001 for natural attenuation (NA) parameters;

ii) groundwater sample collection from 19 wells in October 2001 for NA parameters;

iii) injection testing of 8 existing wells to obtain technical information regarding the physical aspects of implementing the biosparging technology;

iv) installation of new monitoring wells at 10 locations to refine the delineation of the VCM subplume;

v) groundwater sample collection and analyses of the newly installed wells and 3 existing well nests. The newly installed wells were also sampled and analyzed for NA parameters; and

vi) performance of a laboratory study involving microcosm slurry testing to examine the effect of supplementation of air, inorganic nutrients, and carbon sources on the VCM biodegradation rate.

The results of these investigations and evaluation of the results were provided in the report entitled "Off-Site Groundwater Predesign Information Report" dated November 2002. In addition, groundwater samples were collected from 13 wells in August 2004 for VOCs. A summary of these activities is provided in the following subsections.

3.2.1 NATURAL ATTENUATION EVALUATION

The Natural Attenuation evaluations included the data collected by OxyChem in December 1998, which were presented in the OU-3 RI Report; the data collected by Northrop in the third quarter of 2000 and in the second quarter of 2001; and the data collected by OxyChem in the second quarter of 2002. The evaluation provided a summary of the NA conditions throughout the TVOC plume.

The NA evaluation indicated that the groundwater in the regional TVOC plume is generally aerobic, except immediately downgradient of the Hooker/Ruco Site, where it is anaerobic. The proper aerobic conditions exist around all of the VCM subplume edges and in the regional groundwater outside of the VCM subplume which are amendable for VCM degradation. Aerobic conditions are indicated by the presence of substantial DO, sulfate, and nitrate/nitrite, high ORP, and low or non-detect values for Mn^{2+}, Fe^{2+}, sulfide, and methane. However, in the core of the VCM subplume, the available oxygen has been depleted and needs to be replenished to ensure enhanced aerobic degradation of the VCM subplume. Visualization of the spatial distribution of redox conditions in the vicinity of the Hooker/Ruco Site is presented through the use of radial diagrams produced using the computer visualization program SEQUENCE version 1.1 (Environmental Software Solutions, 1998). The spatial distributions of redox conditions in the groundwater using this visualization technique are presented on Figure 3.3 for the regional groundwater and on Figure 3.4 for the area of the VCM subplume. The redox indicator parameters DO, NO_3^-/NO_2^-, Fe^{2+}, SO_4^{2-}, and methane are presented on each radial diagram. The redox radial diagram for each monitoring well location is overlaid with the radial diagram representative of background conditions. The axis for each redox indicator parameter is set up in such a manner that decreasing groundwater redox potential (i.e., conditions conducive to reductive dechlorination) is apparent when the area representing monitoring well groundwater conditions shrinks relative to background conditions (wells A-1 and R-1).

In summary, the redox conditions in the TVOC plume are generally aerobic. Aerobic conditions are conducive to the degradation of VCM. However, continued degradation in the VCM subplume may become limited by the lack of carbon sources and potentially by a lack of phosphorus. Natural attenuation of VCM by biodegradation has occurred via reductive dechlorination in the vicinity of monitoring wells MW-50J1, MW-50J2, MW-52S, and MW-52I. Natural attenuation of VCM by the oxidation pathway will be enhanced by the addition of dissolved oxygen and carbon sources in the VCM subplume. PCE and TCE biodegradation is limited, but has occurred historically as demonstrated by the presence of cis-1,2-DCE in the PCE/TCE plume wells, boundary wells, and downgradient wells. This slow degradation is likely due to the presence of aerobic conditions which inhibit PCE degradation and retards TCE degradation. Some of the PCE and TCE that have already degraded to DCE may have already further degraded directly to chloride, water, and carbon dioxide via aerobic processes available in the TVOC plume.

In summary, the NA data leads to the following key observations:

i) The distribution of redox parameters indicates that, in general, groundwater in the regional area is aerobic and oxidative biodegradation of VCM to chloride and carbon dioxide could be occurring;

ii) The redox parameters in the center of the VCM subplume indicate that the groundwater in this area is anaerobic;

iii) Natural attenuation of VCM by the oxidation pathway will be enhanced by the addition of dissolved oxygen and carbon sources in the VCM subplume;

iv) VCM anaerobic degradation products (ethane and ethene) were observed at monitoring wells MW-50J1, MW-50J2, MW-52S, and MW-52I, indicating that anaerobic biodegradation of VCM by reductive dehalogenation has occurred in the VCM subplume;

v) The PCE and TCE degradation product cis-1,2-DCE was observed in the regional TVOC plume wells and downgradient monitoring wells in association with the parent compounds, indicating that anaerobic degradation of PCE and TCE has occurred historically in some locations; this process is unlikely to occur under the current, predominantly aerobic conditions; and

vi) The DCE may be degrading directly to CO_2, chloride, and water because of the aerobic conditions. This is likely why VCM is not being detected outside the limits of the VCM subplume.

The results of the natural attenuation evaluation indicated that destructive natural attenuation processes have contributed to the reductions in PCE, TCE, and VCM concentrations over time. They have resulted in the biotransformation of some PCE, TCE, and VCM to relatively innocuous compounds (i.e., ethene, ethane, methane, chloride, carbon dioxide and water). However, continued PCE and TCE degradation will be slow to occur in the TVOC plume due to the predominantly aerobic conditions. Similarly, continued VCM degradation in the VCM subplume will be slow to occur due to the predominantly anaerobic conditions and lack of additional election donor therein. VCM degradation can be significantly enhanced by the addition of oxygen and may be further enhanced by the addition of carbon sources and, potentially, nutrients into the VCM subplume.

3.2.2 INJECTION TESTING

Injection testing was performed to determine the physical practicality of injection and to provide insightful information that was applied to the design of the proposed biosparging system for the VCM subplume. Data was collected to determine air injection capacity and to assess impacts to the groundwater quality.

The principal results obtained from the injection testing were:

i) the formation has the capacity to easily accept the planned air flow rates;

ii) the addition of both liquid and gas amendments were practical;

iii) air plugging of the formation is unlikely to occur;

iv) DO can permeate into silty intervals that do not accept injected air directly;

v) water injection can be used to redevelop wells that decrease in air capacity;

vi) no detectable vapors should reach the ground surface; and

vii) the injection tests were not run long enough to establish an area of influence for an individual well. Such establishment was not an objective of the testing performed. The design strategy is to install and operate Phase I of the biosparge system over a longer term to determine an effective well spacing for a full scale remedial system.

Other operational issues regarding an injection system that were considered in the proposed design. These are discussed in the following sections.

Oxygen Demand: Estimation of the air flow required to match the total oxygen demand of reported analytes in groundwater in the VCM subplume was calculated to be 30-40 hours of sparging at 100 scfm per well for initial aeration, and 3-4 hours per month per well to keep up with groundwater inflow to the well from the upgradient portion of the aquifer. This assumes a 100 ft spacing, and a ten foot overlap of influence between the injection wells.

To ensure sufficient oxygen will be provided, the initial aeration period will be 40 hours, and two 8-hour injections will be made per month.

Silting of wells: This may be caused by the vibration of normal sparge operations or the too-rapid shutting on or off of the sparge system. In sparging MW-52D, a reduction in air injection capacity was seen at one stage, which was overcome by the sugar byproduct solution injection. Thus, it is expected that capacity may be recovered by injection of a slug of water which would force the sediment either out of the well or back into the formation. It may also be prudent to disinfect the water slug with hypochlorite to discourage biofouling of the screen.

Air plugging of the formation: Air or nitrogen residual after oxygen is consumed could occupy pore space in the aquifer even after sparging, and that such aerated areas could affect groundwater flow paths. This possibility is not supported by the test data and pragmatic experience.

Vertically continuous volumes of gaseous air will continue to rise even after sparging ceases, possibly forming transitory extended gas lenses under finer grained traps, but will not hang in place. As long as an air body is continuous in the sand, it will flow upward following the pressure gradient. If it breaks up into discontinuous bubbles where buoyancy is insufficient to overcome the air entry pressure (that is, to push into saturated pores), it can divert local water flow on the scale of the bubble, but not macro-scale water flow.

Sparged air flows in finger channels rather than continuous sheet structures, so that even in active sparging there is no damming of groundwater flow.

Possible stripping of volatiles to the surface: This is unlikely to occur, even if sparging is sustained for some time. To verify that this does not occur, vadose zone monitoring points will be installed. Data from the field tests suggest that vapors stripped from below the water table should not be detectable at the surface, but this will be demonstrated by monitoring.

3.2.3 GROUNDWATER CHEMICAL PRESENCE

The areal extent of the VCM subplume is shown on Figure 3.1.

As presented in the OU-3 RI Report, the pattern of VCM analytical results with time for GP-6, GP-8, and GP-14 showed that when these three wells were pumping, they reinforced the natural north to south groundwater gradient and drew VCM toward them from areas to the north and northwest of these wells. These pumping wells also helped draw the VCM to deeper portions of the aquifer. This pumping scenario resulted in the creation of two prongs of VCM migration, one to the area of GP-6 and the other to the area of wells GP-8 and GP-14. This occurred until 1992 when these wells were turned off. It is believed that chemicals potentially attributable to the Hooker/Ruco Site migrated to and were captured by these wells prior to 1992 and that the most southerly extent of the VCM subplume prior to 1992 was GP-6.

When pumping stopped at GP-6, GP-8, and GP-14 in 1992, the groundwater flow system returned to a more natural condition in the areas of these wells. However, the natural north to south gradient was still being maintained by the pumping of GP-1 and GP-3 which are located further downgradient. With the pumps at GP-6, GP-8, and GP-14 no longer drawing the VCM toward them, the chemicals in the VCM subplume have migrated with the natural southerly groundwater flow and are converging on the flow paths associated with the pumping of Northrop wells GP-1 and GP-3.

An evaluation was performed to determine if the current southerly extent of the VCM subplume is consistent with the conceptual understanding of the groundwater flow system. Using the hydraulic conductivities and porosities assigned to the groundwater flow model presented in the OU-3 RI Report and the gradients listed in Table 4.1 of the

PDIR, interstitial groundwater flow velocities were calculated for four intervals of the formation (shallow, intermediate, deep, and very deep). As shown on Figure 4.8 of the PDIR, the VCM subplume from the area of GP-6 to GP-3 is located in the very deep interval. The rate of groundwater flow at this depth is on the order of 0.4 ft/day. For the time period from the end of 1992 to the end of 2004 (12 years) the groundwater travel distance would be on the order of 1750 feet which is slightly less than the 1900 feet between GP-6 and GP-3. Given the increase in velocity as water approaches a pumping well, it is not unreasonable to expect that the leading edge of the VCM subplume has reached GP-3. This is supported by the groundwater results from GP-3, which show VCM concentrations greater than 5 μg/L starting in October, 2000.

3.2.4 MICROCOSM STUDY RESULTS

To complement the field activities, a laboratory study involving microcosm slurry testing was performed to examine the effect of supplementation with air, inorganic nutrients, and carbon sources on the VCM degradation rate. Sugar byproducts, propane, and methane were selected as the supplemental carbon sources for the study.

The microcosms amended with carbon sources all showed significant VCM degradation, indicating that organic carbon supplementation enhances VCM degradation. Two percent methane amendment produced the largest VCM reduction (42 percent), followed by sugar byproducts and 0.4 percent propane (40 and 38 percent reduction, respectively), while 2 percent propane was less effective (16 percent reduction). Methane was not significantly reduced in the headspace in the methane-amended microcosms, suggesting that the methane cometabolic pathway may not have been occurring or that its acclimation period was longer than 20 weeks. VCM degradation in the microcosms amended with carbon was more significant after week 4, suggesting that there may be an acclimation period before aerobic degradation is enhanced. It is anticipated that the enhanced biodegradation of VCM would have continued after week 20 until either the carbon, nutrient, or oxygen sources were exhausted.

Based on the results of the laboratory study, it is recommended that carbon supplementation be included in the final air injection design. The most effective forms of carbon sources for supplementation were low concentrations of sugar byproducts and propane. The two sources were very similar in their ability to increase VCM degradation; therefore, the choice of the source (i.e., sugar by-products) was made based on the ease of field addition and the need for lateral (sugar byproducts) vs. vertical (propane) distribution. There will likely be a acclimation period before VCM degradation begins to accelerate.

While the rate of VCM degradation in the microcosms were not limited by nutrients, (because di-ammonium phosphate was added to each microcosm), it is possible that nutrients may become a limiting factor for degradation of the VCM subplume as those nutrients already present in the formation are consumed by the biodegradation processes, especially when it is accelerated. Performance monitoring results of the biosparging system will be used to determine if it is necessary in the future to supplement the nutrients.

3.3 SELECTION OF BIOSPARGE SYSTEM

One of the major components of the work performed in 2002 involved the field testing of air injection as a remedial technology. The testing was performed to determine the physical practicability of injection and to provide insightful information that could be applied to the final design of the proposed biosparging system for the VCM subplume.

Sparging pilot tests were conducted in the summer of 2002 using existing monitoring wells from two areas; the Hooker/Ruco Site and Northrop Grumman's Plant 12. A trailer unit equipped with controls, instrumentation, and gas addition capacity was constructed. A second trailer equipped with a 200 psi – 400 scfm compressor was also delivered to the Hooker/Ruco Site. The testing primarily consisted of air being delivered to one wellhead at a time, and injection capacity and impacts in the injected and adjacent wells being monitored over several days in each test.

The principal results obtained from the injection testing were:

i) the formation has the capacity to easily accept the planned air flow rates;

ii) the addition of both liquid and gas amendments were practical;

iii) air plugging of the formation is unlikely to occur;

iv) dissolved oxygen can permeate into silty intervals that do not accept injected air directly;

v) water injection can be used to redevelop wells that decrease in air capacity; and

vi) no detectable vapors should reach the ground surface.

The next step of the design strategy is to install and operate the Phase I system over a longer term (i.e., 1 year) to determine an effective well spacing for a full scale remedial system. This Phase I system is the subject of this scope of work and is discussed in detail below.

4.0 BIOSPARGE TREATMENT SYSTEM DESIGN

4.1 GENERAL

The planned remedial action will focus on developing an injection system that is capable of delivering the necessary components (oxygen and carbon sources) to create conditions conducive to aerobic degradation of VCM within the VCM subplume. The remedy will primarily concentrate on the central core areas of the VCM subplume where elevated concentrations have been found to exist. Once the concentrated VCM areas have been remediated, the peripheral low concentrations are expected to be susceptible to the naturally occurring degradation conditions that exist, or will be created, in the groundwater resulting in a collapsing reduction of the VCM subplume.

The design basis for the biosparge treatment system is presented in Section 3. This section describes the various aspects of the design.

The main core of the biosparge treatment system is the control center. The control center building will be located on a parcel of property currently owned by Northrop Grumman that is set west of South Oyster Bay Road and south of Hazel Street. The Northrop/Grumman pumping well GP-6 was historically located on this parcel. This location was selected due to its proximity to the middle injection well fence line and its availability.

The control center facility includes process equipment designed to inject air and a carbon source into the main VCM area in order to catalyze VCM degradation.

Details of the injection system design are presented in Section 4.2. Design drawings for the injection system and the control center building are attached separately. The list of design drawings is contained in Appendix B.

4.2 DESIGN BASIS

This remedy consists of the injection of air at a rate sufficient to convert the generally anaerobic conditions in the groundwater downgradient of the injection wells located within the VCM subplume to aerobic conditions and then supply sufficient oxygen to continue to maintain aerobic conditions as biodegradation of the chemical compounds, principally VCM, occurs. This remedy will also take into consideration the requirement that the air flow rate selected will not result in the release of VOCs to the atmosphere. To accelerate the rate of biodegradation, low level concentrations (approximately 5 to

10 mg/L) of a carbon source (i.e., sugar byproducts) will also be injected. If monitoring shows that biodegradation is being inhibited by insufficient nutrients, nutrients will be added through the use of diammonium phosphate (DAP) or a similar material. The particle tracking results provided in the May 27, 2004 submission to the USEPA showed that the entire VCM subplume will be captured by either the combined pumping of GP-1/GP-3 at pumping rates of 1075 and 375 gpm, respectively, or the pumping of GP-1 only at a pumping rate of 1075 gpm. Thus, any amendments injected into the aquifer and not consumed, will be captured and will not impact areas outside the containment area of GP-1/GP-3.

The distance from the most downgradient injection wells to the groundwater extraction wells must be large enough to allow sufficient contact time between the VCM and the injected air/carbon source to achieve biodegradation of the VCM to the selected target concentration before reaching extraction well GP-3. It is recognized that VCM degradation will continue to occur as long as there is sufficient oxygen, carbon source, and nutrients available in the groundwater. Therefore, it is expected that VCM degradation to non-detect concentrations is possible as long as the conditions conducive to degradation are maintained.

4.3 INJECTION SUPPLEMENTS

The results of the groundwater sampling and microcosm testing performed during the predesign phase of this project identified that there may be components necessary for biodegradation, other than just oxygen, that prove to be rate limiting. The first of these is a suitable carbon source. Although some carbon source is present in the groundwater, monitoring throughout the area identified that the groundwater carbon concentration (as measured by TOC) was very low and in many cases, non-detect at 1 mg/L. In addition, microcosm studies showed that aerobic biodegradation was enhanced considerably by supplementation with carbon sources. Thus, to accelerate the aerobic biodegradation of VCM, low level concentrations of a carbon source will be injected. Based on the microcosm results, the preferred carbon source is sugar byproducts.

4.4 OXYGEN MASS LOADING

The proposed air injection system is comprised of two injection well fences with 10 and 12 injection locations for the middle and northern fences, respectively (see Drawings CI-01 and MP-01), and potential individual injection wells in select locations in the southern portion of the subplume (see shaded area on Figure 3.1). Up to three injection wells at different depths will be installed at each injection location. Air injection will be initially performed at least twice monthly. It is believed that the periodic stop/start of the injections will result in better distribution of the injected materials into the formation since a slightly different flow path will be created by each injection, thereby spreading through more of the formation. Continuous injection is not needed since the groundwater only flows at a rate of 0.4 ft/day (12 feet/month) and sufficient air can be injected in a short time period to saturate the volume of water that surrounds each injection well. The semi-monthly injection schedule will be evaluated during the early operations period of the full scale Phase I system and adjusted as necessary to ensure that the air distribution is sufficient to achieve the targeted VCM reductions. Air will be pulse injected into each well on a rotating basis cycling between the deeper and shallower injection points. The initial air flow rate for each well will be approximately 100 scfm for 8 hours twice per month following the initial oxygen saturation injection at each well which is expected to take on the order of 40 hours (based solely on a theoretical calculation assuming even distribution throughout the subplume and a 10% efficiency). At this flow rate, approximately 2,880 pounds of oxygen, at an efficiency of 10 percent, is anticipated to be delivered per month along the middle injection fence (when fully constructed).

4.5 BIOSPARGE SYSTEM

4.5.1 INJECTION WELL LAYOUT

A number of remedial injection well layouts were evaluated in order to determine which would be the most appropriate for the VCM subplume. Based upon the evaluation, it was determined that the use of two injection well fences (north and middle) and potential injection wells at select locations in the south provides the best solution for the VCM subplume. Each injection well fence/individual well location will inject the air and carbon source into the concentrated VCM intervals in sufficient quantity to insure that the desired aerobic degradation conditions are created. The duration of aerobic exposure is then the major component that allows the degradation to occur. As long as each necessary component is present in sufficient quantity, the aerobic degradation process will continue and will eventually degrade all of the VCM present. By using this method, the treated water from the north injection fence will eventually migrate to the middle injection fence which will then allow the middle injection fence to cease operation. In turn, the treated water from the middle injection fence will subsequently reach the southern portion of the VCM subplume. The need to install injection wells in the southern portion of the subplume will depend on the VCM concentrations monitored. Eventually, the treated water will reach the Northrop Grumman GP-1/GP-3 extraction system and will not require any further treatment for VCM removal.

The plan for the injection well layout consists of two fences of injection wells as shown on Figure 3.1 and Drawing CI-01 and potential injection wells in the shaded area shown on Figure 3.1. The lines are spaced approximately 700 feet apart (equivalent to approximately 5 to 7 years of groundwater travel time). These two fence lines of injection wells are expected to result in a substantial reduction in the overall length of time that the VCM remedy must operate.

4.5.2 INJECTION WELL INSTALLATIONS (SEE DRAWINGS CI-01, MP-01, MP-05, AND MP-06)

There will be 22 injection wells in two fence lines. Twelve wells are to be installed in the north fence line and ten wells are to be installed in the middle fence line. The actual number of injection wells may vary due to field conditions identified at the time of installation of the wells. The wells will be installed in the following sequence to assist in this determination:

i) the wells at the center core of the VCM subplume will be installed first at each fence line; and

ii) subsequent wells will be installed out to the east and west edges of the VCM subplume.

The borehole for the injection and monitoring wells may be drilled by either the hollow-stem auger/mud rotary (HSA/MR) method or the rotary sonic method.

For the HSA/MR method, soil samples will be collected at 20-foot intervals using a split-spoon sampler for the entire depth of the borehole. Soil samples will not be collected from the borehole for vadose zone wells. The samples will be screened with a PID equipped with a 10.6 eV lamp, immediately when the split-spoon samples are opened. In addition, after drilling is completed, geophysical logging (i.e., natural gamma, single point resistance, and spontaneous potential) will be performed.

For the rotary sonic method, a continuous soil core will be collected. The entire core will be screened with a PID. No geophysical logging will be performed.

For both borehole installation methods, groundwater samples will be collected from approximately 50-foot intervals. The interval between collected groundwater samples may be slightly adjusted taking into consideration the results of the PID readings. Groundwater collection will start at a depth of approximately 200 ft bgs for the north fence and 300 ft bgs for the middle fence based on the current definition of the depth to the top of the VCM subplume (see Figure 3.2).

Samples will not be collected from boreholes that are located within 25 feet of a borehole previously sampled (e.g., MW-83/VZ-10 which are located 20 feet downgradient of IW-16). For both methods, the groundwater and soil samples will only be collected from the deepest borehole at each location which has multiple boreholes.

The PID, groundwater, and geophysical (if collected) results will be reviewed to select the appropriate interval for the well screen.

The rationale for the selection of the depth of the coreholes is the depth of the measured bottom of the VCM subplume at the location of the injection fences/wells. As shown on Figure 3.2, the depth of the borehole will extend approximately 50 feet below the previously measured bottom of the VCM subplume. This will ensure that the borehole will fully penetrate the VCM subplume and allow selection of the appropriate intervals in which to install the injection wells. Confirmation that the bottom of the plume has been reached will be provided by the PID readings and the groundwater sample that will be collected from or near the bottom of the borehole.

The groundwater data will be collated with the measured soil headspace readings and reviewed to determine whether another well further out along that particular fence line is needed. A minimum of six wells at 100 foot centers will be installed along each fence line.

The borehole will be 6 to 8 inches in diameter depending upon whether two or three well screen intervals are needed for air injection. One air injection well screen will be set at the base of the high permeability layer that contains the elevated VCM concentrations. A second air injection well, complete with its own screen, will be installed approximately 20 feet below the base of the previously identified high permeability layer. This well screen must also be set in a high permeability layer and is intended to provide an upward cascading air pocket through the entire overlying VCM impacted interval. If necessary, a third air injection well, complete with its own screen, may be installed above the high VCM concentration layer if a second high VCM concentration layer is identified. This third air injection well screen is unlikely to be needed. All of the air injection well screens and riser pipes will be 1 inch diameter.

In addition to the air injection well screens, each well will be equipped with one liquid supplement injection well and screen. The setting for the 15-foot long screen (maximum) liquid supplement injection well will be from just above the base of the high permeability layer that has the highest VCM concentration. A shorter screen may be used to prevent hydraulic connection through a clay layer. At this elevation, the base of the liquid supplement injection screen will be the same elevation as the top of the adjacent air injection screen. This will allow for maximum dispersion of the injected liquids by the air injections.

4.5.3 INJECTION WELL SPACING (HORIZONTAL)

The injection wells along each fence line are set at a spacing of 100 feet and are connected by an air supply forcemain. Should it be determined, based on performance monitoring, that a closer spacing is needed at select locations, additional wells can be installed and tied into the forcemain.

It is noted that as the groundwater flows towards GP-3, it is anticipated that the groundwater flow paths will merge together, thereby creating better contact of the injected materials with the VCM impacted groundwater that flowed between the effective radius of the individual injection wells. In addition, the injected materials will at least initially disperse both horizontally and vertically as they are injected and to some degree as southerly migration continues. This natural distribution of injected materials with the converging VCM impacted groundwater will make the remedy more effective as the groundwater continues to flow south. The monitoring described in Section 9.0 will determine the correctness of the above.

4.5.4 INJECTION WELL SPACING (VERTICAL)

The injection points for the wells were strategically placed so that either gases or liquids can be injected into or near the high concentration portion of the VCM subplume. The method of air injection relies on the pressure gradient created by the air injection to distribute oxygen vertically above the point of injection. It will be most effective to inject air in between the fine-grained lenses that define the high VCM concentration subplume and also into the interval beneath the underlying fine-grained unit. Thus, multiple injection points will be used at each individual well that make up the injection fence. Within the VCM subplume, the gases will be injected into the bottom of the defined permeable interval (the permeable zone containing elevated VCM concentrations that is sandwiched between two low permeability layers). Injecting into the bottom of the permeable zone will allow the gases to rise and disperse as much as possible throughout the entire permeable interval. The reason for also injecting gas below the fine-grained lenses that define the high concentration VCM subplume is that such injection will result in better areal distribution of the air. The air will find its own path around the lenses and bubble up through the high concentration portion of the VCM subplume. Bubbling up of the air will occur as dictated by the slope of the underside of the discontinuous and randomly located clay lenses. Nonetheless, with the overlap of gaseous injections from neighboring injection wells along the fence, a continuous upward cascading curtain of gases will develop which will spread oxygen through the desired permeable unit.

For liquids, it is likely to be more effective injecting directly into the high concentration VCM plume. Mixing will be assisted by the air injection process and also more significantly by the natural flow/dispersion forces that exist in nature.

When injecting directly into the high concentration subplume interval, the air injections will occur via screens set just above the top of the underlying clay layer. From this release point, gases will bubble up through the high concentration subplume (and be trapped under the overlying clay layer). Liquids will be released throughout the flow interval. The VCM within the interval will pass through the injected fluids present throughout the interval as the VCM continues its downward migration to the lower depths of the screened intervals of GP-3/GP-1 (see Figure 4.1).

Each air injection well will be constructed of 1-inch diameter black steel pipe with one 5-foot long stainless-steel well screen. In cases where multiple wells will be installed in one borehole, a cement/bentonite seal will be installed between each screened interval. Typical injection well details are shown on Figure 4.1.

4.5.5 FORCEMAINS (SEE DRAWINGS MP-01 THROUGH MP-06)

The injection well forcemains will consist of two completely separate piping systems. The air portions of the forcemain system will be wrapped (for corrosion resistance) Schedule 80 carbon steel pipe. High density polyethylene (HDPE) pipe (SDR11) will be used for all direct buried underground forcemains that are used to distribute the liquid supplements throughout the system.

The forcemain piping configuration is presented on the Design Drawings in Appendix B. Forcemain design calculations are contained in Appendix A. Sizing of the liquid supplement forcemain piping is based on maintaining a fluid velocity between 3 and 5 feet per second (based on 25 gpm) while at the same time maintaining a certain diameter pipe to allow easy cleaning during maintenance. Air line sizing is based on maintaining a minimum pressure drop in the pipe in order to minimize the size of the compressor.

The maximum internal pressure at any point in the air forcemain piping system is not expected to exceed 200 pounds per square inch gauge (psig).

4.5.6 AIR/LIQUID DISTRIBUTING SYSTEMS (SEE DRAWINGS MP-01 THROUGH MP-06)

4.5.6.1 GENERAL

The primary components of the biodegradation remedy are the air distribution system and the liquid supplement (sugar byproducts) delivery system. Air distribution to the injection wells will consist of the following sub-systems:

i) air compressor; and

ii) air distribution forcemains, and control and power cables to the well points.

Liquid supplement distribution to the injection wells will consist of the following sub-systems:

i) liquid supplement mixing unit; and

ii) liquid amendment distribution forcemains, and control and power cables to the well points.

For the air distribution system, the air will be supplied by an electric driven air compressor. The air compressor will be housed in a permanent structure at the control center. The control center will also house a liquid supplement mixing unit, a workstation for the operator, a washroom, and an equipment cleaning station. The structure will likely be a prefabricated, insulated, and weathertight modular building, with approximately 1000 square feet of space (e.g., 28 x 38 feet). The building will be placed on a compacted gravel base for support and will have an oversized door. The building will be split into two main areas; one for the office and controls and one for the compressor and mixing unit. The office/control portion of the building will have HVAC for heating and cooling while the equipment side will only have heating.

The air from the compressor will be directly piped to each individual injection well head via a main supply forcemain, with appropriate valves at each individual well head. The main air supply forcemain will consist of a 3-inch diameter steel pipe that will be connected to each individual injection well via a 1 1/2-inch diameter steel pipe equipped with a motorized valve. If gas supplements are needed at a future date, they will be injected via the same air lines. A main supply forcemain constructed of 1-inch HDPE pipe will also be installed to supply the liquid supplements. The main liquid supply forcemain will be connected to each individual injection well via a 1 1/2-inch diameter steel pipe equipped with a motorized valve. The air and liquid pipe networks are completely independent from each other.

The valves at each individual well head will be activated from the control center. Control and power cables will be linked from the control center to the well heads in separate 2 or 3-inch diameter conduits. Separate conduits are needed so that the power in the power cables do not create false signals in the control cables. The forcemains, conduits, and cables will be of sufficient capacity to allow for the installation of injection wells at 50-foot spacings along each fence line, should the need for additional wells be determined.

The airflow to the injection wells will be controlled by a variable speed drive (VFD) on the compressor and flow meter contained in the permanent structure. The flow meter will send a flow signal to the controller which will automatically control the VFD to maintain a constant flow. If the flow falls below a set rate, an alarm will sound. Each injection well has a maximum of three air injection points. Each point has an automatic shutoff valve, flow indicator, and manual valve to allow for fine tuning of the air flow. The total flow from the control building can be directed down more than one well by opening one or more of the automatic valves. If more than one point is utilized at a time, the flow must be manually adjusted at the wells to insure that each well is receiving air. This manual adjustment only needs to occur once the first time the combination of injection wells is used to fine tune the air release into each well. This is due to the fact that slight differences in well screen elevations, as measured with respect to depth below the water table, can result in different pressures being required to depress the water table to the top of the well screen to allow the air to be released into the groundwater formation. If the pressure differential between two wells is too large, the air will preferentially be released into the well that has the least water table height above it.

The liquid supplement flow to the injection wells will be controlled by a mixing unit, a control valve, and flow meter, which will also be contained in the permanent structure.

The liquid supplement will be fed from the automatic mixing unit into the main water supply and then on to the wells. The flow meter will send a flow signal to the controller which will automatically control the valve to maintain a constant flow to the wells. If the flow falls below a set rate, an alarm will sound. Each injection well has one liquid injection well point which extends into the formation to a point just above the base of the permeable interval that contains the highest VCM concentration. Each well point has an automatic shutoff valve, flow indicator, and manual valve to allow for fine tuning of the liquid flow. The total flow from the control center building can be directed down more than one well by opening one or more of the automatic valves. If more than one point is utilized at a time, the flow may have to be manually adjusted at the wells to compensate for pressure differences. Again, this will be necessary to insure that each open well is receiving the intended liquid supplement.

Water without supplements will be used to flush the pipeline after each liquid supplement injection to help prevent bio fouling of the supply lines, well screens, and the soils immediately adjacent to the well screen. The liquid supplements, which will be small in volume, will also be injected prior to air injection whenever possible so that the large volume of injected air will assist in the distribution of the liquid supplement in the groundwater formation.

If available, treated groundwater from Northrop Grumman's GP-1/GP-3 treatment system will be used. If not available, city water will be used. The advantages of this groundwater are as follows:

i) the treated water is not chlorinated;

ii) the treated water has to be reinjected into the groundwater formation anyway under the rules and regulations of the local water district administration (at the present time it is reinjected at the ground surface); and

iii) the treated water has a high dissolved oxygen content due to having been run through the Northrop Grumman treatment facility air stripper.

As previously discussed, the control instruments for each well will consist of local flow and pressure indicators, and an automatic valve. The operating status of the valve will be displayed in the control room (e.g., Open or Closed). Also, each flow indicator is equipped with a flow switch to indicate that the well is accepting flow. Injection pressures will be maintained below the formation rupture pressure. Furthermore, to reduce potential silting of the well, air injections will be applied and relaxed gradually over several minutes.

The main panel in the control center will contain a Programmable Logic Controller (PLC) by Allen-Bradley to control the operation of the system. The PLC will allow interfacing with an operator from a personal computer (PC) running a Human Machine Interface (HMI) software package by Intellution. An HMI is a graphical operator interface package that will operate, in this case, under a Windows software operating system.

The system, once set up, is intended to run in an automated mode and will not require an operator. Operator presence at the facility will only be required during the initial set up, to respond to major alarms of the system, and for routine operation and maintenance.

The operator will initiate the injections from the PC and the injection sequence will continue until stopped from the PC by the operator or the controls measure an alarm condition (e.g., pressure too high) which will shut the system off. The sequence can also be programmed to start over once it has been completed. The PC will also allow the operator to be able to change the timing of the air sparging and liquid injection sequences. The PC will be used to display injection header pressure, flow rates, temperature, injection sequence status, and alarms. It will be connected to a phone line to allow for remote access of the control system. The injection times and well sequencing can all be controlled and programmed at the HMI for complete automation and flexibility.

A security system will be installed at the control center which will be monitored 24 hours a day. The system will monitor the power to the control room, fire/smoke detectors, entry detection sensors, and process alarms. In the event of an alarm or indication of a failure of the security system (security breach), the monitoring company will contact the appropriate personnel to take action.

4.5.6.2 COMPRESSOR

The compressor size was determined by the flow and head requirements for each as shown in the design calculations presented in Appendix A. The compressor type and model were chosen to maximize efficiency at full design flow rate and highest expected pressure.

4.5.6.3 SUPPLEMENT MIXING UNIT (MAKE-UP AND DELIVERY SYSTEM)

The mixing unit will be used to combine the liquid supplement (sugar byproducts) with water for transfer to the injection wells. The mixing unit will include a metering pump and mixing chamber.

The supplement metering pump will inject concentrated sugar byproducts into the mixing chamber where it will mix with water prior to being injected into the ground. The mixing rate will be about 1 pound of sugar byproducts per 150 gallons of water (approximately 800 ppm). The supplement metering pump can pump up to two gallons per hour of sugar byproducts.

After mixing in the mixing chamber, the diluted sugar byproducts solution will be injected into the forcemain (with additional feed water) that feeds the wells to maintain a concentration in the groundwater of up to 25 mg/L (e.g., one gallon per minute for 100 minutes each day). This feed rate will be used initially during the full scale Phase I system and will be revised as appropriate based on the performance monitoring results. The supplement injection pump can deliver the liquid supplement to 5 wells at a time, if so desired.

If the treated/aerated water from Northrop Grumman's GP-1/GP-3 treatment system is available, the initial injection rate will be initially increased to 5 gpm per well. This will require increasing the pump capacity to 25 gpm. Mixing the supplements with a much higher water volume and pumping at a higher rate would substantially improve the mixing zone and assist in keeping the injected supplements at much lower concentrations. This, in conjunction that the treated water has elevated DO concentrations, reduces the chance for the creation of an anaerobic zone in close proximity to the liquid injection well.

Due to the differing depths of the liquid injection points below the groundwater table, it will be necessary to rotate the injections, either to individual wells or among groupings of wells with similar depths, in order to ensure that the water and associated amendments are being appropriately distributed to all the injection points.

4.5.6.4 AIR DELIVERY SYSTEM

The air compressor will be used to supply the oxygen required for the bioremediation to the injection wells. The compressor will have a 337 cfm capacity at a pressure of 175 psi.

The compressor will be a positive displacement, screw type design. It will be located inside the control center (described in Section 4.6). The compressor will be 8 feet, 6 inches in length and 4 feet in width.

The air will be filtered by a pre-filter and a polishing filter to remove any water and oil that is carried over from the compressor prior to being injected into the ground.

4.5.7 INSTRUMENTATION AND CONTROL LOGIC (SEE DRAWINGS E-01 TO E-16)

4.5.7.1 GENERAL

The injection facility's control logic is designed to allow the system to operate without supervision in a fail-safe mode. All control signals are fed to one PLC. The PLC will supply appropriate responses to the signals using a PLC programming language. The PLC is located in the main control room at the control center. An operator can monitor and control the treatment system through the HMI. All process equipment can be shut down locally, or through the HMI. An emergency shut down button is located at the HMI, which will shut down the entire injection system.

4.5.7.2 INJECTION WELLS

All inputs and outputs associated with the individual wells will be routed to the PLC.

Each extraction well will have a pressure indicator, flow indicator, low flow switch, and control valve for the air injection and flow indicator, low flow switch, and a control valve for the liquid supplement addition. The low flow alarms and valve position will be transmitted to the PLC. These alarms and the valve positions will then be displayed on the HMI computer screen.

4.5.7.3 SUPPLEMENT MIXING UNIT (MAKE-UP AND DELIVERY SYSTEM)

Supplements are pumped into the mixing unit and water is diverted into this unit to form a solution to be injected into the forcemain and from there into the injection wells.

A flow transmitter will measure instantaneous combined flow from the mixing unit and water source to the injection wells. The instantaneous flow rate will be displayed locally on the flow meter. The instantaneous flow rate will be transmitted to the PLC and displayed on the HMI computer screen. Total flows will be displayed on the instrument only.

The dosing rate of sugar byproducts will be sent from the HMI to the mixing unit. The metering pump will add the correct amount of sugar byproduct to the mixing unit based on the required dosing rate and flow to the wells.

Following the mixing of the supplement in the mixing unit, the mixture will be injected into the forcemain and mixed with the water source.

After the injection of the sugar byproducts into the water source, the mixture will flow through an automatic flow control valve. This valve will be operated by a Proportional/Integral/Derivative (PID) loop in the PLC based on the flow of the combined stream of water and sugar byproduct solution. As the flow rate deviates from a specified flow set-point, the PLC will automatically adjust an analog control signal to open/close the valve in order to compensate for the difference in flow. As the flow rate returns to the set-point, the PLC will decrease the rate at which the analog control signal changes and attempt to maintain the valve's position. Overall, the PID loop will adjust the valve's position to maintain a constant flow to the injection wells.

Flow to the wells will be measured by a flow transmitter which will display instantaneous flow locally. The flow rate will be transmitted to the PLC and also displayed on the HMI computer screen.

4.5.7.4 AIR DELIVERY SYSTEM

Air (oxygen) from the compressor flows from the control center to the injection wells.

A flow transmitter will measure instantaneous flow and temperature of the air leaving the compressor as it is injected into the injection wells. The instantaneous flow rate and temperature will be displayed locally on the flow meter. The instantaneous flow rate and temperature will be transmitted to the PLC and displayed on the HMI computer screen. Total flows will be displayed on the instrument only.

The compressor speed is controlled by a VFD. This VFD will be operated by a Proportional/Integral/Derivative (PID) loop in the PLC based on flow from the compressor. As the flow rate deviates from a specified flow set-point, the PLC will automatically adjust an analog control signal to "ramp up" or "ramp down" the speed of the compressor in order to compensate for the difference in flow. As the flow rate returns to the set-point, the PLC will decrease the rate at which the analog control signal changes and attempt to maintain the compressor's speed. Overall, the PID loop will adjust the compressor's speed to maintain a constant flow to the injection wells.

At the discharge of the compressor, the air will flow through an automatic flow control valve. This valve is an open/closed valve used for system isolation during a shutdown condition. This valve will be operated by signal in the PLC based on a permissive from the PLC. As the flow, temperature, or pressure deviates from specified set-points, the PLC will automatically shut down the compressor and close the valve. The operator will be required to determine the problem prior to restarting the system.

4.5.8 ELECTRICAL (SEE DRAWINGS E-01 TO E-16)

4.5.8.1 GENERAL

The electrical design will provide for the project electrical loads and conform to the latest requirements of ANSI/NFPA 70 "National Electrical Code" and ANSI/IEEE C2 "National Electrical Safety Code".

Design calculations in support of the electrical design are contained in Appendix A. The electrical drawings are included in Appendix B. The electrical scope of work and specifications are included in Appendix C.

4.5.8.2 SAFETY CONSIDERATIONS

All electrical equipment and systems are designed to meet the following minimum safety requirements:

i) electrical equipment and material are specified with adequate current carrying capacity, short circuit, and Basic Impulse Insulation Level (BIL) interrupting and/or withstand ratings;

ii) equipment and device enclosures will be of a dead front type;

iii) non-current carrying electrical equipment exposed metallic parts (such as enclosures, raceways, etc.) will be grounded;

iv) equipment and device enclosures will be properly identified and, where required, will be supplied with the rating nameplates;

v) sufficient access to and working space around all electrical installations will be maintained to provide for ready and safe operation, and to allow for equipment maintenance; and

vi) electrical classification of all work areas as non-hazardous.

4.5.8.3 PROJECT LOADS

The project electrical loads consist of the process equipment motors, heat tracing, HVAC, lighting, process instrumentation, controls, communication equipment, and other similar items.

The project loads will require 480V, 277V, 208V, and 120V, 60 hertz (Hz) power supplies. The power will originate in the control center and be distributed to the well vaults as needed.

4.5.8.4 POWER SERVICE

There will be a designated power service at the control center. It will be provided by the local power provider operating in the project area.

The power service will be a 480 VAC, 3-phase, 4-wire solidly grounded system. It will be sized to the project power load requirements and it will provide for the anticipated power load growth.

The service entrance arrangement will be in accordance with the power service provider specifications.

4.5.8.5 POWER DISTRIBUTION AND CONTROL EQUIPMENT

The project power distribution and control equipment consist of 480 volt (V) service panel, 480V-208/120V step-down transformers, 208/120V distribution panel boards, low voltage motor controllers, and safety switches. All power equipment and control will be located in the areas designated on the Drawings.

4.5.8.6 LIGHTING

Lighting will be designed to provide adequate illumination in the operation areas, and to supply required illumination in emergency situations. Lighting will be provided as follows:

i) project lighting includes the outdoor and indoor lighting systems;

ii) the outdoor lighting consists of high intensity discharge (HID) lights which will be photo-electrically controlled with manual over-ride; and

iii) the indoor lighting consists of a mixture of HID and fluorescent lights, self-contained individual emergency lighting units, and exit signs as follows:

   a) the HID and fluorescent lights will be manually controlled,

   b) the emergency lighting units will be strategically located to illuminate passages to the exit doors and will illuminate automatically in the case of indoor general lighting failure, and

   c) the exit signs will be battery supported and will be placed in strategic locations to direct occupants to the entrance doors.

4.5.8.7 CONVENIENCE OUTLETS

120V AC convenience outlets will be furnished at accessible locations in operational areas of the facility to provide power for portable lighting and small tools.

4.5.8.8 WIRING

Wiring will be provided to interconnect all project electrical, instrumentation, and communication equipment and loads.

The project wiring falls into one of the following three categories:

i) low voltage power and control wire and cable for the project power and control equipment and loads;

ii) instrumentation cable for the project instruments; and

iii) data communication cable for the project data communication network.

The project wiring will be carried out in cable tray and conduit and will meet all specified application and environmental conditions.

4.5.8.9 GROUNDING

Grounding will be designed to provide for the electrical system grounding requirements, lightning protection system, and personnel safety. It will consist of ground rods and interconnecting grounding cable. The grounding will be designed to obtain a maximum of 5 ohms resistance to ground.

4.5.8.10 OVER-VOLTAGE PROTECTION

Over-voltage protection will be provided against voltage surges induced by lightning, equipment switching, and other sources of voltage transients. All project power equipment will be specified with proper BIL ratings, and transient voltage surge suppression devices will be provided.

4.6 CONTROL CENTER (SEE DRAWING CI-01 THROUGH CI-04 AND ST-01 THROUGH ST-07)

The control center will be a 1,064 square foot one-story pre-engineered structural steel building designed in accordance with the Building Code of New York State. The building is designed as Facility-Industrial with Occupancy Code of Use Group F-2. The building construction material classification is non-combustible Type 2B.

The control center building will consist of the main service area and a control room/lavatory. The building will be 28 feet by 38 feet with an eave height of 14 feet 6 inches above its floor level. The control room area will be 13 feet by 26 feet 8 inches, and located in the eastern part of the control center building. The building roof will be at a 2:12 slope directing precipitation/rainwater from the roof to the ground surface adjacent to the building. The exterior grades around the building will be graded to direct rainwater away from the building.

The building will be a rigid framed steel structure with a single clear span, straight (non-tapered) columns and gabled roof beams. The building roof and walls will have insulated pre-finished metal panels. Pre-finished interior liner panels of limited height will be installed along the building perimeter walls. The interior wall between the control room and treatment area will be 4-inch insulated gypsum board.

Access to the service area of the building will be provided through a 6 foot by 7 foot double door. The control room will be accessed using a 3 foot by 7 foot man door from the service area.

The control room will include a motor control center, and a lavatory. The electrical equipment and instrumentation will be wall or floor mounted. The lavatory is intended for occasional use.

The mechanical piping in the service area will be supported using steel pipe supports mounted on the building floor. Electrical conduits will be wall or building ceiling supported. The process equipment will be supported by a reinforced concrete floor slab.

The building floor is designed as a slab-on-grade. The building foundations are designed as standard isolated columns or continuous wall footings.

The heating system for the control center building is designed to maintain an inside temperature of 55 degrees Fahrenheit (°F) based on an ambient outside temperature of 11°F. One electric unit heater with diffusers to distribute heat will be located in the facility for this purpose. One combined louver/shutter and one panel fan will be furnished for ventilation. The ventilation system will provide a minimum of one air change per hour, or an induced ventilation exhaust of at least 1 cfm per square foot of floor space. The control room will be equipped with a through-the-wall air conditioner/heater unit. An exhaust fan will be installed in the lavatory.

The building is categorized as light (low) fire hazard and will be equipped with portable fire extinguishers (Class ABC) to provide fire protection.

4.7 UTILITIES (SEE DRAWINGS CI-01 THROUGH CI-04 AND MP-01 THROUGH MP-06)

4.7.1 GENERAL

The utilities required at the Site include potable water, sanitary, electrical power, and phone service.

4.7.2 POTABLE WATER

Potable water supply will be required for liquid injection system, hose stations, and the lavatory. The source of potable water supply will be from the water main located on the north side of Hazel Street. A pressure of 30 to 70 psi is available at the water main. A new 2-inch diameter water service line will be installed, extending from the water main to the control center.

In the event that it is available, treated groundwater from Northrop Grumman's GP-1/GP-3 system will be used to supply water for the liquid injection system.

4.7.3 SANITARY

The municipal sanitary sewer on Hazel Street will be tapped into to provide sanitary sewer discharge for the control center

4.7.4 ELECTRICAL

There will be one designated power service required for the injection process and it will be located in the control center.

Each power service will be a 480V 60 Hz, 3-phase, 4-wire solidly grounded system. The services will be sized according to the area load requirements.

The power services will be provided by a local electrical power provider having jurisdiction in the project area. The service entrance arrangements will be in compliance with the provider specifications.

4.7.5 PHONE SERVICE

The control center will be provided with two voice grade phone lines. One line will be connected to the building telephone and control panel Autodialer. In the event one of the monitored points on the Autodialer goes into alarm, it will capture the phone line and make the appropriate emergency call outs. The second line will be connected through a modem to the control PLC so that calls can be made into the site for troubleshooting purposes.

5.0 SPECIFICATIONS

The following specifications for the construction of the in situ bioremediation system are contained in Appendix C:

- Section 01010 - Summary of Work;
- Section 01015 - General Requirements;
- Section 01300 - Submittals;
- Section 01400 - Quality Control;
- Section 01500 - Construction Facilities and Temporary Controls;
- Section 01600 - Material and Equipment;
- Section 01700 - Contract Closeout;
- Section 02200 – Site Preparation;
- Section 02316 – Fill;
- Section 02317 - Excavation;
- Section 02318 - Trenching;
- Section 02501 - Buried Utilities;
- Section 02522 – Injection and Monitoring Wells;
- Section 03300 - Cast-in-Place Concrete;
- Section 05500 - Metal Fabrications;
- Section 09900 - Paints and Coatings;
- Section 10001 - Miscellaneous Equipment Specialties;
- Section 11300 -Process Equipment;
- Section 11375 - Compressed Air Equipment;
- Section 11550 – Storage Tanks;
- Section 13121 - Pre-Engineered Buildings;
- Section 15160 - Pumps;
- Section 15410 - Process Piping and Valves;
- Section 15710 - Heating and Air Conditioning Units;
- Section 15830 – Fans;
- Section 15850 – Air Inlets and Outlets;
- Section 16000 - Electrical and Instrumentation; and
- Instrument List.

6.0 PERMITS/NOTIFICATIONS

6.1 BUILDING PERMITS

Several permits are required by the Town of Oyster Bay for the construction and occupancy of the planned control center. These permits are as follows:

i) Area Variance;

ii) Construction Permit:

  a) Electrical Sub-Code,

  b) Plumbing Sub-Code,

  c) Fire Protection Sub-Code, and

  d) Building Sub-Code; and

iii) Certificate of Occupancy.

Copies of the preliminary permit applications will be included in Appendix D at a later date.

6.2 INJECTION PERMITS AND OPERATING PERMITS

Any substantive permit requirements will be met. At the present time, there are no known permits required for the injection system.

The liquid amendment injection wells are Class V injection wells. As such, they are "permitted by rule" wells and no permit is needed. The applicable regulatory requirements for Class V wells pursuant to §144.27 include the submission of the installed well details and the periodic submission of monitoring (e.g., groundwater and soil gas) and injection fluid analysis results.

6.3 NOTIFICATIONS

Notice will be provided to the USEPA, NYSDEC, Nassau County Department of Health, and the local fire department and emergency personnel the first time injection occurs for the startup of Phase I of the biosparge system. Because the injection for operation of the biosparge system will be made continually, it is impractical to provide notification each time an injection occurs.

7.0 IMPLEMENTATION

7.1 GENERAL

The first step of the remediation strategy is to install and operate a Phase I system over a longer term to determine an effective well spacing for a full scale remedial system. This Phase I system will include the control center, force main to four injection wells in the central portion of the middle fence line, four injection wells (IW-16 through IW-19), and the monitoring wells for these injection wells (see Drawing MP-01).

The operation of the Phase I system will provide the information necessary to finalize the injection well spacing, injection rates, supplement rates, and other operating parameters to insure that the rest of the full system is properly developed. The Phase I system will operate for approximately one year. Thereafter, the remainder of the middle fence line will be installed and put into operation and fine tuned. The information obtained from the entire middle fence line will then be used to finalize the details for the north fence line and south wells. The north fence line and potential south wells will be installed in the following spring.

Following USEPA approval of this Design Report, the groundwater remediation for the Site will be implemented as presented in this section. Project implementation will include the following tasks:

i) secure property access/easements from property owners (Section 7.2);

ii) obtain the required construction/operating permits (Section 7.3);

iii) construct the remediation systems (Section 7.4); and

iv) startup of the remediation systems (Section 7.5).

7.2 PROPERTY ACCESS

Prior to initiating the construction of the groundwater remediation, easements and access agreements must be negotiated with the affected property owners. The site layout drawing (Appendix B) shows the layout of the remediation system. As shown, there are several properties that will be affected.

Upon approval of the Final Design Report by the USEPA, the process of obtaining easements and property access will be implemented as follows:

i) the owner(s) of each affected property shall be identified;

ii) each property owner will be contacted to begin negotiations which will continue until an easement or access agreement is finalized; and

iii) in the event that negotiations with a particular property owner reach an impasse or it appears unlikely that the property owner will grant access, then the remedial design will be reviewed to evaluate whether the design could be reasonably modified to eliminate the need for access to that property. If reasonable, the design will be modified; otherwise, assistance from the USEPA will be requested.

7.3 PERMIT APPLICATIONS

Following USEPA approval of the finalized Remedial Design, the permit applications outlined in Section 6.0 will be submitted to the appropriate State and local agencies.

There is a possibility that the area variance will not be granted. This would result in the need to obtain a different parcel of property and in some design modifications. These activities would result in a delay of the project.

7.4 CONSTRUCTION

During the permit approval process, bids for the construction of the remedial system will be solicited from qualified contractors. Construction contracts will be awarded pending approval of the required permit(s). Remedial construction activities will be initiated upon receipt of the required permits. Construction will continue according to the Schedule presented in Section 10.0.

The Construction Quality Assurance Plan (CQAP), presented in Appendix E, presents the quality assurance program which will be implemented during the remedial construction activities to assure that the remedial construction meets or exceeds all design criteria, plans, and specifications.

The Health and Safety Plan (HASP) for the Remedial Construction is attached as Appendix F.

7.5 STARTUP

Upon completion of the construction, the injection system will be tested. All of the process equipment and piping will be hydrostatically tested. All of the instrument and electrical loops will be checked. All instruments will be calibrated and the communication between the systems and PLCs verified.

After the above tests have been successfully completed, the in situ bioremediation system will be started up.

It is anticipated that the commissioning and startup period will take up to 3 months.

8.0 OPERATION AND MAINTENANCE

8.1 LICENSING REQUIREMENTS

There are no known licenses or permits required to operate the biosparge treatment system.

8.2 OPERATION AND MAINTENANCE

The draft Operation and Maintenance (O&M) Plan is included as Appendix H. The final O&M Plan for Phase I will be submitted with the Construction Report for Phase I. This will allow the inclusion of any modifications made to the remedial system during construction. Modifications, if needed, will be made to the O&M Plan after construction of the remainder of the middle fence and again after construction of the north fence/potential south wells.

A summary of the basis of the O&M Plan is provided in the following paragraphs.

Operator presence is required on a periodic basis once the system is in full-scale operation. The system is designed to operate unsupervised, with the PLC monitoring key parameters for proper operation. Should an operating parameter be out of range, the system will attempt to adjust for it or if necessary shut down the process safely, while notifying the operator of the shut down. The system can not be started up remotely following a major alarm. The operator will have to go to the facility, evaluate the problem, and make corrections, prior to restarting the system. The operator will receive a summary of system operation from the PC HMI hooked up to the PLC. Information related to instrumentation readouts (i.e., process equipment and piping) and any alarms will be provided on the HMI. The operator will check the system's operation, log data, and sample as necessary. The PLC will be designed to assist in the accumulation, storage, and trending of operating data. The operator will also be responsible for the maintenance of the building and equipment.

The health and safety procedures for the operation and maintenance of the system will be in accordance with those presented in the HASP (Appendix F).

The O&M Plan for the Site addresses the long term operation, maintenance and monitoring of the system. The purpose of the O&M Plan is to provide a summary of the O&M requirements for the various components of the system.

The draft O&M Plan has been organized as follows:

- A general introduction, and the purpose and organization of the O&M Plan.
- A description of the organizational structure.
- A description of the system.
- Detailed operating instructions for the system.
- A description of all equipment, including inspection, records retention, and reporting requirements.
- A description of shutdown procedures, potential operating problems, and emergency notifications.
- Inspection and maintenance procedures for the system.
- Performance monitoring for the system.
- The record keeping requirements for the system.

The draft O&M Plan also includes:

- Equipment manuals and maintenance information.
- Equipment and instrumentation vendor information.
- Human-machine interface (HMI) screens and information.
- Set-points.
- Operator logs.
- Spare parts list.

9.0 PERFORMANCE MONITORING

Performance monitoring will include groundwater and vadose zone monitoring and process monitoring. Additional details regarding the scope of the monitoring is provided in the following sections. A summary of performance monitoring is shown in Table 9.1. As stated in Sections 3.0 and 7.0, it is planned to first construct and operate a portion of the middle injection fence (i.e., Phase I system). A longer monitoring period prior to finalizing the design of the remainder of the middle fence would be highly advantageous in ensuring that more data are available for the design. Considering the groundwater flow velocity is 0.4 ft/day, at least 8 months would be needed for the groundwater around the injection point to flow to the monitoring wells located 100 feet downgradient. Thus, considering that the VCM subplume is being fully contained by the pumping of GP-1/GP-3, the Phase 1 system will be monitored for approximately 1 year before finalizing the design for the remainder of the middle fence. These data would also assist in the design of the north fence/potential south wells. The frequencies of sampling described below are applicable to each fence section when it becomes operable.

9.1 GROUNDWATER MONITORING

The proposed locations of the groundwater monitoring wells are shown on Drawing MP-01. The majority of the monitoring points are located at a distance of approximately 100 feet downgradient of the injection wells which is equivalent to approximately 8 months of groundwater travel time. Thus, these wells will be monitored semi-annually except for the wells corresponding to Phase 1, which will be monitored quarterly for the first year of operation. As shown on the Drawing, this layout results in 5 and 6 monitoring locations for the middle and north injection fence lines, respectively. The monitoring well nests will be installed at approximately the midpoint between every other pair of injection wells. The midpoint location was selected as the primary monitoring location since this is the area least expected to be impacted by the injected materials. Thus these locations should be typical of worst case conditions. The well nests will typically consist of two wells in the groundwater and two wells in the vadose zone. The screened intervals of the groundwater monitoring wells will be set at:

i) an elevation equal to the mid point between the top and bottom of the VCM subplume; and

ii) in the next overlying sand unit above the VCM subplume.

A cross-sectional schematic of the monitoring wells is shown on Figure 9.1. The groundwater monitoring well screens will be 10 feet in length. Typical groundwater monitoring well details are shown on Drawing MP-05.

Furthermore, to provide an early indication of the impact of the biosparging system, groundwater monitoring wells will also be installed at two locations approximately 5 feet downgradient of the injection fence at the midpoint between adjacent injection wells and at three and two locations, for the middle and north fence, respectively approximately 20 feet (2± months travel time) downgradient of each of the injection fences. These last five monitoring locations will be installed at locations that are immediately downgradient of an injection well. The two wells located approximately 5 feet downgradient will be monitored monthly for the first quarter of operation to assess the oxygen distribution and evaluate the zone of biosparging influence. Thereafter, all groundwater monitoring wells located 5 and 20-feet downgradient will be monitored quarterly for a period of 2 years after startup of operation.

Existing wells, if located in the appropriate location (e.g., MW-61D and MW-61D2 for the middle fence), will be included in the monitoring program in lieu of new installations.

Sample collection and analyses will be in accordance with the procedures presented in the OU-3 QAPP (see Appendix G). All groundwater sampling will be performed using the Low Flow Procedures included in Attachment A of the OU-3 QAPP.

Initially, the groundwater will be monitored for VOCs (including TICs), TOC, N, P, and the natural attenuation parameters, DO, ORP, pH, temperature, conductivity, and ferrous iron (Fe^{+2}). VOC TICs will be analyzed and reported for the groundwater event samples collected from the first sampling event of each new well installed and the next sampling event from any existing well. If TICs are present in a well, TICs will continue to be analyzed/reported for the subsequent samples from each well until they are no longer present. For wells in which no TICs are present, no future analysis/reporting will be performed. In addition, heterotrophic microorganisms will be analyzed annually for the first 2 years.

Prior to the start of air injection at each section of the injection well fence, baseline monitoring will be performed at the appropriate wells. The frequency of the baseline monitoring will be once two weeks prior to the initial air injection and then daily for the 3 days immediately prior to the initial air injection. The parameters to be analyzed/monitored are the same as those described above with the exception that VOCs will be sampled/analyzed once for the 4 background events.

9.2 VADOSE ZONE MONITORING

Vadose zone wells will be installed in the same locations and monitored at the same frequency as the groundwater monitoring wells installed at distances of 20 and 100 feet from the injection fence. The one exception to this is that the vadose zone wells located 20 feet downgradient will also be monitored shortly after air injection starts and monthly for the first quarter.

Two vadose zone wells will be installed at each location; one at a depth of approximately 8 feet bgs and one immediately above the groundwater table (approximately 60 feet bgs). The 8-foot depth was selected to be representative of a basement depth. The vadose zone wells will be constructed of 1-inch diameter PVC pipe with screens 2 feet in length for the 8-foot deep wells and 5-feet in length for the groundwater table wells. A longer well screen for the deeper vadose zone well is believed prudent to account for fluctuations in the groundwater table. The sandpack will extend 2 feet above the screen. The annulus above the sandpack will be sealed with a 2-foot bentonite pellet/chip seal overlain with cement grout containing 6 percent bentonite to prevent short-circuiting between wells and with the atmosphere. The well head will be airtight and include a stop cock that will allow direct connection of a gas sample monitor and/or container. Typical vadose zone monitoring well details are shown in the drawings (Appendix B).

The vadose zone gases will be monitored using a PID. Gas samples will be collected for laboratory analysis of VOCs and methane. The samples will be collected semi-annually for a period of 2 years at each portion of the biosparge system as that portion becomes operational. In addition, an ambient air sample will be collected at ground surface near the shallow vadose zone well which had the highest reading greater than 10 ppm above background, if such reading is obtained.

The soil gas and ambient air sample results will be compared against the short-term SGC valves (e.g., 180,000 $\mu g/m^3$ for VCM). The short-term values were selected because the biosparge system is being installed in open areas on which only the occasional person traversing the area to get from one location to another is present. Sample collection and analyses will be performed in accordance with the procedures presented in the OU-3 QAPP.

In addition, the air immediately above the ground surface at each injection well will be periodically monitored using a PID to determine if short-circuiting up the well annulus is occurring. Short-circuiting will be evidenced by a PID reading >10 ppm above background.

9.3 PROCESS MONITORING

Injection header pressure and temperature as well as injection on/off cycle times and quantities of materials injected will be monitored and stored by the HMI software on the PC. In addition, in accordance with 40 CFR 144.27, the liquid supplements will be sampled and analyzed annually (TOC for the sugar by-product solution and phosphorus and nitrogen for the DAP). The data will allow estimates to be made of the quantities of materials injected at each point (i.e., the quantity of an injected gas is a function of volume, pressure, and time). These mass estimates will be used to evaluate the distribution of the injected materials at each injection point and, in conjunction with the soil gas and groundwater monitoring, will be used to assist in optimizing the timing, locations, and rates of material injection. The data will be used to assess the rate of VCM biodegradation, injection material distribution and migration, and monitor groundwater flow pathways.

9.4 DECISION LOGIC

All of the decision logic will be based upon the redox conditions, VCM concentrations, and TOC concentrations measured in the monitoring wells in the vicinity of the injections. The primary goal of the injections is to create an aerobic environment. The collected data will be used to assess what actions may be necessary to improve the remedy.

Dissolved Oxygen

- the desired concentration is >2 mg/L
- if < 2 mg/L, the options are:
  - o increase the length of time of oxygen injection
  - o increase the frequency of oxygen injection
  - o increase the volume of oxygenated water injection
  - o install an additional injection well at the midpoint between the injection wells

TOC - the desired concentration is $5 \leq TOC \leq 10$ mg/L
- if < 5 mg/L, the options are:
  - o increase the injection volume
  - o increase the injection frequency
  - o check whether the VCM concentration is decreasing
  - o evaluate other injection materials

VCM - the measured concentrations should be decreasing
- if not decreasing
  - o increase the dissolved oxygen and/or TOC concentration
  - o install additional injection well at the midpoint between the injection wells
  - o install injection well in south portion of subplume

Of the above three parameters, the VCM concentration is the critical one. If the VCM concentrations are decreasing and consistent with meeting the remediation objectives, the significance of the remaining parameters in achieving their desired levels is not significant.

9.5 EVALUATION OF MONITORING PROGRAMS

The scope of the groundwater monitoring and vadose zone monitoring will be evaluated using the first two years of data. Based on the evaluation, the scope of monitoring may be modified for the next 5-year period. USEPA concurrence will be obtained prior to implementation of any modifications.

9.6 REPORTING

The reporting schedule shall be:

i) Monthly progress reports until submission of the 100% Design Report;

ii) Quarterly progress reports after submission of the 100% Design Report until submittal of the modified design for the remainder of the middle fence; annually thereafter. These reports will contain validated biosparge system performance monitoring data as they become available. The third and fourth quarterly reports from the first year of the Phase I operational period will provide the information regarding the completion of the design of the middle fence, the northern fence, and a potential injection scheme for the southern portion of the subplume;

iii) Biosparge Construction Report(s) (one for each at Phase 1, remainder of middle fence, and north fence/south wells); and

iv) Final O&M Plan, Biosparge System (60 days after construction completed of Phase 1). Modified for remainder of middle fence and north fence/south wells, as needed.

10.0 SCHEDULE

The schedule for the implementation, construction, and startup of the in situ bioremediation system is presented on Figure 10.1.

The schedule is based upon the implementation and construction of the groundwater remediation systems presented in this Design Report. The schedule may be impacted due to the timing of EPA approvals, weather conditions, or delays in securing property access or construction permits.

10.1 INSPECTIONS

It is anticipated that inspections will be performed by the USEPA on an as-desired schedule as construction/operation/monitoring is ongoing. The NYSDEC is also welcome to inspect if they so desire.

The Pre-Final Inspection of each constructed phase of the remedy will be held approximately two weeks before the Final Inspection.