CONSTRUCTION COMPLETION REPORT

Seaboard Chemical Corporation

and

Riverdale Drive Landfill Site

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and

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EXECUTIVE SUMMARY

INTRODUCTION

The Remedial Treatment System at the former Seaboard Chemical Corporation (SCC) facility and closed City of High Point NC (City) Riverdale Drive landfill (Landfill) properties (the SCC facility and the Landfill are collectively referred to as the "Site") has been constructed and is being extensively tested prior to commencing full scale operations upon approval of this Report and written notification by the North Carolina Department of Environmental Quality (NCDEQ), Division of Waste Management (DWM). This report explains, among other things, the significant changes to the design, configuration, function, or operation of the Remedial Treatment System components from those described in the Physical Treatment System *"Pre-construction Report,"* (ERM-NC, P.C. December 28, 2009), and the "*Phytoremediation System Pre-Construction Report*" (URS Corporation October 26, 2010), collectively referred to as the "Pre-construction Report" or "PCR".

REMEDIAL OBJECTIVES

As stated in the PCR, the objectives of the remedy implemented at the Site include the following:

1. Contain the contaminated soils at the source areas to prevent direct contact by potential human and environmental receptors, reduce percolation and intrusion of storm water and surface water to reduce the migration of contaminants of concern[1] (CoCs) into the groundwater;
2. Control migration of Landfill leachate to prevent discharge to surface waters at the Site;
3. Control migration of contaminated groundwater at the Site to prevent offsite migration and unacceptable impacts to surface waters;
4. Achieve compliance with North Carolina surface water quality standards for the CoCs in the surface waters of the onsite streams and the Randleman Reservoir (Reservoir);
5. Achieve compliance with North Carolina Ground Water Quality Standards for the CoCs in the groundwater beneath the Site; and
6. Restrict future uses of the Site and certain surrounding properties, that could present potentially unacceptable exposure risks (e.g., residential development, use of impacted ground water, etc.).

REMEDIAL TREATMENT SYSTEM INSTALLED

Seaboard Group II (SGII) and the City of High Point (collectively the "Parties") determined, through the remedial investigation and feasibility study process, as approved by the NCDEQ[2], the most effective long-term method to accomplish the hydraulic containment of the plumes and treatment of the groundwater and leachate collected at the Site would be shallow and deep groundwater extraction in conjunction with leachate recovery and treatment in physical and natural systems. This is primarily due to the presence of chlorinated and non-chlorinated organics, dense non-aqueous phase liquid organics (DNAPL), and 1,4-dioxacyclohexane (1,4-dioxane)[3] in the shallow and deep groundwater and Landfill leachate.

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[1] Contaminants of Concern or "CoCs" are identified as certain chlorinated and non-chlorinated volatile organic compounds, semi-volatile organic compounds, metals and metallic salts. A complete list of the CoCs is included as Attachment 3 to this report.

[2] At the time the Pre-construction Reports were approved the State Agency was the North Carolina Department of Environment and Natural Resources. That has since been changed to the North Carolina Department of Environmental Quality or NCDEQ.

[3] 1,4-Dioxane is a common name for 1,4-Dioxacyclohexane - CAS Number 123-91-1. It is often called simply dioxane because the 1,2 and 1,3 isomers are rarely used. It is a heterocyclic organic compound that is a colorless liquid with a faint sweet odor similar to that of diethyl ether, and is used mainly as a stabilizer for the solvent

Given the presence of DNAPLs in the subsurface, and the highly fractured and heterogeneous bedrock conditions present at the Site, restoration of groundwater quality to regulatory standards within a reasonable timeframe was determined to be technically impracticable. Therefore, the Remedial Treatment System components have been designed based on their operating economics and ability to remain in operation for an extended period. Considering all these factors, the Parties determined a containment remedy based on the use of a Natural Treatment System (phytoremediation and biodegradation)[4] to treat the CoCs in the extracted groundwater and leachate would best address the requirements and remedial objectives at the Site.

Due to initial concerns that the Natural Treatment System could become ineffective at certain times due to natural perils such as weather, disease, insects, or other causes beyond the Parties control, NCDEQ requested the Parties include in the remedial design a backup to the use of the Natural Treatment System. The Parties installed an advanced oxidation (AOP^+)[5] unit, which the Manufacturer[6] warranted to be capable of consistently reducing the concentrations of the CoCs, particularly 1,4-dioxane (one of the more problematic CoCs to degrade or destroy), to levels below pretreatment limits allowing it to be discharged to the City Eastside Wastewater Treatment Plant. Unfortunately, testing performed after installation determined that the AOP^+ unit is not capable of reliably producing effluent that consistently conforms to the pretreatment requirements specified in the City pretreatment permit and, therefore, it cannot be operated. With DEQ's approval the AOP^+ unit been taken out of service.

The Remedial Treatment System provides containment of the plumes by (1) groundwater extraction from the bedrock aquifer at a rate necessary to establish a capture zone[7] that hydraulically controls the contaminant migration; (2) leachate collection in tanks and sumps; and (3) treatment of the extracted groundwater and Landfill leachate by chemical, physical and natural treatment methods. It is designed to achieve all of the remedial objectives listed in the PCR. It treats extracted Southern Intermittent Stream (SIS), Northern Intermittent Stream (NIS) and Landfill recovered shallow groundwater, deep groundwater from extraction well PWDR-1, leachate from the five existing leachate collection tanks, and the leachate drainage from the piped sections of the NIS. The System provides continuous monitoring of the groundwater drawdown to ensure a capture zone is maintained through seven permanently installed transducers and treatment of the Physical Treatment System process effluent in a approimately 33-acre Natural Treatment System. The System provides control of the migration of Landfill leachate to prevent its discharge to surface waters and the migration of contaminated groundwater to prevent offsite migration and unacceptable impacts to surface waters. The System treats the process flow to reduce the mass of contamination at the Site and is designed to achieve compliance with North Carolina Ground Water Quality Standards for the CoCs in the impacted groundwater beneath the Site over time.

The remedial design provides for improvement of the cover system for the Soil Residue Mound, and maintenance and improvement of the existing Landfill cap. This has been achieved largely by the installation of a permanent geosynthetic cover over the soil residue mound, as well as Landfill cap improvements in certain areas of the Site, and a soil moisture-monitoring network installed to facilitate use of the cap for phytoremediation and biodegradation. In addition, the Site is secured from public access by a single chain link fence surrounding the entire Landfill, and a double chain link fence surrounding the entire SCC facility. Both fences have three strands of barbed wire to deter trespass, and are locked at all times the Site is unattended. These measures help contain the contaminated soils at the source areas to prevent direct contact by potential human and environmental receptors.

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trichloroethane. 1,4-Dioxane has an LD_{50} of 5,170 mg/kg and is classified by the IARC as a Group 2B carcinogen and by the U.S. Environmental Protection Agency as a probable human carcinogen and a known irritant. Like some other ethers, dioxane combines with atmospheric oxygen upon prolonged exposure to air to form potentially explosive peroxides.

[4] Phytoremediation and biodegradation, in this instance, involve the use of an upland system comprised of a mixed conifer tree stand to provide year-round treatment effectiveness through irrigation and plant uptake, and certain other biological degradation treatment mechanisms known to be present in the soils at the Site. Phytoremediation and biodegradation were found to be capable of destroying the main CoCs after preliminary treatment to remove certain phytotoxic metals and salts.

[5] AOP^+ or advanced oxidation process at this Site is used to indicate a Titanium Dioxide Photo-catalytic process that uses ultraviolet light to degrade organic materials.

[6] The Manufacturer, as used in this report, refers to Purifics ES, Inc. of London, Ontario, Canada.

[7] When an extraction well is pumped, the water level in the well is lowered. By lowering this water level a gradient occurs between the water in the surrounding aquifer and the water in the well. Water flowing to the well is referred to herein as a capture zone.

The Landfill and Soil Residue Mound cap improvements also help to reduce percolation and intrusion of stormwater into the underlying solid waste to reduce the migration of contaminants into the groundwater.

To restrict future uses of the Site and certain adjacent properties that could present potentially unacceptable exposure risks, Land Use Restrictions (LUR) have been recorded at the SCC property, Landfill property, and the Material Recovery Facility (MRF) property. On certain properties adjacent to the Site, land use is controlled by restrictions placed on land and groundwater use within the Randleman Reservoir Critical Watershed, the rules of the Piedmont Triad Regional Water Authority (PTRWA) specifically precluding development within a 200 foot wide buffer surrounding the Reservoir, restrictive conditions of the Army Corps of Engineers (ACE) permit issued for the dam and Reservoir, regulations administered by the NCDEQ Division of Water Resources (DWR), and the Guilford County Water Well Regulations, which limit water well placement within 1,500 feet of a known source of groundwater contamination. The Parties have notified the Guilford County Health Department that the Site is a source of groundwater contamination. Although the Parties made substantial efforts to place LURs on the property that abuts the PTRWA buffer on the north side of the Reservoir, the landowner refused to allow them to be recorded. The Parties concluded there are sufficient other existing restrictions, as previously discussed, on the use of the lands and groundwater in the vicinity of the Site to preclude any increased risk to human health or the environment from the CoC-affected groundwater and leachate at the Site.

The diversion of the stormwater flow from the piped section of the NIS prevents contaminated stormwater from entering the Reservoir. This will help reduce the time required to achieve compliance with North Carolina surface water quality standards for the CoCs in the surface waters of the on-Site streams and the Reservoir.

CONCLUSION

The Remedial Treatment System components have been constructed and, with certain exceptions that are described in this report, are substantially consistent in function, performance and operation to those presented in the PCR and address all the remedial objectives for the Site. The construction of the Remedial Treatment System is now complete, and the Parties have substantially completed the process of pre-operational testing. Construction, although taking longer than expected, progressed relatively well considering the overall complexity of the Remedial Treatment System, the failure of the AOP$^+$ system to perform in accordance with contract requirements, the necessity to address higher than expected levels of certain CoCs and metal salts in the groundwater and leachate, and the unique nature of the remedy. All of the repairs, upgrades and modifications to the Remedial Treatment System have been necessitated by the need to correct problems with the AOP$^+$ unit, install alterations that enhance or improve the overall treatment system efficiency, provide additional CoC and metal salts removal, or provide flow path flexibility to improve performance or safety. All modifications to the Remedial Action Settlement Agreement (RASA) Statement of Work (SOW) were submitted to the NCDEQ in ten (10) Technical Memoranda (TM), which are included in Attachment 5. At this time, the Parties have completed all construction and pre-startup testing of the Remedial Treatment System, and have requested that NCDEQ provide the requisite authorizations and approvals necessary to begin continuous operation of the system.

REMEDIAL TREATMENT SYSTEM CONSTRUCTION COMPLETION REPORT

GENERAL INFORMATION

INTRODUCTION

Pursuant to the Remedial Action Settlement Agreement (RASA) Statement of Work (SOW), and at the request of the North Carolina Department of Environmental Quality (NCDEQ), this report has been prepared by the Seaboard Group II (SGII) and the City of High Point NC (City) (collectively the Parties), with the assistance of the professional engineers, contractors and consultants who have planned, designed, overseen or performed the work related to the Remedial Treatment System construction. The remedial construction activities have been completed at the Site, and the Parties request all necessary authorizations and approvals to begin full remedial system operations as described in this report.

SCOPE

This report presents details concerning the construction of the Remedial Treatment System, and the alterations, delays, defects, and other matters that have significantly affected the design, scope of work, cost or schedule of construction. It also contains information that is relevant to the selection and final design of the Remedial Treatment System and how it compares in features, function, and operation to that presented in the Pre-construction Report (PCR).

PURPOSE

This report presents information concerning the following:

- General information about the Site including a brief history, background, the basis used to determine the need to perform a remedial action and the appropriate remedial design,
- General information about the remedial design as built, and the various components included in both the Natural and Physical Treatment System,
- The significant problems, oversights, omissions, defects, deficiencies and design errors (collectively defects)[1] and the resultant changes or corrective measures undertaken that have significantly affected the cost, scope and timing of the construction and startup of the remedial system, The details of changes in system design, operating procedures, upgrades or improvements, (collectively alterations)[2] made to the system to improve efficiencies or address safety or operational issues, and
- The significant changes to the Remedial Treatment System design, function, or operation from what is described in the Physical Treatment System *"Pre-construction Report*" (ERM-NC, P.C. December 28, 2009), referred to in this report as the "Physical System PCR," and the "*Phytoremediation System Pre-construction Report*" (URS Corporation October 26, 2010), referred to in this report as the "Phytoremediation PCR" (collectively both reports are referred to as the "PCR")

DEFINITION OF TERMS

In this report certain terms have been used to describe components or portions of the Remedial Treatment System and certain types of construction activities. These terms are as follows:

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[1] A defect refers to any change in the design or method of operation necessitated by an oversight, omission, design error, equipment defect, safety violation, bid specification nonconformity or failure to comply with a professional or regulatory requirement.

[2] An alteration refers to any change in the design or method of operation of a component of the remedial system in order to improve the overall performance. Revisions, or changes in operations of any nature, that were not necessary to correct a defect are referred to simply as "alterations."

- Remedial Treatment System refers to the overall system including the Physical Treatment System and the Natural Treatment System.
- Physical Treatment System refers to those components of the Remedial Treatment System, including the extraction well network, the leachate collection network, Lift Station-1, the Clarifier, the Sludge Handling System, the Filter Building, Lift Station-2, the Effluent Treatment System and all other components, that are not part of the Natural Treatment System.
- Natural Treatment System refers to the components of the Remedial Treatment System, including the Phytoremediation tree stand and Biodegradation in the landfill cap soils, the Irrigation System, the Soil Moisture-monitoring System, and all other components that are not part of the Physical Treatment System
- Component refers to a discrete portion of the Physical Treatment System or Natural Treatment System, including, for example, the Soil Moisture-monitoring Network, the Filter Building, and the Effluent Treatment System.
- Repair is a change in the Remedial Treatment System necessary to correct a defect.
- Upgrade is a change in the Remedial Treatment System necessary to install an alteration.
- Lift Station-2 has historically been referred to as a lift station; however, it does not actually serve a lift station function. LS-2 is where all of the various process flows (i.e., LS-1, PWDR-1, shallow groundwater recovery wells, etc.) enter into the system before being sent into the Clarifier. An inlet manifold and proportioning valves control the Clarifier inlet process flow; however, there is no provision to pump (or lift) the process flow from LS-2 to the Clarifier. LS-2 is more correctly part of the Effluent Treatment System, because it contains the Effluent Storage Tanks, the Effluent Manifold to the Irrigation System and the disabled line to the City of High Point East Side Wastewater Treatment Works (POTW), the recycle line, Effluent Pumps, the Irrigation System control manifold and the Effluent Proportional Sampler. However, since it was referred to as LS-2 in the PCR, it is addressed in that manner in this report.
- Effluent Treatment System refers to Enclosures 1 through 5, which contain the Settling Vat, Settling Vat Effluent Filters and the inoperable AOP$^+$ unit that are the final treatment components for the process flow before it is sent to the Effluent Storage Tanks in LS-2 for final disposition.
- Contaminants of Concern or CoCs refer to those compounds listed in Attachment 3 that have been identified as being present in the soils and groundwater at the Site. It should be noted that although the compound 1,4-dioxane is one of the CoCs that has driven much of the design of the Remedial Treatment System, it is not the only recalcitrant that could be present in the Physical Treatment System process effluent. Therefore, unless 1,4-dioxane is being addressed, to the exclusion of the other CoCs, the term CoCs will be used in this report.

SITE HISTORY

Seaboard Chemical Corporation Site

The SCC facility is located on the north side of Riverdale Drive in Jamestown, Guilford County, NC. The facility covers approximately 13 acres, including an approximately 5-acre former plant and processing area, with the remaining area undeveloped and wooded. It is bordered on the north and east sides by the Landfill, and the Material Recovery Facility (MRF) is on the west side. Riverdale Drive borders the SCC facility to the south.

Between 1974 and 1989, SCC operated as a solvent recycler, toll processor and waste derived fuel blender, and was granted interim status under the Resource Conservation and Recovery Act (RCRA) as a treatment, storage, and disposal facility in 1982. The facility operations included distillation, fractionation, polymerization, packaging of organic solvents and wastes, and reclamation of off-specification commercial chemical products. Other operations included wastewater treatment, storage of incoming bulk and drummed commodities and wastes, operation of aboveground storage tanks, operation of a covered drummed hazardous waste storage area, and operation of two boilers. The facility also operated three surface impoundments including an unlined pond (referred to as Pond 3) located in the northeast corner of the SCC facility. This pond is thought to have been a major contributor to the contaminant migration into the groundwater from the SCC facility. NCDENR has terminated the RCRA operating permit and revoked the interim status of the facility. SCC declared bankruptcy in 1989, and the bankruptcy proceeding has been closed. The trustee was unable to dispose of the real property, which has remained unoccupied and is believed to have reverted under North Carolina law to the dissolved former Seaboard Chemical Corporation. SGII and the City have a permanent recorded easement for access to the SCC Facility to conduct remedial actions.

Riverdale Drive Landfill

The Riverdale Drive Landfill, a closed municipal solid waste landfill, bounds the SCC facility on the North and East sides and the MRF is on the west side. The Landfill was operated from the 1950's until October 1993 as a municipal solid waste disposal facility, and was permitted by the NCDENR in 1979. It occupies approximately 150 acres and, other than the Material Recovery Facility (MRF) operation, only post-closure care activities are conducted on the property at this time. The main areas of the Landfill, as used in this report, are the burn pit area, the soil residue mound, the main treatment area, LS-1, LS-2, the Effluent Treatment System enclosures, the East Lobe Node Building, the West Lobe Node Building, and the East and West lobes of the Landfill. Figures showing the Site location and the main areas addressed in the remedy are included in Attachment 1 to this report (see Figures 1 and 2).

During Landfill operations, sections of the two tributary streams that dissect the Landfill property were piped with reinforced concrete pipe (RCP), and solid waste was used to fill the drainage valleys. The two streams are referred to as the Southern Intermittent Stream (SIS) and the Northern Intermittent Stream (NIS). The SIS crosses the northern portion of the SCC property outside the former processing area. This stream is mainly a storm water drainage feature that begins west of the SCC property. It is an open stream on the SCC property near the location of the former Pond 3, and then enters the head works of the RCP stretch and crosses under the Landfill northeast of the SCC property. During filling of the SIS valley, geosynthetic liner fabric was used to cover the RCP and a limited leachate collection system was installed adjacent to the stream channel, outside the liner, to collect leachate migrating from the overlying solid waste. In 1989, the leachate collection system was expanded to control side seeps (leachate leakage) along the side-slopes of the Landfill facing the Reservoir. The leachate is collected in five underground storage tanks (referred to herein as leachate collection tanks or LCHTs).

The NIS originally began on the Landfill property and was piped with RCP under the entire fill area. There was no liner fabric used to cover the NIS pipe, and a video inspection of the interior of the pipe revealed extensive cracks and joint leaks. This required that the NIS flow be diverted around the landfill and the RCP section sealed at the head works to preclude contamination of storm water entering the Reservoir due to mixing with the leachate that leaked into the RCP pipe.

From approximately 1966 to 1970, Landfill operations included the disposal and open burning of liquid organic wastes. This waste burning occurred in what were referred to as "burn pits." These open unlined pits received bulk and drummed flammable organics. When sufficient material was collected, open burning was used to empty the burn pit. Periodically, a burn pit was cleaned of residue and that residue was accumulated in an area referred to as the Soil Residue Mound. This mound consists of approximately 600 cubic yards of contaminated residue. Tests conducted during the remedial investigation indicated this material is characteristically non-hazardous waste.

The Landfill itself is capped with an earthen cover of varying thickness and maintained under a Post-Closure Care Plan approved by NCDEQ. The average cap thickness is estimated to be slightly less than 3 feet, and the soil has characteristics similar to those of sandy loam. Because of the relatively thin cap and the permeable soils, leachate is generated at a high rate during storm events.

SITE FEATURES

In addition to the Site features previously described, the following features were also important in designing and constructing the Remedial Treatment System.

FORMER DEEP RIVER

The Deep River flowed in a generally north-to-south direction upstream of the Site. Near the northeastern boundary of the Landfill it made an abrupt turn to the east. This west-to-east flowing stream bed continued across the northern boundary until, immediately northeast of the Landfill, it made another abrupt turn back to the south. In early reports and documents, such as the *"Remedial Action Work Plan"* (RIWP), *"Remedial Investigation Report"* (RI), *"Feasibility Study"* (FS), *"Baseline Risk Assessment"* (BRA), and *"Remedy Recommendation Document"* (RRD), the Deep River still flowed across the north and east sides of the Landfill, and that term is used in those documents to refer to the water body that was present at the time those documents were created. As explained below, the Deep River has been dammed, and the portion that abuts the Site is now incorporated into the Reservoir.

RANDLEMAN RESERVOIR

The Piedmont Triad Water Regional Authority (PTRWA) was incorporated in 1986 by the cities of Greensboro, High Point, Jamestown, Archdale, and Randleman, as well as Randolph County, to administer the Reservoir and a 200-foot wide restricted buffer that surrounds it. Because the proposed location was within the Cape Fear River Basin, which includes traditionally navigable waters of the United States, in 1987 the PTRWA proposed the Reservoir and dam construction to the U.S. Army Corps of Engineers (ACE). The final Federal Environmental Impact Statement for the project was issued in 2000, and on April 6, 2001 the ACE issued a permit to allow construction of the Reservoir and dam.

By damming the Deep River approximately 10 miles downstream of the Site, the PTRWA created a roughly 3,000-acre Reservoir in Randolph and Guilford Counties. It extends from just northwest of the city of Randleman to east of the City of High Point, encompassing the stretch of the Deep River that abuts the Site. Construction began on the dam in 2004 at a location about 10 miles south-southeast of the Site. The Reservoir was constructed to supply area drinking water needs as well as recreational opportunities. The dam construction was completed and the reservoir began filling in 2007, reaching the normal pool elevation in 2009. On March 1, 2010, the Reservoir officially opened for public recreation. Due to the proximity of a Police Shooting Range, a portion of the Reservoir is closed to recreational traffic, and all other public uses, at a point downstream of the Site. Figure 2 depicts the overall Site layout including the location of the Reservoir and the 200-foot wide buffer.

REMEDIAL TREATMENT SYSTEM COMPONENTS

The Remedial Treatment System refers to the overall treatment process, which includes the Physical and Natural Treatment Systems. The following information explains the terms used to refer to specific components and some of the component parts of those systems.

LANDFILL COMPONENTS

Main Treatment Area

The Main Treatment Area is located near the end of Recovery Way just east of the junction with the MRF access road on the east side of the Soil Residue Mound. This is the area where the majority of the Remedial Treatment System equipment is installed in what are referred to as Enclosures 1 through 7. These enclosures house the AOP$^+$ unit, Settling Vat, the Settling Vat Effluent Filters, the water chemistry laboratory, the Effluent Storage Tanks, and LS-2. It also is where the Clarifier, Filter Building, Maintenance

Building, main electrical transformers, weather station and the storage enclosure are located. (See Figures 11, 12, 13 and 14)

Material Recovery Facility

The MRF is located on Riverdale Road a short distance beyond Recovery Way. This is a single large building in which the City operates municipal solid waste (MSW) material recovery and recycling operations. MSW is brought to the facility where it is sorted into its component parts such as paper, plastic, glass, metal and cardboard for recycling. Although the MRF is a significant feature of the Site, it is not a component of the Remedial Treatment System (see Figures 2 and 3 for location).

Burn Pits

From approximately 1966 to 1970, Landfill operations included the disposal and open burning of certain waste organics. This organic waste burning occurred in what were referred to as burn pits. These open unlined pits received flammable organic liquids. The burn pits were located in the area generally north of Recovery Way. When sufficient material was collected, open burning was used to empty the active burn pits (see Figure 3).

Soil Residue Mound

Periodically, each active burn pit was cleaned of residue, and that residue was accumulated in an area referred to as the Soil Residue Mound. This mound consists of approximately 600 cubic yards of contaminated soil and burn pit residue. Early testing performed during the remedial investigation determined the material was not characteristically hazardous waste (see Figure 2).

Landfill Lobes

The Landfill was constructed such that it has been divided into three separate areas, which are referred to as "lobes." Each was filled at different times and in different manners including direct burial, shredding and bailing. One section is located on the east side of the Landfill and is referred to as the East Lobe. Another is located on the west side of the Landfill and is referred to as the West Lobe. The center section has not been used in the remedy due to concerns that the soils are not suitable for sustained tree growth and biological activities (see Figures 6 and 7).

Natural Treatment System

The East and West Lobes comprise about 33 useable acres, roughly 12.5 on the East Lobe and 20.5 on the West Lobe. They are used for phytoremediation and biodegradation of the treated Remedial Treatment System process effluent. The non-native tree zones are planted with several species of conifer trees[1] that comprise the Natural Treatment System.

Landfill Tributary Streams

As described in the previous section, during the period of Landfill operations, sections of the two tributary streams that dissect the Landfill property were piped with RCP, and solid waste was used to fill the drainage valleys. The two streams are referred to as the SIS and the NIS. These features are still present at the Site although the NIS has been diverted around the Landfill (see Figure 10 for location).

Landfill Leachate System

During filling of the SIS valley, geosynthetic liner fabric was used to cover the RCP, and a limited leachate collection system was installed adjacent to the stream channel outside the liner to collect leachate

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[1] As explained later in this report hardwood trees, which are deciduous, were originally planted in certain zones. In these zones the hardwoods have been interplanted with conifer species making the tree stand effectively all conifer trees. Eventually the conifer species will dominate the hardwoods and they will die out. The hardwood trees have been especially sensitive to disease, insect damage and deer browsing. Moreover, conifer trees will take up irrigation water year-round.

migrating from the overlying solid waste. In 1989, the leachate collection system was expanded to control side seeps (leachate leakage) along the slopes of the Landfill facing the Reservoir.

Leachate Collection Tanks

The leachate collection system drains leachate to five in-ground tanks referred to as leachate collection tanks (LCHTs). These tanks receive leachate from the side-seeps and SIS leachate collection pipes. Each tank has been fitted with a pneumatic peristaltic pump that pumps any excess accumulated leachate into LS-1 for treatment in the Remedial Treatment System.

Northern Intermittent Stream Leachate Sump

After the NIS was diverted around the Landfill, it was necessary to collect the leachate that flowed into the abandoned pipe. This required the installation of a sump at the outlet end of the pipe to collect the leachate and divert it to the remedial treatment system before it can enter the Reservoir. The sump is fitted with two extraction pumps, which are set to operate at different levels. Normally a single lower pump operates to extract accumulated leachate. When the level rises due to increased flow, the sump level rises and the second pump is actuated to remove the excess accumulated leachate.

PHYSICAL TREATMENT SYSTEM COMPONENTS

The Physical Treatment System refers to the equipment and processes in the extraction well network, the leachate collection network, LS-1, the Clarifier System, the sludge handling system, the Filter Building, LS-2 and the Effluent Treatment System, the discharge network and the irrigation network up to the Node Panels. The Node Panels separate these components and their associated treatment equipment from those used in the Natural Treatment System. The division between the Physical Treatment System and the Natural Treatment System, as used in this report, is at the Node Buildings on the Landfill East and West Lobes. Within each Node Building there is a large electrical control panel (referred to as a Node Panel) that contains the data loggers and multiplexers,[2] as well as the translation interfaces needed to convert the data logger output from Modbus to Profibus[3]. The Physical Treatment System encompasses everything up to and including these translation devices in the Node Panels. Everything beyond these devices is considered part of the Natural Treatment System.

It should be pointed out that, although this point of division is used for descriptive purposes in this report, the Natural Treatment System could not be operated without also operating most of the components of the Physical Treatment System. All flow must pass through the extraction network and all of the Physical Treatment System up to the Settling Vat Effluent Filters to be suitable for use as irrigation water in the Natural Treatment System. Figures 11, 12, 13 and 14 in Attachment 1 depict the layout of the various components of the Physical Treatment System.

Landfill Node Buildings

This refers to two small prefabricated buildings, one on the East Lobe and one on the West Lobe of the Landfill, that contain the equipment (Node Panels and appurtenances) installed to collect and transfer data from the soil moisture probe network to the main control and instrumentation network (supervisory control and data acquisition system, or SCADA).

Lift Station 1

This is a single 8’ x 40’ (approximate) enclosure (sometimes referred to as Enclosure 8) used to collect and transfer the recovery well groundwater and the leachate from most of the sources and pump it to the inlet

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[2] Data loggers are devices that read and record the data from the probes. Multiplexers are devices that connect directly to the data loggers to allow multiple probes to send separate and discrete data to the data loggers.

[3] Modbus is an open computer language that is commonly used in automation. It is a serial communications protocol published by Modcom. It has become a de facto standard communication protocol, and it is now amongst the most commonly available means of connecting industrial electronic devices. The data loggers output the data they collect from the soil moisture network in Modbus. Profibus (Process Field Bus) is a standard for field bus communication in automation technology used by Siemens. Profibus is not an openly published protocol as older ones such as Modbus.

manifold in Lift Station 2 (LS-2). This includes flow from the five leachate collection tanks (LCHT) pumps, the NIS leachate sump, and recovery wells RWNIS-1, RWSIS-1, RWLFS-1, and RWLFS-2.

LS-1 is located nearly 80 feet (vertically) below the elevation of LS-2 near the Landfill perimeter road. LS-1 contains the pneumatic controls for most of the shallow groundwater recovery wells and all the leachate pumps, and the inlet header from the leachate and shallow groundwater recovery well networks. See Figure 11.

Lift Station 2

LS-2 consists of two 8' x 40' (approximate) enclosures (sometimes referred to as Enclosures 6 and 7) used to regulate the inlet flow to the Clarifier, provide pneumatic control for the remaining shallow groundwater recovery wells, and store and transfer the process flow from the Physical Treatment System to the irrigation network in the Natural Treatment System, or to the POTW. The LS-2 inlet manifold contains the proportioning and shutoff valves used to regulate the system flow into the Clarifier, then into the Filter Building, and from the Filter Building into the Settling Vat. It also receives the treated process flow from the Settling Vat proportioning manifold, or the advanced oxidation process (AOP^+) discharge header, and controls the flow to the discharge networks.

Enclosure 6 contains three Effluent Storage Tanks that can be configured to receive the process flow from the Settling Vat Effluent Filters without processing in the AOP^+ unit, or from the discharge of the AOP^+ unit after processing. Enclosure 7 contains the inlet manifold for the LS-2 extraction network, the inlet manifolds from LS-1 and the Filter Building, the control manifold for the irrigation network valves, the discharge lines to the POTW, the Natural Treatment System, the Recycle Line, and three sets of Physical Treatment System process effluent pumps, which can be used in any combination to pump to the discharge or recycle headers from any of the Effluent Storage Tanks. (See Figure 12).

Two totes outside LS-2 in a containment enclosure store chemicals used for treatment of the process flow. The totes contain 32% active hydrogen peroxide (H_2O_2), which is continuously fed into the Filter Building inlet line and can be fed, as needed, to the Settling Vat or the inlet of the AOP^+ unit. A large double walled storage tank holds liquid fertilizer, which is blended into the process flow from the Physical Treatment System to feed nutrients to the Natural Treatment System when the effluent is used for irrigation.

Clarifier System

The Clarifier is a vertical wall cylindrical Clarifier system which is approximately 15 feet tall and 18 feet in internal diameter. It receives all the flow from all sources in LS-1 and LS-2 and performs the initial treatment to remove mineral salts by pH adjustment, flocculation and settling.

The Clarifier consists of the cylindrical concrete body which has a sloped floor and a set of moving rakes that rotate to move the settled sludge to the center extraction line. Process flow entering the Clarifier is initially mixed with lime to raise the pH and cause the mineral salts to precipitate. The precipitate is mixed with ferric chloride to cause it to flocculate and settle to the bottom of the Clarifier. This is accomplished in the mixing zone of the Clarifier. Following the chemical addition and mixing, the process flow exits the mixing zone near the bottom of the Clarifier and rises through the settling zone allowing the precipitated solids to settle to the bottom and the clarified waters to rise to an overflow weir. The Clarifier effluent flows by gravity to the Aeration Tank in the Filter Building.

Sludge Handling System

The sludge from the bottom of the Clarifier is pumped to one of two Sludge Dewatering Boxes (referred to as Tipper Boxes). These two dewatering boxes are mounted on elevated stands to allow them to be tipped to empty the dewatered sludge. A polymer is added to the sludge in the line between the Clarifier and the Tipper Boxes to enhance dewatering. Sludge is directed to one of the Tipper Boxes until it is full. At that time, flow is directed to the idle Tipper Box, and the full box drains any free water to a sump that is pumped into the Clarifier Equalization Tank. Once the sludge is dried sufficiently, the box is emptied and the solids disposed. These devices are located outside the Maintenance Building near the Clarifier. See Figure 14.

Filter Building

The Filter Building receives flow from the Clarifier including LS-1 and the shallow bedrock recovery wells RWSIS-2, RWSIS-3, RWSIS-4, and deep groundwater pumping well PWDR-1. It provides oxidation and aeration prior to filtering to 25-microns+/- and polishing it in a 6-tray Air Stripper. It is then passed through to the Settling Vat in the Effluent Treatment System. See Figure 13.

Filter Building Inlet Aerated Storage Tank

This tank has ceramic fine bubble diffusers that aerate the inlet process flow. The air is exhausted outside the Filter Building. Aeration is used to strip any possible methane, remove some of the VOCs and cVOCs that enter the system from the process flow, and help oxidize the metals before they are removed in the filters.

Filter Building Main Filters

This refers to two large filters in the Filter Building. Their cross sectional area and filter bed capacity make them suited for processing at a flow rate of 50 GPM or more, and their filter media capacity allows sustained operation without excessive backwash. They are loaded with a dual bed filter media consisting of an upper layer of Filter AG to remove larger particles, and a lower bed of garnet that is intended to filter particles as small as 25 microns. Prior to the process flow entering the filters, a coagulant or flocculent may be added to improve the efficiency of the filters.

The filters are automatically backwashed based on differential pressure. Process water is stored in a 2,000-gallon backwash tank in the Filter Building. The backwash tank can be supplemented with City water as needed. The backwash pump draws water from that tank and pumps it through the off-line filter in the reverse direction at a rate twice the normal process flow rate. That lifts the bed and flushes the solids out of the media. The backwash water is sent to the Equalization Tank located behind the Filter Building. The Equalization Tank is pumped to the Clarifier for further processing.

Filter Building Air Stripper

This unit provides the final polishing treatment for VOCs and cVOCs in the process. It processes all of the flow coming out of the filters prior to it being pumped to the Settling Vat. It is a 6-tray counter flow air stripper with a 5-HP blower. It produces a much larger surface area of fluid exposed to a much higher flow of air than can be achieved by aeration. This makes it very effective in VOC removal. A sequestering agent may be added to the Air Stripper inlet line to avoid scale deposition in the Air Stripper and downstream components.

A tank in the Filter Building holds a polymer-based flocculent that is added to the sludge line from the Clarifier to the Tipper Boxes. This improves the dewatering of the sludge.

Maintenance Building

The Maintenance Building is located near the Filter Building and contains the lime and ferric chloride storage tanks, chemical feed pumps, air compressor and other appurtenances associated with the Clarifier chemical feed systems. It is also used for storage of spare parts and equipment.

EFFLUENT TREATMENT SYSTEM COMPONENTS

This system consists of five 8’ x 40’ (approximate) enclosures (sometimes referred to as Enclosures 1 through 5) and refers to the portion of the Physical Treatment System that includes the Settling Vat, Settling Vat Effluent Filters, AOP$^+$ unit and the water chemistry laboratory. This term refers to the area where the final treatment of the process flow occurs prior to exiting the Physical Treatment System and where control of the process flow path occurs. It distinguishes this portion of the treatment system from LS-1, LS-2, the Clarifier, the Filter Building and the primary Natural Treatment System. This system receives process flow from the Filter Building and treats the combined flow of 50 GPM (maximum) to remove any residual light organic materials, heavy organic materials, as well as any remaining metal salts that can become phytotoxic (damaging or destructive to vegetation) if allowed to accumulate in the soil. It is also where the AOP$^+$ unit is located.

Settling Vat

The Settling Vat is a large approximately 6,000 gallon rectangular stainless steel vat that receives all the process flow from the Filter Building for additional settling and separation of dense non-aqueous phase liquid organics (DNAPL), light non-aqueous phase liquid organics (LNAPL) and solids before it is used for irrigation water or further processed in the AOP$^+$ unit. There are provisions to raise and lower the pH and add an oxidizing agent following the Settling Vat, if needed.

In order to eliminate safety concerns due to the possibility of methane in the inlet flow, and to eliminate the potential for exposure of workers to the CoCs, the open top of the vat has been covered, the entire headspace swept with air from outside the Enclosures, and the air exhausted through an explosion-proof blower outside the Enclosure.

Because the unit did not operate properly during startup, the Parties installed two baffles in the vat to dissipate turbulence, capture separated materials, and facilitate separation and settling. At the inlet, an underflow baffle was installed to dissipate turbulence and capture light materials before the flow enters the settling section. In the settling section, the water flows across an overflow baffle and then enters the final section, where it is picked up in the transfer pump suction manifold, which can extract from any or all of four different levels on the sidewall of the vat. Because the suction lines are well above the vat floor, the final baffle should also assist in removing any heavy materials.

Settling Vat Effluent Filters

The process flow from the Settling Vat is sent to the Settling Vat Effluent Filters. These filters consist of a set of two bag type filters and a cartridge filter. The bag filters are operated as paired filters during normal operation, and the cartridge filter is bypassed. The process flow from the bag filters is sent either directly to the three Effluent Storage Tanks in LS-2 through the bag filters using a 25-micron bag, or to the AOP$^+$ unit through the same bag filters operated in series using a 25-micron initial filter and a 5-micron secondary filter, and then to a 1-micron cartridge filter before being processed in the AOP$^+$ unit. Process flow from these filters is sent directly to the Effluent Storage Tanks for discharge, to the AOP$^+$ unit inlet filter for processing or it may be recycled. This component occupies all of Enclosure 5.

AOP$^+$ Unit

This refers to a treatment system component that utilizes photo-catalytic (UV light and TiO_2 catalyst) “advanced oxidation” which the Manufacturer represented can destroy organic compounds, including 1,4-dioxane, that are persistent in the other processes in the Remedial Treatment System. The TiO_2 photo-catalytic process, in brief, is intended to employ a catalyst to expand the useful bandwidth of the ultraviolet (UV) light in the formation of hydroxyl radicals (OH-), and creates what are called “super-oxides.” These positively charged “holes” (h+) form on UV irradiated TiO_2 and are a stronger oxidizing agent than hydroxyl radicals. This component occupies all of Enclosure 2 and was intended to provide backup treatment when the primary Natural Treatment System is not functioning.

When delivered to the Site, the AOP+ Unit was not operable, and despite repeated efforts the Manufacturer was unable to make the Unit operational. The Parties spent considerable time and money to repair the system and to render the Unit operational. Ultimately, even when operational, the AOP$^+$ could not consistently treat the effluent to the required levels established in the City’s Pretreatment Permit Therefore, it cannot be operated, and the Parties are not able to discharge any treated effluent to the POTW. The Parties have explored alternative technologies that might improve or replace the AOP$^+$ unit. However, the available alternative technologies are very limited due to the high levels of 1,4-dioxane in the groundwater and leachate and the presence of high levels of radical scavengers in groundwater and leachate at the Site. At this time, the Parties have not been able to identify a suitable enhancement or replacement for the PhotoCat. As a result the Parties submitted Technical Memorandum E-10, which presented the case for operating the system as is without any backup. TM-E10 was approved by NCDEQ.

Supervisory Control and Data Acquisition Network

The Supervisory Control and Data Acquisition Network (SCADA) controls the operation, alarm, interlock, data collection and other functions necessary to safely operate the Remedial Treatment System components. It is comprised of a central programmable logic controller (PLC) and four operator input stations, one in LS-2, one in Enclosure 3 in the Effluent Treatment System, one in the Filter Building and one in LS-1. This allows the operator to input commands from any of those locations.

Natural Treatment System Components

The Natural Treatment System (sometimes referred to as the Phytoremediation System and the Biodegradation System) is currently established and maturing on the cap of the Landfill. It is a 33-acre tree stand consisting of a variety of conifer tree species (primarily pine tree species). A buried drip-irrigation system for irrigation and fertigation[4] of the trees is divided into 16 two-acre (approximately) zones that can be automatically activated sequentially to dispense irrigation water and nutrients at a rate of approximately 50 GPM per zone. An irrigation monitoring and control system is managed by the SCADA and provides irrigation based on data from soil suction (soil water tension) and temperature probes installed at various depths in each zone. The SCADA is programmed to automatically control irrigation. If the soil profile within a given zone becomes too wet, and excessive percolation below the root zone is imminent, the SCADA will skip that zone and move to the next zone. When the SCADA senses soils have sufficiently dried because of transpiration and percolation, it will again allow irrigation of the skipped zone. Figures 6 and 7 in Appendix 1 show the general layout of the Natural Treatment System.

Phytoremediation Tree Stand

The Phytoremediation Tree Stand refers to an upland tree stand planted on the East and West Lobes of the Landfill. It consists of a planting of mixed conifer [5] trees which uptake soil moisture. It is designed to uptake irrigation water and destroy the CoCs contained in the groundwater and leachate through phytovolatilization, a process in which the trees take up the CoCs dissolved in the irrigation water and translocate the CoCs to the leaves. The CoCs exit the leaves with the transpiration gas via the stomata. In the atmosphere, the CoCs are destroyed by ultraviolet light. This process is the predominant method by which the Natural Treatment System degrades the CoCs during the months in which the trees are actively growing and evapotranspiration is high. In addition to this process, biodegradative processes are known to act on the CoCs in the soils, particularly in the area immediately surrounding the root zone of a tree or other plant. This area around the plant root is referred to as the rhizosphere, and biodegradation in the rhizosphere is called rhizodegradation. These biodegradation processes can degrade the VOCs, cVOCs and 1,4-dioxane, and contribute significantly to the overall treatment effectiveness of the Natural Treatment System.

Irrigation System

For the Natural Treatment System to be effective, it is important that most of the CoC-containing irrigation water be taken up by the trees during the period when the evapotranspiration rate (ET_o) is high, and the irrigation water is retained in the soil for a sufficient time to allow the biodegradation processes to be effective. The rate of water input from irrigation plus precipitation is compared to the rate of water exiting the system, primarily through transpiration by the trees and percolation below the root zone soils, to maintain the proper balance.

The main controller for the Irrigation System is the SCADA, which is networked to remote input and output (I/O) devices. Data input from the Natural Treatment System to the SCADA comes from data loggers that record the data from the soil suction probes and soil temperature probes and provides hourly averages to the SCADA. In addition, the SCADA can receive overriding commands input by the system operator.

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[4] Fertigation is the injection of fertilizers, soil amendments, and other water-soluble products into an irrigation system.

5 As explained earlier, the hardwood trees have been interplanted with alternative conifer species effectively making the tree stand act as if it were planted in all conifer trees.

Data loggers collect data from the soil suction (water tension) and temperature probes installed at various depths in the Landfill cover soils. Based on this data, the data loggers calculate the soil suction on a scale of 0 to 200 kilopascals (kPa), the higher the tension the dryer the soil. Information from the data loggers is averaged hourly, translated from Modbus to Profibus, and transmitted to the SCADA. The SCADA also receives information directly from other probes (e.g., weathers station sensors and water flow meters). Based on this information, the controller regulates soil suction within an acceptable range for the various zones.

One key set of program instructions are the zone-specific values for saturation points based on the water holding characteristics of the soil in each zone. Based on these instructions, the SCADA automatically allows an irrigation zone to be turned on or off, and automatically determines the next available zone to irrigate. These values are input by the operator based on soil samples collected from each moisture probe nest area.

Each irrigation zone contains 1 to 2 nests (23 total nests in 16 zones) of soil suction[6] probes installed approximately 1 foot (horizontal distance) from a drip-irrigation line. Soil suction is a measure of the tension exerted on the soil by the moisture present. Within each nest there are three probes installed at different depths in the soil profile. The probes are designated u- (upper), m- (middle), and d- (deep). The number of nests within each irrigation zone and the depths of the three probes in each nest are determined by the varying depth of the Landfill cap material and differing areas of each zone. All of the u-probes are installed 12 inches below ground surface (bgs); all of the d-probes are installed 1 to 2 inches above the soil/waste interface, and all of the m-probes are installed roughly equidistant between the u- and d-probes. The readings from each are recorded by the data loggers and averaged hourly. The set point is the maximum soil moisture of the root-zone soil that allows the moisture to be held in the soil without rapid drainage. The set points are different for each irrigation zone and are dependent upon the water-holding characteristics of the soil within each zone.

Soil Moisture Probes

The Irrigation System Repair and Upgrade modified the soil moisture control network. The network has been upgraded by using the existing 23 nested probe locations. However, the 3 soil moisture, temperature, and salinity probes originally installed at each nest have been replaced with soil suction probes. These probes use a simple current flow, or more correctly the resistance to current flow, to determine the soil tension or suction, and are more reliable than the original probes.

Temperature Probes

In addition to the soil suction probes, 6 soil temperature probes were installed to monitor the upper, middle, and deep probe depth soil temperatures on each lobe of the Landfill. These temperatures are used to correct the soil suction probe readings. In addition, two temperature probes, one on each lobe, monitor the temperature of the soil approximately 4 inches bgs. These are used to determine the critical temperature at which irrigation may be stopped due to hard freeze conditions.

Data Loggers

Data loggers are the core devices that generate the signals necessary to read the soil suction and temperature probes, record, manipulate and average those readings as needed, and present them in tabular format for input into the SCADA. These devices are the last piece of equipment in what is referred to as the Soil Moisture Probe Network. One data logger is located in each Node Building Panel.

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[6] If the water contained in the voids of a soil were subjected only to gravity, the soil lying above the water table would be completely dry all the time. However, molecular and physical-chemical forces act at the boundary between the soil particles and the water and cause the water to be either drawn up into the otherwise empty void spaces, or held there without drainage. The attraction that the soil exerts on the water is termed “soil suction.” The magnitude of the attractive force that the soil exerts on water is governed by the size of the voids. The smaller the void, the harder it is to remove the water from the void. Therefore, soil suction is a function of both the molecular forces and the soil characteristics. Basically, the dryer the soil the higher the soil suction. It is measured in units of kilopascals (kPa).

Multiplexers

Multiplexers are devices that are used to connect multiple data inputs (probe inputs) to a single data logger. In this case, the soil suction probes and the temperature probes each occupy an address on a multiplexer. These devices are mounted in the Node Panels located in each Node Building.

Node Panels

Within each of the East and West Lobe Node Buildings, there is a large control panel referred to as the Node Panel. These panels each contain several components that are part of the Natural Treatment System. This includes a data logger and one or more multiplexers that are used to connect 69 soil suction probes and 8 temperature probes to two data loggers.

Weather Station

The weather station is located in the Main Treatment Area near Enclosure 1. It provides temperature, barometric pressure, relative humidity, wind speed and direction, the amount of rainfall and the amount of solar radiation to the SCADA. The SCADA in turn uses the data to calculate the evapotranspiration rate (ET_o) for the Site. That information is balanced against the amount of irrigation water and the amount of rainfall to manage the water balance for the irrigation network control. The rate at which the trees use water, the transpiration rate, is a function of ET_o.

REMEDIAL TREATMENT SYSTEM DESIGN

GENERAL INFORMATION

The original selection of the remedy implemented at the Site was based largely on the presence of DNAPLs and 1,4-dioxane in the groundwater and leachate. The compound 1,4-dioxane has very poor treatability characteristics in conventional treatment systems and does not respond well to most of the commonly used remedial treatment techniques. This is because it has a relatively low Henry's Law[1] constant, and therefore is not volatile and cannot be air-stripped. Its boiling point is 101 °C, very similar to water, and therefore it will not distill or easily separate. It has a low organic-carbon partitioning factor (K_{oc}); therefore, it will not readily separate in processes such as carbon adsorption. It does not adsorb to organic material and is highly soluble in water.

Given the presence of DNAPLs in the subsurface, and the highly fractured and heterogeneous bedrock conditions present at the Site, restoration of groundwater quality to regulatory standards within a reasonable timeframe was determined to be technically impracticable. The presence of 1,4-dioxane mandated that a remedial treatment system be capable of degrading, mineralizing or destroying this compound, which is highly mobile and resistant to treatment techniques more commonly employed in treatment systems.

The modifications made to the original treatment design were based upon the higher than expected amount of solids generated due to the higher levels of metal salts. This consisted of the addition of the Filter Building in an effort to manage the solids by direct filtration. When this proved insufficient, the Clarifier was added to remove the solids prior to the flow entering the Filter Building.

As a result, the treatment methods employed at the Site have been designed to provide for reasonable operating economics coupled with long-term operating capabilities and reduction of the concentrations of all the CoCs including 1,4-dioxane. The Remedial Treatment System employs the extraction and treatment of groundwater at a rate necessary to capture and contain contaminant migration and the collection and treatment of SIS, Landfill and NIS recovered shallow groundwater, leachate from the existing leachate collection tanks, and leachate drainage from the abandoned piped sections of the NIS. It also provides for the improvement of the cover system for the Soil Residue Mound, diversion of the flow from the piped section of the NIS and restrictions on specific uses of the land on and adjacent to the Site through the recording of Land Use Restrictions and other limiting rules, regulations and permit conditions.

REMEDIAL OBJECTIVES

The objectives of remedial action implemented at the Site include the following:

1. Contain the contaminated soils at the source areas to prevent direct contact by potential human and environmental receptors, reduce percolation and intrusion of storm water and surface water to reduce the migration of CoCs into the groundwater;
2. Control migration of landfill leachate to prevent discharge to surface waters at the Site;
3. Control migration of contaminated groundwater at the Site to prevent off-site migration and unacceptable impacts to surface waters;
4. Achieve compliance with North Carolina surface water quality standards for the CoCs in the surface waters of the on-Site streams and the Reservoir; and
5. Achieve compliance with North Carolina Ground Water Quality Standards for the CoCs in the groundwater beneath the Site; and

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[1] At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.

6. Restrict future uses of the Site, and certain adjacent properties, that could present potentially unacceptable exposure risks (e.g., residential development, use of impacted ground water, etc.).

It is important to point out that the primary objective of this remedy is to control the migration of Landfill leachate to prevent discharge to surface waters, and the migration of contaminated groundwater to prevent unacceptable impacts and off-Site migration to surface waters. This is accomplished by a hydraulic containment system that is monitored by transducers installed in key wells to monitor and demonstrate the effectiveness of the capture zone.

Containment of the contaminated soils at the source areas to prevent direct contact by potential human and environmental receptors and reduction of the intrusion of storm water and surface water to restrict the migration of CoCs into the groundwater are accomplished by the capping of the Soil Residue Mound and general Landfill cap maintenance. The method used to restrict future uses of the Site, and certain adjacent properties that could present potentially unacceptable exposure risks (e.g., residential development, use of impacted ground water, etc.) is the recording of “Land Use Restrictions” (LURs) on the SCC property, the Landfill property and the MRF property.

On certain properties adjacent to the Site, land use is restricted by the limitations placed on land and groundwater use within the Randleman Reservoir Tier 2 critical watershed, the rules of the PTRWA which specifically preclude development within the Reservoir and the 200 foot wide buffer surrounding the Reservoir, restrictive conditions of the Army Corps of Engineers (ACE) permit issued for the dam and Reservoir, regulations administered by the NCDEQ Division of Water Resources, and the Guilford County Well Regulations, which limit water well placement within 1,500 feet of a known source of groundwater contamination.[2] Although the Parties made substantial efforts to place LURs on the Crutchfield property that abuts the PTRWA buffer on the north side of the Reservoir, the landowner refused to allow them to be recorded. The Parties concluded there are sufficient other restrictions on the use of the lands and groundwater in the vicinity of the Site such that not recording LURs on that property would not result in increased risk to human health or the environment.

SITE HYDROGEOLOGY

The geology of the Site consists of fractured granite gneiss[3] that has been intruded by mafic dikes. The mafic dikes are generally oriented N20°E (20 degrees east of north) and are sub-vertical, dipping to both the northwest and the southeast. The mafic dikes generally do not occur as single massive tabular bodies, but as a swarm of thinner tabular and irregular dikes within larger fracture zones within the granite gneiss. The thickness of individual mafic dikes ranges from less than one foot to more than 30-feet. Smaller ephemeral mafic dikes that are not associated with fracture zones are disseminated throughout the granite gneiss.

The physical character of the subsurface geologic media grades with depth from unconsolidated soil and saprolite[4] to partially weathered rock to bedrock. In some areas across the Site, outcrops of competent bedrock occur at the ground surface. The saprolite, where present at the Site, generally consists of clayey sands to silty clays and is less than 20 to 30 feet in thickness. The partially weathered rock is composed generally of medium to coarse-grained granite gneiss and is interbedded occasionally with fine to medium-

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[2] See Guilford County Well Rules Chapter 2, Section III Standards of Construction, Paragraph A Location, Subparagraph 2 which states “Special consideration shall be given for wells within 1,500 feet of a point or source of groundwater contamination.” The Guilford County Health Department (GCHD) must review these wells before they are permitted. The Parties have notified the GCHD that the Site represents a source of groundwater contamination.

[3] Gneiss is a typical rock type formed by regional metamorphism, in which a sedimentary or igneous rock has been deeply buried and subjected to high temperatures and pressures. Nearly all traces of the original structures and fabric are lost as the minerals migrate and recrystallize.

[4] Defined as soft, friable, is volumetrically weathered bedrock that retains the original rock’s structure and fabric but with a lower bulk density.

grained silty sands. Where present, the partially weathered rock zone varies from depths of approximately 25 feet near MW-2A to 90 feet near PW-13I (see Figure 3).

Several prominent geologic structures have been identified and mapped at the Site. Based on the conceptual model, which was developed during the Remedial Investigation process, the most significant geologic features are as follows:

Southern Intermittent Stream Fault

A N80°E oriented fracture zone/fault that parallels the southern intermittent stream. Based on an on-site outcrop measurement and fracture orientation data from the PW-3D core, the fracture zone is believed to dip 43° to the south.

Seaboard Dike

A N20°E oriented mafic dike that extends from the Seaboard facility to the vicinity of monitoring well PW-13I and north of the Deep River.

PW-5D Dike or Fault

A N20°E oriented diabase dike / fault that extends northward from the east side of the Seaboard facility near PW-8S to the vicinity of monitoring well PW-5D north of the Deep River. The PW-5D Fault has an inferred connection with the Southern Intermittent Stream Fault beneath the Landfill.

Regional Dike

A major regional mafic dike that extends N20°E near PW-6I/6D and extends north of the Deep River.

Deep River Fault

A southward-dipping fault that forms the east-west segment of the Deep River. Based on an on-site outcrop measurement and fracture orientation data from the PW-5D core, the fracture zone is believed to dip 50° to the south.

These structural features serve as preferred pathways for groundwater flow and contaminant migration at the Site. The Southern Intermittent Stream Fault represents a significant groundwater flow and contaminant migration pathway to the east, toward the Reservoir. Groundwater flow is diverted northward from this fault by north-south trending geologic structures, which extend to the Reservoir in the vicinity of PW-5D. At the east-west segment of the Reservoir, the Deep River Fault controls the flow path. This southward-dipping fault intercepts the main VOC plume at the Reservoir. The Regional Dike serves as a natural cut-off feature to limit the eastward migration of contaminants within the shallow bedrock aquifer and limits the discharge zone of contaminated groundwater into the Reservoir. Similarly, the Seaboard Dike that extends from the Seaboard facility northeastward to the vicinity of PW-13I represents a northwest boundary of the main VOC plume (see Figure 3).

GROUNDWATER HYDRAULIC CONTAINMENT DESIGN

An aquifer test was conducted at the Site during the period of July through August 2002. Using extraction well PW-DR1, pumping rates were periodically varied to evaluate the potential capture zone using drawdowns observed in nearby monitoring wells. The determination of the extraction rate that would capture flow from the Regional Dike and the Seaboard Dike was of particular interest. The extraction rate test results indicated that the VOC plume could be contained at the Reservoir by pumping at a relatively low rate (10 – 20 GPM) at PW-DR1. The drawdown data indicated that pumping at a rate of approximately 10 GPM produced a capture zone that extends parallel to the east-west segment of the Reservoir. The capture zone extends along the Deep River Fault to beyond the Seaboard Dike to the west and beyond the Regional Dike to the east.

Based on the results of the extraction test, the main plume of VOC-impacted groundwater migrating from the bedrock aquifer to the Reservoir is intercepted by pumping from groundwater extraction well PW-DR1, located at the Reservoir near the SIS confluence. The estimated pumping rate for PW-DR1 is 10 to 20 GPM. Four additional shallow groundwater recovery wells also are located along the Reservoir: RW-NIS1 located at the NIS confluence with the Reservoir; RW-LFS1 and RW-LFS2 located along the southeast portion of the Landfill; and RW-SIS1 located near the SIS confluence with the Reservoir. RW-SIS1 is used only if needed (i.e. if capture of shallow impacted groundwater in the eastern SIS area is not achieved by pumping at PW-DR1). The estimated pumping rates of the four additional extraction wells along the Reservoir range from 0.5 GPM for RW-SIS1 to 6 GPM for RW-NIS1.

In the western SIS area, located upstream of the Landfill, five shallow groundwater extraction wells are used to intercept the affected groundwater migrating to the SIS. Three extraction wells (RW-SIS2, RW-SIS3 and RW-SIS4) are located along the south bank of the stream and have an estimated pumping rate of 0.5 GPM each. Two extraction wells (RW-SIS5 and RW-SIS6) are located along the north bank of the stream and will be used if capture of shallow impacted groundwater in the western SIS area is not achieved by pumping at the three wells along the south bank. The location of the groundwater extraction wells is shown in Figure 9.

SYSTEM EFFICACY

To evaluate the efficacy of the extraction network, transducers were installed to monitor water levels in seven existing monitoring wells as described in the modified Remedial Monitoring and Effectiveness Evaluation Plan. These seven monitoring wells include OW-DR-2, OW-DR-3, OW-DR-4, PW-6D, and OW-LFS-2, which are located on the Landfill property, and PW-15D and PW-16D, which are located across the Reservoir on property within the PTRWA buffer. During December 2014, while startup testing of all of the recovery wells was underway, the transducers indicated drawdown and good hydraulic control in most of the monitored wells, including two monitoring wells located across and north of the Reservoir. The observed water level drawdowns during startup testing are summarized in Table 1. An exception is monitoring well OW-DR3, which has historically been unresponsive to pumping and did not show significant drawdown during the limited startup testing of the extraction system. Information similar to the results of drawdown testing during the December 2014 startup was also observed during collection of the static monitoring well water levels during the 2014 Annual Water Quality Monitoring Event. The groundwater levels in MW-3C, MW-12D, OW-DR2, PW-5D, PW-6D, PW-SF1, and W-4A showed evidence of drawdown because of the startup test extraction. The startup test pumping of extraction well PW-DR1 has altered the groundwater flow regime in the bedrock aquifer along the northern portion of the Landfill adjacent to the Reservoir. The operation of extraction well PW-DR1 indicates a significant capture zone for monitoring wells along the northern section of the Landfill adjacent to and across the Reservoir.

Observations of groundwater drawdown during recent startup testing confirm the design data developed during the 2002 aquifer testing. The drawdown pattern and extent of the capture zone observed from the permanently installed transducers during the 2014 Annual Water Quality Monitoring Event support the findings of the aquifer testing and indicate hydraulic control of the contaminant plume is achieved using an extraction rate of ± 20 GPM at PW-DR1. Given the drawdown indicated in deep monitoring wells on the north side of the Reservoir (PW-15D/PW-16D), the designed extraction system exceeds the anticipated design performance. Evaluation of the efficacy of the capture zone will continue as full operation of the extraction system is implemented.

Table 1 - Transducer Well Levels

Well ID	Water Level Drawdown at 24 hours	Water Level Drawdown at 48 hours
PW-DR1 (extraction well)	-19.24	-19.25
OW-DR4	-13.72	-13.74
OW-DR2	-13.93	-13.96

OW-DR3	-0.14	0.31*
PW-6D	-8.53	-8.59
OW-LFS2	0.70*	1.76*
PW-16D	-7.62	-7.55
PW-15D	-5.29	-5.26

Notes: Pumping rate set at ± 30 GPM.
Drawdown shown as feet below static observed at startup.
* Increase in water level likely attributable to fluctuations in Reservoir levels.

NATURAL TREATMENT SYSTEM DESIGN

The Natural Treatment System at the Site is an approximately 33-acre stand of conifer trees that is irrigated year-round with process flow from the Physical Treatment System. The process flow contains 1,4-dioxane and low levels of VOCs as well as some metal salts. Phytoremediation processes include the transpiration of the irrigation water, phytovolatilization of the CoC-components (including 1,4-dioxane)[5], as well as rhizodegradation (Biodegradation in the plant root-zone) of residual VOCs.

Phytovolatilization is the primary mechanism of CoCs removal, a process in which the dissolved CoCs including 1,4-dioxane are taken up via the roots and transferred to the atmosphere along with water vapor in the transpiration gas. Thus, the rate of phytovolatilization is tied to transpiration (water up-take by the trees). The transpiration rate of the tree stand matches or exceeds the irrigation rate from spring through fall when reference evapotranspiration (ET_o) is high. In winter, with low ET_o, the rate of irrigation will exceed the rate of transpiration, and some percentage of irrigation water will percolate below the root zone.

The current operating procedures for the Site include on-going tasks related to the Natural Treatment System, specifically, monitoring the performance of the 33-acre system as well as performing tests with a pilot-scale system.

The monitoring program has the following objectives:

1. Tracking the extent of plant stress will assess the health and sustainability of the tree stand. Stress will be estimated by on-going measurements of the ratio of transpiration to ET_o.
2. Landfill cover soils will be monitored for soil moisture, electrical conductivity (an indication of salinization), CoC concentrations, and agronomic characteristics. There is a system of 23 nests of soil moisture sensors within the 33-acre tree stand (three sensors per nest).
3. The volume and CoC content in the drainage water collected in bucket lysimeters will be monitored and the masses of CoCs percolating below the root zone will be calculated. There are 10 bucket lysimeters installed within the 33-acre system;
4. Potential imbalances in plant nutrition created by uptake of inorganics in the irrigation water will be monitored by analyzing samples of plant tissue. These imbalances will be addressed by appropriate changes in the fertigation protocol.
5. Pilot tests will be conducted within a small plot of mature trees located on the west lobe of the Landfill that is fully representative of the full-scale system. The plot is instrumented so that drainage and transpiration rates and soil moisture can be extensively monitored. The pilot tests will provide monthly data for the treatment efficiency of the Natural Treatment System, specifically the volume of drainage water, the mass of CoCs leaching below the root zone and remaining in the soil, and the rates of 1,4-dioxane phytovolatilization. Rates of 1,4-dioxane phytovolatilization will be estimated by multiplying data for the volume of water transpired by the trees during a given study period (L) by the concentration of 1,4-dioxane in the xylem sap (mg/L).

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[5] As explained earlier, although 1,4-dioxane has been one of the primary CoCs that has driven some of the design of the Remedial Treatment System it is only one of several CoCs that could be persistent in the Physical Treatment System. Therefore, unless

The area of the tree stand as well as the species and maturity of trees was used to determine the theoretical water losses attributable to transpiration. The rate of transpiration by the tree stand is indicated in Table 1 below as ET_c (ET_c is a function of reference evapotranspiration, ET_o) The transpiration rate of the tree stand varies each month, as reflected by the values for average ET_c. Therefore, as the tree stand is irrigated it will only consume the amount of irrigation water equal to the losses through evaporation ET_c offset by precipitation. The difference between ET_c and precipitation is the net amount of irrigation water that can be used by the tree stand (I_c in Table 1). If Ic is greater than the rate of irrigation, there is no net infiltration; if I_c is less than irrigation, the difference represents the water available for infiltration. Because the irrigation system uses buried drip emitters and lines, evaporation is assumed zero.

Table 2 - Monthly Potential Infiltration Rates

Month	ET_c	Precipitation	I_c	Infiltration
January	53.8	53.8	0	50
February	69.2	50	19.2	30.8
March	123.1	59.6	63.5	0
April	161.5	61.5	100	0
May	196.8	55.8	141	0
June	207.7	61.5	146.2	0
July	207.7	71.2	136.5	0
August	192.3	59.6	132.7	0
September	142.3	76.1	66.2	0
October	107.7	50	57.7	0
November	96.9	51.9	45	25
December	52.6	48.1	4.5	45.5

January represents the only month in which the infiltration rate is equal to the irrigation rate. Infiltration begins in November at 25-GPM, becomes higher in December and January, and lessens throughout February until it is zero again in March.

This infiltration water is needed in the system to flush any potential salt buildup out of the Site soil and into the upper layer of the Landfill material. In the PCR for the Natural Treatment System it was explained that the soils needed to be periodically flushed of accumulated salts using City water. At that time, it was assumed there would be a greater salt concentration in the process effluent water than was seen during recent testing. Therefore, the excess Physical Treatment System process effluent water applied to the Natural Treatment System during the period when ET_o is low will replace the use of City water for this purpose. In the PCR, it was planned that it would be necessary to cease irrigation with Physical Treatment System process effluent during the period when ET_o is low, shift to discharging to the POTW, and irrigate with City water at a rate of 50 GPM during this entire period.

One main factor that has resulted in the improved quality of the irrigation water was replacing the originally planned constructed treatment wetlands (CTW) with various chemical and physical pre-treatment processes, as described in this report. At the time the PCR was submitted, it was planned for the CTW to receive extracted groundwater and leachate without significant pretreatment. The flow from LS-1 and LS-2 was to be sent to the CTW without prior treatment and the cVOCs and VOCs would be biodegraded in the CTW. With the elimination of the CTW, and the inclusion of various chemical and physical pre-treatment processes, such as aeration, air stripping, flocculation, softening, and filtration, the levels of metal salts and chlorides in the irrigation water is much lower than anticipated when the PCR was submitted. The much lower levels of metal salts and chlorides found to be present in the Site soils during startup testing appear to confirm this.

With the lower accumulation rate of salts experienced during startup testing, due to the enhanced removal in the Physical Treatment System, it is not necessary to stop irrigation during the period when ET_o is low. Because the Physical Treatment System process effluent now contains salts below phytotoxic levels, it is acceptable to use process effluent to flush accumulated salts from the Site soil. This approach has the added benefits of keeping the Physical Treatment System process effluent inside the capture zone of the Physical and Natural Treatment Systems, and not discharging it to the POTW, which does not have the capability to treat some of the CoCs, especially 1,4-dioxane. In addition, even when ET_o is low and tree uptake is at a minimum, the biodegradative activities in the soil are still active. Moreover, some transpiration occurs during periods of low ET_o due to the use of mostly conifer trees in the Natural Treatment System, providing a degree of continuing reduction in the CoCs.

REDUNDANT SYSTEM DESIGN

At the time the remedy was approved, NCDEQ was hesitant to accept that phytoremediation and biodegradation alone were sufficiently reliable to meet the Remediation Goals over a long period. This was mainly due to the lack of long-term operating data and experience with the natural treatment technology at the time and a concern that disease or other natural processes could destroy or diminish the ability of the Natural Treatment System to process the Physical Treatment System effluent flow necessary to effectively control the contaminant plumes.

Therefore, the Parties attempted to provide an alternative to the use of the Natural Treatment System in the Remedial Treatment System design. After investigation of the treatability of 1,4-dioxane and other CoCs, and based on representations of the Manufacturer, the Parties installed the AOP^+ unit as a backup treatment technology. That system is described earlier in this report

Thus the Remedial Treatment System was originally designed with two possible flow paths for the final disposition of the Physical Treatment System process effluent that share all the Physical Treatment System components except for the AOP^+ unit. Had the AOP^+ unit performed, the groundwater and leachate flow would have been the same through the Physical Treatment System up through the Settling Vat Effluent Filters regardless of the configuration selected for flow beyond that point. At that point, flow was designed to be directed either directly to the Effluent Storage Tanks in LS-2, or through the AOP^+ unit and then to the Effluent Storage Tanks. From the Effluent Storage Tanks, the operator would have had three options: (1) use the process flow for irrigation in the Natural Treatment System; (2) discharge to the POTW[6]; and (3) in the event of a system upset, return the flow to the Filter Building for further processing. Because the AOP^+ unit cannot be operated to reliably produce an effluent that meets the City pretreatment permit limits, that discharge flow path has been disabled in the SCADA. As a result, the operator has two options at this time: to use the effluent for irrigation of the tree stand or return it to the Filter Building for further processing.

SITE TREATMENT SYSTEM EFFECTIVENESS EVALUATION

Groundwater and surface water sampling in conjunction with continuous monitoring of the groundwater elevations at selected monitoring wells using transducers will be employed to monitor the effectiveness of the remedy and ensure there is no unacceptable migration of contaminants into the Reservoir or the groundwater beneath the lands north and east of the Landfill. The effectiveness of the selected remedy will be evaluated every five years after startup to assess performance and explore alternative new and developing technology that might influence remedial design.

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[6] Throughout this Report there are references to the Physical Treatment System's ability to discharge to the POTW. It is important to understand that, although the capability is there, the actual ability to discharge to the POTW is contingent upon compliance with the limits established by the City of High Point Industrial User Pretreatment Permit (IUP) Number 0150, which includes among other limitations, a maximum concentration of 10 ug/L of 1,4-dioxane in the system effluent. Because the AOP^+ unit is not able to meet that discharge limit, it is not permitted to discharge to the POTW..

SITE INVESTIGATION

GENERAL INFORMATION

Two phases of Site investigation occurred once the remedial activities began in 1990. These are as follows:

> Phase I work consisted of two surface removal action phases and the preparation and submission of the plans and procedures needed to conduct a remedial investigation. Seaboard Group I conducted this work
>
> Phase 2 work consisted of the investigatory work necessary to prepare and submit a Remedial Investigation Report, a Baseline Risk Assessment, a Feasibility Study, and a Remedy Recommendation Document, as well as execute a Remedial Action Settlement Agreement. The City of High Point and Seaboard Group II jointly conducted this work.

SYSTEM ENGINEERING STANDARDS

The Remedial Treatment System installed at the Site was designed to comply with the latest edition of the following codes and standards:

1. National Electrical Code (NEC)
2. Occupational Safety and Health Administration (OSHA)
3. National Fire Protection Association (NFPA)
4. National Electrical Manufacturer’s Association (NEMA)
5. American National Standards Institute (ANSI)
6. Insulated Cable Engineer’s Association (ICEA)
7. Instrument Society of America (ISA)
8. Underwriter’s Laboratories (UL)
9. ETL Testing Laboratories (ETL)
10. American Society of Heating, Refrigeration, and A/C Engineers (ASHRAE)
11. International Building Code (IBC)
12. North Carolina State Building Code
13. North Carolina Modular Building Code
14. American Society for Testing and Materials (ASTM)
15. NEMA 12 for dry, electrical control rooms.
16. NEMA 4 for indoor process equipment rooms.
17. NEMA 4 for outdoor locations.

The remedial design and construction at the Site has occurred in multiple phases spanning over 25 years. Many engineers specializing in various disciplines assisted in the development of the project design and specifications. The various plans, specifications and reports, signed and sealed by the responsible engineers for their disciplines, have been submitted separately to NCDEQ.

These plans, specifications and reports include the following:

- Pre-construction report
- Phase 1 construction plans
- Phase 2 construction plans (Filter Building)
- Phase 3 construction plans (Clarifier)
- Process and Instrumentation Diagrams
- Hazen & Sawyer report
- Arcadis Report

The original design, as submitted in the PCR, was certified by the various participating professional engineers as attested by their seals and signatures on the various plan set drawings. As modifications to those plans were being designed, registered professional engineers licensed to practice the requisite disciplines required by the State of North Carolina were retained to oversee all engineering. A full plan set of drawings with the requisite signatures and seals of the appropriate professional engineer has been provided to NCDEQ as a separate submittal. These plans and drawings attest to the oversight by licensed North Carolina Registered Professional Engineers.

PHASE 1 SITE INVESTIGATION WORK

Seaboard Group I Activities

Because SCC was bankrupt and there was evidence potentially serious environmental risks remained at the Site, NCDENR notified identified parties that had allegedly shipped material to the facility, referred to as Potentially Responsible Parties (PRPs), that a meeting was to be held in Raleigh, NC in the spring of 1990 to discuss the remedial needs at the SCC facility. Because of that meeting, Seaboard Group I (SGI) was formed by some of the PRPs to implement and fund a surface removal action and undertake the initial steps necessary to mitigate risks of environmental impacts at the SCC facility.

SG I conducted removal activities at the SCC facility from 1990 to 1992, during which all waste materials, tanks and equipment, other than the main building, were removed from the Site. The SCC facility was then fenced with a 6-foot chain link fence with 3-strands of barbed wire on the top to deter unauthorized trespassing which had been a recurring problem.

In addition, SGI agreed to prepare and submit a remedial investigation work plan (RIWP) (Geraghty and Miller 1993), and a Health and Safety Plan (HASP) (Geraghty and Miller 1994) and Sample and Analysis Plan (SAP) (Geraghty and Miller 1994) for the scope of work outlined in that RIWP. This work was completed during the period from 1992 to 1994, and the necessary documentation was submitted to NCDENR, which approved the RIWP for implementation.

PHASE 2 SITE INVESTIGATION WORK

City of High Point and Seaboard Group II Activities

Following the Phase 1 work, around 1995 the PRPs formed SGII to conduct further remedial activities at the Site. SGII and the City agreed to perform a remedial investigation (RI) and prepare and submit a RI Report, a feasibility study (FS) and a baseline risk assessment (BRA) for the Site. The City and SGII entered into an interim agreement to cooperatively fund the cost of this work. Blasland, Bouck, and Lee, Inc. (BB&L) was retained to perform the required investigatory tasks listed in the RIWP and prepare the RI report. ERM-NC, P.C. (ERM) was retained to prepare the FS and BRA.

Remedial Investigation

The RI determined the Reservoir would be located down-gradient of the Site groundwater plume, which contained 1,4-dioxane and a mixture of chlorinated volatile organic compounds (cVOCs), volatile organic compounds (VOCs), semi-volatile organic compounds (sVOCs), and metal salts, referred to collectively as the contaminants of concern or CoCs. Table 1 lists the most significant CoCs identified at the Site.

Table 3 - Summary of Significant Contaminants of Concern

Chlorinated Ethenes	Chlorinated Ethanes	BTEX Compounds	Other Organics
Perchloroethene	1,1,1- Trichloroethane	Benzene	Chloromethane
Trichloroethene	1,1- Dichloroethane	Ethyl benzene	Dichloromethane
1,1-Dichloroethene	1,2- Dichloroethane	Toluene	Chlorobenzene
cis-1,2- Dichloroethene			Acetone
trans-1,2- Dichloroethene			Vinyl acetate
Vinyl chloride			1,4-Dioxane

The CoCs originate from groundwater contaminated by materials that are assumed to have entered the bedrock beneath the Site because of the activities conducted by SCC during operations, particularly in the area of the closed Pond 3 located in the northeast corner of the facility. In addition, contaminants have resulted from groundwater and leachate originating at the Landfill from surface water and stormwater percolation into the waste and burn pits, and subsequent leachate percolation into the bedrock beneath the Landfill. The Landfill generates recoverable leachate at the average rate of about 8,000 gallons per day. However, some of the leachate enters the groundwater through percolation before it reaches the leachate collection system, because the leachate collection system has limited coverage, it does not extend to the burn pit area, and there is no liner underlying the waste.

Figure 8 shows the conceptual hydrogeologic flow and transport scheme developed for the Site. Groundwater flow is controlled by the fault structures located at the Site. These faults are highly fractured heterogeneous formations that provide a preferential flow path for the deep groundwater. At the Site, most of these faults are oriented about 20 degrees east of north-south. Groundwater flow follows those faults to a major east-west trending structure referred to as the Deep River fault. This fault structure approximately follows the east-west section of the former Deep River stream bed. It is angled toward the surface at about a 45-degree angle, rising into the stream bed of the former Deep River, now the Reservoir.

The RI revealed the Site is contaminated with, among other things, DNAPLs in fractured bedrock. This situation has been determined to be technically infeasible to effectively remediate in a reasonable period by the United States Environmental Protection Agency (EPA). In addition, unacceptable levels of VOCs, cVOCs, and 1,4-dioxane were detected in the groundwater and leachate. 1,4-Dioxane was used as a stabilizer in the solvent trichloroethane and is found at significant levels in many personal care products, soaps and detergents[1]. It has very poor treatability characteristics in conventional treatment systems. As a result, the proposed Remedial Treatment System needed to contain the contaminant plumes and prevent future migration of contaminants into the Reservoir, NIS, and SIS, and to prevent human exposure to impacted soils, leachate, and groundwater at the Site.

The RI tasks were completed by 1998, and the initial draft RI Report was submitted to NCDENR. Following completion of the initial work, and review and comment by NCDENR on the draft RI Report, supplemental investigatory work was performed to better characterize the contaminant plumes, and additional on-Site work was performed to remove the remaining surface structures and further secure the SCC facility. This was completed in 2001 when the main building on the SCC facility, which included offices, vehicular maintenance and a small processing area, was demolished, additional samples were collected and a second

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[1] As a byproduct of the ethoxylation process, a route to some ingredients found in cleansing and moisturizing products, 1,4-dioxane can contaminate cosmetics and personal care products such as deodorants, shampoos, toothpastes and mouthwashes. The ethoxylation process makes the cleansing agents, such as sodium lauryl sulfate, less abrasive and offers enhanced foaming characteristics. 1,4-Dioxane is found in small amounts in some cosmetics, a yet unregulated substance used in cosmetics in both China and the U.S.

tier of chain link fence was installed surrounding the SCC facility to eliminate continuing problems with trespass.

This was followed by the preparation of the final RI Report and an amended FS and BRA. Work also began on development of a series of treatability studies and pilot studies of Natural Treatment Systems such as Phytoremediation and Biodegradation to treat the groundwater and leachate to acceptable levels for use in irrigation, or for discharge to the City's Eastside Wastewater Treatment Plant (POTW). In addition, 1,4-dioxane treatability and feasibility studies were performed to examine the possibility of using the Landfill cap for the location of a treatment system using natural processes such as Biodegradation and Phytoremediation. The FS identified Phytoremediation as one of the more promising methods of dealing with the CoCs over what was anticipated to be a long-term remedial action.

The CoCs and the Site hydrogeologic setting were identified and characterized during the RI through a process in accordance with EPA guidelines, and the NCDENR Inactive Hazardous Site Branch publication "*Guidelines for Assessment and Cleanup*" ("Guidelines for Assessment and Cleanup"). Through analyses of soil, surface water and groundwater samples, and hydrogeological studies, the CoCs at the Site were identified and a conceptual hydrogeological model of the groundwater flow and contaminant transport was developed. Notice requesting public comments on the final RI Report was published in the *North Carolina Register* and in a newspaper of general circulation, the *Greensboro News-Record*. After the comment period ended, NCDENR approved the document.

Baseline Risk Assessment

Once the contaminant source areas and nature of the Site and the CoCs were characterized in the RI, a Baseline Risk Assessment (BRA) was developed which characterized the risks and identified the need to perform remedial work at the Site. The BRA was developed in accordance with EPA and NCDENR guidelines. Notice requesting public comments on the BRA was published in the *North Carolina Register* and in a newspaper of general circulation, the *Greensboro News-Record*. After the comment period ended, NCDENR approved the document.

Feasibility Study

After the BRA was complete, a Feasibility Study (FS) was prepared which evaluated various remedial alternatives and helped determine the most effective means to implement a remedy. It examined a number of remedial alternatives and was prepared in accordance with the EPA and NCDENR guidelines. Notice requesting public comments on the FS was published in the *North Carolina Register* and in a newspaper of general circulation, the *Greensboro News-Record*. After the comment period ended, NCDENR approved the document.

Remedy Approval

After several other preliminary activities were completed, the Parties submitted a proposed remedial design in a document titled "*Remedy Recommendation Document*" (Southwestern Environmental, LLC. - 2000) to NCDENR in early 2000. Notice requesting public comment on this document was published in the June 1, 2000 *North Carolina Register* and the *Greensboro News-Record*. After a public hearing, NCDENR approved the document and the proposed remedy.

Cost Sharing Agreement

In the beginning of the remedial investigation process, the RIWP identified four "operable units."

These included:

1. The Seaboard Site soils; and
2. The Landfill contents and associated leachate; and
3. The burn pit soils; and
4. The groundwater beneath the entire combined Site.

The City and SGII determined the remedy would be more efficient and economical if a single process, or group of processes, was designed and implemented to address the remedial needs of both the SCC facility and the Landfill. As a result, in May of 1997 the City and SGII entered into an interim cost sharing agreement to fund the activities at the Site until a longer-term agreement could be executed. In October 2008 the City and SGII executed an agreement that specified a method to be used to jointly fund the long-term costs of the remedy at the combined Site.

Remedial Action Settlement Agreement

The Parties then entered into a Remedial Action Settlement Agreement (RASA) with the NCDENR on December 28, 2008 to construct and implement the approved remedial action at the Site. The RASA required the Parties, among other things, to complete and submit a final Remedial Treatment System design, in the form of a Preconstruction Report, no later than December 28, 2009 for the Physical Treatment System, and one year after the completion of the final pilot study (October 2010) for the Natural Treatment System.

REMEDIAL TREATMENT SYSTEM CONSTRUCTION

Remedial construction began in the spring of 2010 following the approval of the Pre-construction Report (PCR) and occurred in three phases:

Phase - 1.	Construction that began after approval of the RASA and submission of the PCR in the spring of 2010, through completion of the Automation and Irrigation Repairs in April of 2013.
Phase - 2.	Construction that took place from the completion of the Automation and Irrigation Repairs in April 2013 through completion of construction and initial testing of the Clarifier Upgrade, which commenced in January 2016.
Phase - 3.	Construction that took place from January 2016 through construction completion and initial testing presently in progress.

PHASE 1 – SPRING 2010-APRIL 2013

The RASA was approved on December 28, 2009 and allowed one year from the date of approval of the Physical System PCR to complete the Physical Treatment System construction. The Physical System PCR was verbally approved by NCDENR on April 30, 2010, and the main components of the treatment system were ordered and scheduled for delivery by December 31, 2010.

The construction following the approval of the PCR began in April 2010, when the Parties employed various contractors and undertook the tasks that needed to be completed prior to the delivery of the Physical Treatment System components. This included the installation of the extraction and collection network piping; the installation of the recovery well and leachate pumps; the pouring of the concrete pads needed to support LS-1, LS-2, the Effluent Treatment System structure and the two Node Buildings in accordance with the design provided by the structural engineer; installation of the improvements to the soil residue mound cap; and diversion of the NIS around the Landfill. In addition, the contractors installed the transformer pads, the electrical distribution system and grounding loops in accordance with the plans approved by the electrical engineer. Items completed during these construction activities included:

1. Installation of the main electrical feed and grounding loops.
2. Installation of the piping from the wells and leachate pumps to the lift stations.
3. Installation of the piping from LS-1 to LS-2.
4. Installation of all buried control cables.
5. Installation of the weather station components.
6. Improvements to the cover system on the soil residue mound.
7. Installation of the pneumatic lines to the air operated pumps.
8. Installation of the NIS leachate sump and associated piping.
9. Diversion of the NIS stream flow.
10. Installation of the concrete pads for LS-1, LS-2, and the mechanical system structures.
11. Installation of stainless steel lines to operate the irrigation valves.
12. Installation of all inlet and outlet pipes and stainless steel hoses to connect the pipes to the mechanical system.
13. Installation of all safety equipment including a safety shower.
14. Installation of piping to direct all tank vents to outside the structures.
15. Installation of a cover on the open metals settling tank and venting it outside the structure.
16. Installation of LEL monitors in the metals removal tank area LS-1, and LS-2.
17. Repair and revision of the electrical system to comply with the NEC.
18. Installation of constant level monitoring in PWDR-1.
19. Replacement of components at PWDR-1 wellhead as needed, and connecting PWDR-1 to LS-1 SCADA for control.
20. Installation of the required drains on LS-1 and LS-2 compressors.

21. Installation of the external inlets and outlets for air compressors in LS-1 and LS-2.
22. Completion of the Automation Repair Project.
23. Completion of the Irrigation Repair Project.

This represented most of the construction during this period at the Site.

Soil Residue Mound Cover

The soil residue mound was reshaped, graded, and covered with the required geo-synthetic containment barrier. This work began in May 2010, was completed in early June of that year, and has been approved by NCDENR. The original estimate of the area and amount of fill required for the project, as included in the PCR, was incorrect. The task required significantly more fill and geosynthetic liner material than originally estimated. However, other than the estimation error, the task was completed on time and without any delays or injuries. All work was done in accordance with the *“Site Specific Health and Safety Plan”* (ERM-NC, P.C.), and exclusion zone protocols and protective measures for surrounding areas were used.

NIS Relocation Work

This task involved the acquisition of an easement by the City to install a head works and the construction of a flow channel to divert the NIS flow around the piped section running under the Landfill and into the Reservoir. This required the City to acquire an easement for the use of adjoining property and its annexation into City property. This was accomplished in the summer of 2010, and the Project Managers undertook the work necessary for the diversion of the NIS. Although the diversion work went very well, the contractor encountered landfill materials in the stream bed excavation area outside the expected footprint of the filled area of the Landfill. This resulted in a significant cost overrun for the transportation and disposal of that material.

During this work a subcontractor blasting rock from the stream channel experienced a problem with a controlled detonation that resulted in some damage to the City’s wastewater pump station backup electrical generator building. The contractor repaired the damage, and there was no personal injury. This matter was settled between the City and the blasting contractor. This is the only incident in which remedial construction activities at the Site have resulted in any damage to property.

NIS Leachate Collection Sump

Following the diversion of the stream itself, the leachate that drains from the old pipe under the Landfill needed to be captured before it reached the Reservoir. This was accomplished in the summer of 2011 by the installation of a new NIS collection sump and transfer pump system. The electrical and instrumentation controls were integrated into the SCADA, and the engineering contractor prepared final as-built drawings.

Concrete Pads and Foundations

This work required the Parties to apply for and receive the City and Guilford County Building Departments’ approvals to begin construction related to the structures and concrete pads, and be issued Building Permits for all structures to be constructed at the Site. At the time the Building Departments were contacted, the Parties were informed the structures would be required to meet the North Carolina Modular Building (NCMB) code requirements.

As a result of the NCMB code requirements, the Parties were required to retain a North Carolina registered professional structural engineer (SE) to certify the pad designs as meeting the North Carolina wind loading, seismic loading, and additional structural requirements, among other regulations and standards. The Parties retained Runkle Consulting, Inc. (Runkle) of Lawrenceville, GA to provide these services.

Once the structural requirements were met, the engineers tested and certified the soils in the pad areas as meeting the required compaction prior to installation. The County and the City then issued the Building Permits for all four pads and their associated structures, after their review of the structural engineer’s report, and in accordance with the local requirements and the NCMB Code.

The contractor then poured four separate pads, one to accommodate LS-1 (Enclosure 8), two small pads to accommodate the East Lobe and West Lobe Node Buildings, and the largest pad to accommodate the combined LS-2 and the Effluent Treatment System Enclosures (Enclosures 1 through 7).

As the four pads were poured, the geo-technical engineer obtained concrete samples and performed the required testing for certification of the pads. After the pads had cured for the required period, the contractor obtained the Structural Engineer's certification of the pads prior to receiving and placing the LS-1 Enclosure, the prefabricated Node Buildings, and the LS-2 and Effluent Treatment System Enclosures. Although the City and County issued Building Permits for the construction of the various structures, their rules require that the structures themselves be inspected after they are installed and that "Certificates of Occupancy" be issued prior to allowing them to be placed in service. After extensive repairs and modifications to LS-1, LS-2, and the Effluent Treatment System, those inspections were completed in 2011 and the Certificates of Occupancy were issued in January of 2012.

Main Electrical Distribution System

The Project Managers retained a North Carolina registered professional electrical engineer (EE) to design the distribution system and oversee the electrical work performed at the Site. The EE completed his design drawings and submitted them to the County and City to support the Building Permit applications in accordance with the requirements of the NCMB Code.

The design of the electrical feeds called for the installation of a main transformer by the City. Once that pad position had been located, the contractor installed the conduits in ground, and the feed from the transformer was pulled to an outside main distribution panel with four main breakers inside a weatherproof panel. A grounding loop was installed surrounding the LS-1, LS-2, and Effluent Treatment System pads, and the main feed conductors sized to accommodate the required amperage were pulled to the distribution panel. The electrical contractor then installed five separate electrical feeds: one 225-ampere feed to the distribution subpanel at the Maintenance Building, which in turn feeds the Filter Building; one 20-ampere feed to each of the two Node Building; one 100-ampere feed to LS-2; and one 630-ampere feed to the Effluent Treatment System breaker in Enclosure 1. In addition, an electrical feed was installed from a transformer located between LS-1 and LS-2 near the Landfill perimeter road to a distribution panel to supply LS-1's 250-ampere feed.

Groundwater and Leachate Recovery Pumps

The contractor installed the groundwater and leachate pneumatic recovery pumps as specified in the PCR. This purchase order was issued on September 8, 2010, and the work completed in December 2010, with the exception of installing the NIS leachate collection sump and final installation of some recovery well level alarms. These items were completed in early 2011. All the pumps were installed and connected to their appropriate pneumatic air supplies. Each pump was tested and confirmed as operational when installed.

Constructed Treatment Wetlands Elimination

In the remedial design presented in the PCR, a constructed treatment wetlands (CTW) was included to biodegrade and reductively de-chlorinate the VOCs and cVOCs. This was thought necessary because of a concern that if left untreated and applied to the phytoremediation soils, the levels of VOCs, cVOCs and chlorides in the soil would increase, and this could develop to levels that would leach to the groundwater and/or become phytotoxic and affect tree health. The later pilot studies seemed to contradict this earlier assumption. When the Parties began to look into the available supporting research, they discovered a significant body of work was available, most of which was published after the Remedy Recommendation Document was prepared. This research pointed to successes in VOC and cVOC removal by several mechanisms including air stripping and biodegradation processes in the Landfill soils that are unique in methane-rich soil environments, such as exist at Landfills.

Because there was evidence the CTW was not necessary, the Project Managers explored the effect eliminating the CTW might have on the remedy. Eliminating it provides a simplified treatment process. It removes several control variables and makes control of the phytoremediation irrigation less complex.

Eliminating it also reduced costs and did not increase the potential environmental risk at the Site or the anticipated duration of the remedial action. Therefore, it was decided to request a change in the remedy, and TM E-3 was prepared and submitted to NCDENR. TM E-3 was verbally approved by NCDENR, and the CTW was eliminated from the remedial treatment system design.

Physical Treatment System Construction

The Parties contracted with the Manufacturer to construct, test, and deliver a fully operational Physical Treatment System ready to be placed in service upon delivery. This was to include the components of LS-1, LS-2, the Metals Removal System, the Air Stripper and the AOP$^+$ unit and the Node panels. This also included the automation and integration hardware and software necessary to control the entire Physical and Natural Treatment Systems, including the irrigation system. The order for this equipment was placed April 28, 2010 immediately after the PCR was verbally approved by NCDENR. The equipment was originally scheduled for delivery no later than 26 weeks after the approval of the plans, or mid-December 2010. Because manufacturing delays, however, the equipment did not arrive at the Site until July 2011.

After the AOP$^+$ unit arrived and had been installed at the Site, the Parties attempted to start it up in September 2011 and again in October 2011 and February 2012. The First, Second and Third Startup Attempts were all unsuccessful, because the system had several significant defects that made startup unsafe and impossible. Among other things, the system lacked the automation, integration, alarm, and interlock system software the Manufacturer had agreed to supply. After an extended period of locating and correcting the problems at significant cost and unsuccessfully negotiating with the Manufacturer to render the system operational, the Parties retained an independent electrical contractor, an automation engineer and other contractors to undertake the repairs needed to make the system safe and operable. The repair work included the “Automation Repair Project”, which involved installation of a new Siemens PLC S7-317 programmable logic controller (PLC) in LS-2 that serves as the central control for the entire Physical and Natural Treatment Systems. All input and outputs (I/O) are connected directly to that PLC either through a direct bus feed or through an industrial Ethernet (LAN). The PLC is administered and operated by a Siemens “box computer” (PC-827), referred to as the Server or Historian, installed in a new control cabinet in LS-2 that receives operator inputs from four panel PC screens (referred to as human-machine interfaces or HMIs) located in LS-1, LS-2, the Filter Building and the AOP$^+$ area of the Effluent Treatment System.

The LS-2 panel unit was reformatted to remove all software installed by the Manufacturer, and then installed in LS-1. It was necessary to purchase one completely new panel PC unit to replace the unit provided by the Manufacturer. As LS-1 is the least used operator location, the existing LS-2 unit was determined to be suitable for that installation, and a new panel PC unit was installed in LS-2. The reused units were formatted to remove all software installed by the Manufacturer and loaded with only a runtime version of Windows 7® with its included Internet Explorer®[1] software.

In the revised system, a single Siemens S7 processor (hard-PLC) contains all the logic and controls. One Siemens WinCC HMI server and four Siemens WinCC HMI clients allow operators to access each station with a common set of graphics and security settings. No matter which HMI an operator uses for an input to control the system, or where that HMI may be located, it provides a signal to the PLC, which commands the system operation. This was important in order that a command given from any input location would result in the same output to the PLC, and any output command would originate from the same lines or block of code in the PLC and result in the same action or effect on the system. This eliminated the possibility of conflicts and faults caused by unstructured code, latency and timing issues that plagued the multiple soft-PLC loaded HMIs in the system provided by the Manufacturer.

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[1] Internet Explorer is a computer program that is supplied as a component of the Windows 7 operating system and is a registered trademark of Microsoft Corporation of Redmond, Washington.

Natural Treatment System Construction

A thorough study of the Landfill cap and soils was performed in 2010. The study revealed areas, including some that were remnants of old roads, with poor soil quality, poor tree-growing conditions lacking proper nutrients, soil pH above the level that is recommended for the tree species planted, low organic content reducing moisture retention capabilities, and several other concerns. It was apparent that if the full capacity of the Natural Treatment System were to be realized, a major soil modification program was needed. To be able to amend the soil and incorporate the amendments into the cap it was necessary to remove the drip irrigation lines in most of the irrigation zones. This was done in the early summer of 2010, and a major application of amendments and nutrients was performed. The amendments were allowed to react and incorporate into the soils before the areas were resampled that fall. Unfortunately, certain areas showed indications of extreme carbonate buffering possibly due to the disposal of water treatment plant sludge in certain areas of the Landfill, and the pH remained too high for the tree species planted. This was a surprise, as the Parties had a “Soil Suitability Study” conducted prior to undertaking the initial tree planting. That study indicated the Landfill cap soil was generally suitable for use in the Natural Treatment System. However, the areas of the Landfill with high pH occur in certain limited areas of the Landfill cap, and the detection of these areas was missed in the initial site evaluation during which soil samples were taken at selected locations.

During the spring of 2011, there was a second larger round of soil amendments added to further correct the pH and nutrient deficiencies. For example, an application of approximately 3-inches of compost was added to Zone 3 and incorporated into the Landfill cap. Previously, this zone showed greatly inhibited tree growth and samples were sent to the NC Agricultural Extension Service, the University of North Carolina Soil Laboratory, as well as a commercial laboratory. These analyses indicated extreme carbonate buffering that could not be overcome by amending with aluminum sulfate at any practical levels. Therefore, a heavy application of compost was overlaid on the entire zone and tilled into the existing soil. This amendment proved to be effective for the establishment of a healthy stand of eastern red cedar. At the same time (spring, 2011), the upper layer of the cap in portions of Zone 6 where an old roadway had been built was removed and replaced in rows with suitable soil to allow the rootstock to be planted.

During the spring of 2012, the final amendments to the soil were added, and the drip irrigation system lines were repaired or replaced as needed, and buried approximately 6 inches below grade. In the past, most of the damage to the drip lines had been due to nuisance animals and entanglement in the mowers that maintain the grass on the cap. Burying the lines solved both of these problems.

Irrigation Repair Project

The Irrigation Repair Project involved the repair or replacement of components of a soil-moisture monitoring network installed on the Landfill cover (cap) as part of the Irrigation Control System. This network consisted of 69-soil-moisture, temperature and salinity-monitoring probes (manufactured by Decagon, and all model 5TE probes) that send data in serial data interface at 1200 baud (SDI-12) format to one of two Node Panels located in the east and west Landfill Lobe Node Buildings.

There were 69-probes installed in 23 nests of three probes each, one approximately 2.3 feet below ground surface (“bgs”), one about 1.6 feet bgs, and one about 1 foot bgs. These probes were connected to 23 junction boxes that were in turn connected in series to one of 5 loops of cable that were connected to the corresponding Node Panel inputs. The Node Panels were installed by the Manufacturer to input data from the soil-moisture probes to the control network, and to translate that data from a SDI-12 format transmitted by the probes into a format that could be reliably input into the automation system. Translation problems occurred that were primarily due to a conflict between one of the I/O cards supplied by the Manufacturer and the SCADA. There was no workaround.

The existing configuration had been shown to be unstable and appeared to suffer from lightning damage. The probe failure rate was nearly 50%. The goal of the repair was to rectify the instability and eliminate the high rate of probe failure.

Objectives of the Repair

The scope of the repair was intended to address the problems with the SDI-12 network and the data accumulation and initial translation. The automation system repair contractor was to provide the incorporation of the data into the SCADA.

The goals of the SDI 12 repair were as follows:

1. To specify a soil moisture probe that will provide reasonable accuracy for the determination of soil moisture throughout the 16 active irrigation zones
2. To design a network for collection and transmission of data from the soil moisture probes to the node panels located on the landfill lobes
3. To divide the network so as to minimize the damage caused by lightning and other spurious electrical signals that might damage the components
4. To provide the means of data collection and translation to a format acceptable to the SCADA.
5. To use or reuse any of the existing equipment and code existing outside the node panels in the assembly of the revised network

Scope of Repair

The Parties found it necessary to install a completely new irrigation control network. This required that everything from the Node Panels through to the soil moisture probes needed to be replaced with different components, and the network would need to transmit data in a different format.

The new probe network is managed by comparing the irrigation rate with the theoretical rate of transpiration by the tree stand, ET_c, which is proportional to ET_o. This management approach ensures that overwatering or under watering is not occurring.

In the new irrigation control network, there are three probes installed in each nest (23 nests of 3 probes each or 69 total probes), as was the case in the past. All of the original probes have been replaced with Watermark soil suction (soil water tension) probes. Each nest has an upper, middle, and lower horizon probe. In addition, there are thermistor type temperature probes (CS-108), three on each lobe of the Landfill at selected locations. Each probe (both soil suction and temperature) is read 6 times an hour and averaged with a scale of 0 to 200 kilopascal (KPa) of soil suction, and -35 to +50 C (-31 to +122^{o}F) for the temperature probes. The averaged results from the soil suction probe readings are corrected using the hourly average temperature reading from the three probes on each lobe and compared to set points the operator inputs in 1-KPa increments between 0 and 200. There are three set points for each probe. They are as follows:

1. Dry soil (operator set - 0-200 KPa[2])
2. Optimum soil moisture range (operator set range of 0-200 KPa)
3. Wet to Field Capacity (operator set – 0-200 KPa)

The settings were initially determined based upon soil water characteristic curves run on composite soil samples from each zone of the irrigation system. Field observation, pan lysimeters,[3] and hand-held meter readings were used to refine those settings. Dry conditions are at some point near the upper range of the soil suction probe scale, currently thought to be approximately 80-KPa. Wet conditions are at the lower end of the scale currently thought to be approximately 10-KPa. Optimum range will be

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[2] The Irometer Watermark sensors have a full scale of 0 to 200 KPa and, therefore, the SCADA allows the operator the full instrument scale for all of the moisture settings.

[3] A pan lysimeter is a measuring device that is used to measure the amount of actual moisture that is released by soil through drainage. By recording the amount of precipitation that an area receives and the amount lost through the soil, the amount of water lost to evapotranspiration can be calculated. Lysimeters are of two types, weighing and non-weighing. A pan lysimeter is a non-weighing device that consists of a membrane covered collection vessel with extraction tubes provided to the soil surface. When placed in the soil at the waste interface they provide a measurement of the moisture that drains from the soil into the upper waste layer.

set between 10- and 80-KPa, and frequently refined by field-testing and observation of each irrigation zone.

Soil suction[4] is a measure of the free energy of the pore-water[5] in soil. The less pore-water in the soil, the greater the attractive forces between the moisture and the soil, and the greater the force or suction required to extract it. Thus, the higher the soil suction, the dryer the soil.

In brief, the actual readings from the soil suction probes will be averaged hourly and compared to the optimal soil moisture range (assumed for now to be 10 to 80 KPa). The reading can be within the range, below the range or above the range. From these readings the results will be compared to a matrix determined by the 27 possible configurations of probe readings for each nest. That matrix will determine what the actual field conditions command the system to do. The system will take one of the following four possible actions:

1. Irrigate as was done at the prior event, or
2. Increase the irrigation time by an operator set amount, because the soil is getting too dry, or
3. Decrease the irrigation time by an operator set amount because the soil is too wet, or
4. Not irrigate and skip to the next zone.

Irrigation Logic Repair

To increase the amount of irrigation water the cap can receive during the winter months, in 2011 the Parties replaced, or inter-planted, all of the deciduous trees with conifer species. The conifer species, such as loblolly pine and Virginia pine, transpire at the same rate during the summer as the various deciduous tree species that had been installed on the Landfill (e.g. hackberry, Chinese elm, black locust, Kentucky coffee tree). Conifer trees transpire throughout the winter months at rates that are proportional to ET_o making year-around irrigation possible.

With the possibility of increased irrigation during winter (when ETo is low) because of the interplanting of conifer trees, and improvements made to the Physical Treatment System, an evaluation was made of the possibility of irrigating at a rate of 50 GPM year-around and not discharging to the POTW. This differs slightly from the irrigation logic presented in the PCR. That logic called for a period where the use of Physical Treatment System process effluent for irrigation would cease, and City water would be used to flush any accumulated salts from the soil.

The decision to continue to irrigate with Physical Treatment System process effluent and not use City water for flushing was based on several factors. With the enhancements to the Physical Treatment System installed to address the higher metals concentrations in the groundwater and leachate, the quality of the Physical Treatment System process effluent is significantly improved over that anticipated at the time the PCR was prepared. With the lower metals and salts concentrations in the process flow due to enhanced filtration, and the lower VOC and cVOC concentrations due to the increased aeration and air stripping, the amount of contaminant loading being sent to the Natural Treatment System is considerably less than anticipated in the PCR. During the recent operational testing, the irrigation system has been operated and the soils have been tested and monitored. Samples collected from the soils after being irrigated for an extended period have shown no excessive buildup of VOCs, cVOCs, or salts in the soils.

The water balance on the Landfill is not affected by the continued use of Physical Treatment System process effluent. It was always intended to irrigate at a similar rate during periods of low $ET_{o;}$ the only change is the source of the irrigation water. Because the quality of the Physical Treatment System process effluent has been improved, and there has been no salt or organic buildup noted in the soils,

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[4] Soil suction, in practical terms, is a measure of the affinity of soil to retain water and can provide information on soil parameters that are influenced by the soil water; for example, volume change, deformation, and strength characteristics of the soil.

[5] Pore Water – or Sediment interstitial water is the water occurring in the small openings, spaces, and voids between particles of unconsolidated materials in that portion of the vadose water zone between the ground surface and the water table. The water is held in place by entrapment, ionic attraction, and capillary or adhesive forces, rather than from upward pressure components of saturation, and occupies the spaces between sediment particles.

irrigating to flush the salts into the upper layer of the Landfill waste during periods of low ET_o is possible and should have no effect on the duration of the remedy or risks to human health and the environment.

Fertigation Upgrade

Another concern was the fertigation of the Landfill cap. The Parties had been testing soils to determine why various irrigation zones were not sustaining the rate of tree growth that was seen in other zones. In about six of the 16 zones, trees within certain portions of the zones were stunted or dead for a variety of reasons. In certain cases, testing showed the pH was too high, a condition that restricts the “availability” of nutrients. In these areas of the Landfill, the Parties added sulfur (elemental) to the cap to lower the pH. In most of the zones, the desired decrease in soil pH was observed. The Parties tested to ensure the elemental sulfur had fully converted (a biological process), or was still in the process of being converted.

The fertigation process installed was the only method available, other than manually spreading by conventional techniques as had been done previously, to get needed soil nutrients and amendments onto the cap. Manual spreading was costly and required that measures be taken to avoid damage to the drip lines. As a result, the Parties changed the fertigation process installed in the Natural Treatment System.

Originally plans were to install a fertigation pump, a manual plunger pump set for dosing based on piston stroke. There was no SCADA control other than simple ON/OFF, and a very limited variability of the dosing range. This would have irrigated all zones at a fixed rate. That was changed to a new SCADA-controlled metering pump (150 L/hr. - 1000:1 turndown) that has been programmed to allow both speed and operating time control by zone, giving the system more flexibility when determining the formulation and concentration of the various components of the solution used to fertilize. In addition, the capability has been programmed into the SCADA to regulate dosing at a different amount for each zone.

Because the integration of the fertigation process into the overall SCADA system was advantageous, a new double-walled tank was installed outside LS-2 to hold fertigation solution. The fertigation pump draws from this tank, which has a level control to avoid drawing from the tank when it is empty. The pump discharges to the discharge line from the three sets of pumps on Effluent Storage Tanks. This affords the opportunity to selectively feed a preset dose rate to the Physical Treatment System process effluent mixture from one or more Effluent Storage Tanks being fed to the Natural Treatment System based on the proportioned flow to each zone.

PHASE 2 – APRIL 2013 TO JUNE 2015

This phase of construction consisted of system refinements and modifications to provide additional system flexibility, enhance metal salt removal, and improve CoC removal. The system was also refined chemically to increase its efficiency and allow longer periods of sustained operation.

Fourth Startup Attempt

Following the completion of the Automation Repair Project, the Project Managers began another startup by bringing city water back into the system. After resolving a few problems, the system was operated on City water recirculating back to the Settling Vat. System checks indicated the recent automation and irrigation repairs were functioning as planned.

Shortly after commencing operation, samples were collected from all of the leachate collection tanks and certain groundwater observation wells at the Site. The samples were collected from each leachate tank, the NIS Sump and Deep River Observation wells OWDR-1, OWDR-2, OWDR-3, and OWDR-4. The sampling indicated that, among other things, the levels of iron in the leachate and groundwater were significantly higher during system operation than those detected during earlier testing and used for the process design submitted in the PCR.

Neither the AOP^+ system nor the Natural Treatment System could tolerate the higher metals levels that would result from the higher inlet concentrations. The Settling Vat was not designed to handle the increase in metals loading. At first, this was thought to be a temporary spike in metal concentrations due to initial system operations. However, it was determined to be an indication of a chronically high level of metals particularly in the leachate, but present in the groundwater as well.

Metals Removal System Upgrade

Sampling indicated that the levels of iron, manganese, calcium and magnesium salts in the leachate and groundwater were significantly higher during treatment system operation than those detected during earlier testing. See Attachment 4 for a complete list of parameters and analytical results from the AOP$^+$ Pilot Study Report.

The results of those analyses are presented in the following table.

Table 4 – Pre-startup Sample Results

Parameter	OW-DR1	OW-DR2	OW-DR3	OW-DR4	LCHT-1	LCHT-2	LCHT-3	LCHT-4	LCHT-5	NIS SUMP	Average*
TDS	976	1030	1430	808	1320	2600	4700	3960	808	1100	1873.2
TSS	4	26	2.5	4	220	98	36	226	56	94	76.65
Nitrate -N	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.11	0.68	<0.10	0.33	0.33
Nitrite -N	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.11	0.35	<0.10	0.20	0.2
Iron, total	8.71	8.52	0.37	4.44	44.90	34.10	34.70	93.80	16.80	44.5	29.08
Total Mn	8.19	6.44	1.22	7.57	0.335	0.408	0.633	0.445	2.68	4.06	3.198
Total Mg	92.9	84.5	143.0	78.9	52.1	74.3	61.7	83.9	42.6	58.7	77.26
Total Na	44.8	43.4	27.5	45.1	197.0	512.0	932.0	853.0	85.2	151.0	289.1
pH, lab	NA	NA	NA	6.2	6.5	6.6	7.1	7.4	6.2	6.6	6.66
pH, field	6.6	7.7	6.1	7.3	7.1	7.3	7.5	7.8	7.3	7.5	7.22

NOTE: All results in mg/L except pH.

The total metals concentrations in leachate tanks (LCHT) 1 through 5 and the NIS sump during this sampling event were all considerably higher than the 10 mg/L expected from earlier sampling events. The LCHT tanks and NIS sump iron levels averaged 44.8 mg/l of total iron, which is over four times what was anticipated in the system design. For comparison, a copy of the original testing performed during the AOP$^+$ pilot study is included in this report as Attachment 4. The reason for the increase is undetermined at this time; however, neither the AOP$^+$ system nor the Natural Treatment System could tolerate metals at the determined concentrations.

The amount of sludge generated by this increase in metals concentration resulted in frequent shutdowns of the process to remove the metals' precipitate residues from the Settling Vat. The Settling Vat could not be modified to remove the metals to levels below the concentrations needed prior to final treatment. Therefore, the Parties decided that modifications to the Remedial Treatment System to address the need to remove additional metal salts were required.

Pilot Testing

The initial step in the design of the modified process was to conduct a pilot study. The goal of the pilot study performed by the Parties in April 2013 was to attempt to determine the effects of fine bubble aeration, pH adjustment, filtration and settling on the combined leachate and groundwater flowing through the treatment system at various stages in the process. This included at the inlet to Lift Station (LS)-1, the inlet to LS-2 and at the outlet of the existing Settling Vat in the final treatment area.

In determining the most effective resolution to these problems, the Parties referred to work performed much earlier in the remedial action in support of the Feasibility Study. In a report authored by Dr. Richard Brown, several methods of iron and other metals control were explored, including sequestration, chelation, ion exchange and aeration. The only method determined to be operationally and economically feasible at the Site was aeration.

This required the system design to be modified to add aeration at LS-1 and the installation of a new pretreatment process to include a larger filter to process the combined flow of all groundwater and leachate prior to it entering the Effluent Treatment System. It was also determined that this would require a new building, because the floors installed in the existing structures were not capable of supporting the weight of the properly sized filter bodies once they were full of water.

Based upon this information a pilot study was scoped and performed to simulate a proposed process design. This modification would consist of aeration at LS-1, followed by aeration and filtration in a new Filter Building prior to the combined flows entering the Settling Vat for final pretreatment before either being further processed by the AOP$^+$ or used to irrigate the Natural Treatment System.

Metals Removal System Repairs

The metals removal repairs consisted of several modifications to improve the chemical feed system, chemical mixing and solids separation capabilities of the Remedial Treatment System. This included several modifications to LS-1, the Filter Building, and the Settling Vat.

LS-1 Modifications

The Parties added an aeration tank to the flow path at LS-1. The aeration tank employs ceramic fine bubble diffusers to aerate the combined leachate and groundwater flow exiting the inlet manifold in LS-1. All of the leachate and groundwater entering LS-1 is either collected in a large (approximately 4,200 gallon) tank that is aerated by ceramic fine bubble diffusion, or that tank could be bypassed and flow entering the equalization tank directly. This is due to the high pH caused in the influent flow at times when it is aerated. All influent was configured, at that time, to be pumped through a hydrocyclone to the inlet manifold in LS-2. This manifold directs the flow into the Filter Building.

Filter Building Construction

The main reason the Filter Building was necessary was that the Media Filters provided by the Manufacturer were not adequately sized to handle the designed flow of 50 GPM. It was also determined there were other significant problems with the Media Filters as well. During backwash, the filter media was being washed out of the filters and into the Settling Vat. Further investigation revealed the filter bodies were inadequately sized for the design flow. This made the velocity of the backwash water too high, and rather than just lifting the bed, it was carrying the media out of the vessels and into the Settling Vat.

The Parties determined the cross-sectional area of the Media Filters was insufficient, and the differential pressure across the filters at its maximum capacity would have precluded operation at 50 GPM. In addition, it was determined the floors in Effluent Treatment System Enclosures would be unable to support filter bodies of the size required for proper filtration. With properly sized filter bodies, the vessels were estimated to be 4 feet in diameter and 6 feet tall, which meant the total weight of a single vessel would be approximately 7,000 pounds.

Filter Repair and Upgrade

The problem encountered with the Media Filters, and the lack of adequate support for properly sized filters, led to the decision that the filters and associated equipment needed to be installed in a new 30- by 30-foot metal prefabricated and insulated building constructed on an engineered concrete pad designed to support the filter bodies and the added weight of aeration and other equipment necessary to pretreat the entire flow of groundwater and leachate prior to pumping it to the Settling Vat.

The Filter Building receives the flow from LS-1 and mixes it with the flow from PWDR-1 and certain RWSIS wells in an aerated tank to provide a relatively consistent 50 GPM. A vertical flat-bottomed tank with the fine bubble ceramic diffusers will be used for initial mixing and aeration. Aeration at this point helps reduce the VOC and cVOC loading on the Air Stripper influent thereby improving its efficiency, further oxidizes metals and removes any remaining methane prior to it being further distributed throughout the system.

The aeration tank gravity overflows into an equalization tank before it is pumped through a set of 25-micron fixed bed filters designed to process 50 GPM. Those filters are backwashed to a lined sand bed filter. The underflow from the sand bed filter is pumped through a hydrocyclone and a 25-micron bag filter to capture solids before being returned to the backwash tank for reuse or to the aeration tank for further processing. Solids from the sand filter are properly characterized and stored, handled and disposed in accordance with the North Carolina regulations.

Process flow from the filters is sent to the six-tray Air Stripper, which was relocated to the Filter Building. Process flow from the Air Stripper is pumped back into the Effluent Treatment System structure through a line that discharges into the Settling Vat.

Effluent Treatment System Modifications

Although the system flows remain essentially similar to that proposed in the PCR, there were several piping modifications to the return piping leading to the Effluent Storage Tanks made as part of this modification. This simplified the piping, decreased the number of valves and other flow restrictions and decreased the pressure drop in the system from the Settling Vat to the Effluent Storage Tanks. This piping was supplied by the Manufacturer and had included provisions for alternative flow configurations that are now not needed. This made the piping more complicated than necessary. As a result, the multiple valves, fittings, directional changes and flow consolidations created unnecessary back-pressure on the system and seriously limited the maximum flow to the Effluent Storage Tanks. All of this piping was removed and a simplified process flow manifold was installed. This has reduced the pressure drop and made it possible for the treatment system process flow to be sent to any or all of the Effluent Storage Tanks. This is controlled by the operator set points and by level control by the SCADA.

Settling Vat Problem

During the brief period of operation of the system, the Project Managers noticed that the Settling Vat did not seem to settle some of the suspended solids from the process influent and made no provisions for LNAPL and DNAPL removal. Because there is a possibility that LNAPL and DNAPL could reach the Settling Vat during a system upset, it was decided to add that capability. Examination showed the Settling Vat, as supplied, was a large rectangular vat that contained approximately 6,000 gallons when operated at the maximum operating level of 4 feet. The vat is roughly 6 feet wide, 32 feet long, and 5 feet high.

Settling Vat Repairs

To limit the horizontal flow and turbulence, extend the retention time and force directional changes to occur to minimize particulate carryover and capture any free organic materials, the Settling Vat was modified by installing two stainless steel baffles to compartmentalize the vat, separate LNAPL and DNAPL from the process flow, and enhance solids separation. This modified the vat from being a surge tank in the process flow to being a true clarifier and separator tank that enhances pretreatment and can be modified to provide several additional treatment technologies if needed.

Modification of the Startup Testing and System Monitoring

The PCR proposed that the initial testing would include a 30-day aquifer drawdown test, an AOP^+ performance test and certain other tests thought necessary prior to beginning system operations and monitoring. The Project Managers felt the 30-day drawdown test would not provide significant useful data due to its limited scope and submitted TM-E8. TM-E8 included a revised Remedial Monitoring and Effectiveness Evaluation Plan (RMEEP), which specified a longer-term capture zone evaluation period and the installation of several continuously monitored transducers in key wells. TM-E8 and the new RMEEP were approved by NCDENR during February 2014.

Fifth Startup Attempt

During January 2014, the Parties completed the modification of the treatment system designed to remove the additional metals and handle the associated filtered solids, and the Project Managers resumed startup testing. During the first quarter of 2014, the startup advanced to the point that groundwater and leachate sources were introduced into the process and the entire system operated for short durations in various configurations to test the automation controls. The testing progressed fairly well; however, the amount of filter solids generated made long periods of sustained operation infeasible.

The solids problem was present in two locations. The most serious problem occurred when the air stripper discharge pump impellers (P-605) ceased, causing the system to shut down. Upon inspection it was determined that solids passing through the new filters had caused deposits to build up between the impeller and the backing plate on the pump casing. To address this problem, the Project Managers sent a sample of the scale and filter solids from the system to a NC certified laboratory to be tested. The results indicated the filter media being used in the new filters was not performing as efficiently as required. To address this problem, it was decided to replace the existing filter media (sand) in the new filters with a two-layer bed comprised of a bottom layer of garnet and an upper layer of Filter AG. This two-layer system was intended to provide the requisite solids removal and eliminate the problem in the P-605 pumps. However, it became apparent the filter solids generated at Lift Station-1 (LS-1) would be much more than the existing equipment could properly handle as well. In addition, during the shutdown the Project Managers had all shallow groundwater recovery wells surge blocked to ensure that they would restart with fresh formation water from all shallow wells.

The enhanced filtration in the Filter Building raised the concern that during filter backwash, the amount of solids being removed would be more than the existing bag-filter will be able to efficiently remove. Therefore, the Project Managers sent a sample for testing to determine the particle size distribution in the filtered solids. From that, it was determined about 98% of the larger particles (above 74-microns in size) could be removed using a hydrocyclone. Therefore, a hydrocyclone was added to the filter backwash line before the bag-filter to handle most of the larger solids. The bag-filter was then operated with a filter bag designed to capture particles greater than 25-micron in size, allowing the backwash water to be reused. This modification was installed without a full system shutdown.

After installation, it was determined the hydrocyclone alone would not adequately remove the solids, and the bag filter was plugging frequently during each backwash cycle. This indicated there was a large amount of solids between 25 and 75-microns. As a result, the system was shutdown to install a lined sand bed filter at the back of the filter building. The piping was modified to send all of the backwash water to the lined sand bed filter. The underflow from the lined sand bed is collected, pumped through the hydrocyclone and a 25-micron bag filter, and returned to the backwash holding tank for reuse or to the aeration tank for further treatment. This corrected the problem.

The other concern raised by the amount of solids generated was the possible plugging of the lines from LS-1 to LS-2 and from LS-2 into the Filter Building. These lines have variable and intermittent flow. And the lines from LS-1 to LS-2 raise up-hill with a vertical lift of about 80-feet and could become fouled with the high solids content of the incoming groundwater and leachate. Therefore, it was decided to install a sand bed filter at LS-1 as well, and direct all flow from the inlet equalization tank into the sand bed filter. The underflow from the sand bed filter is directed to a sump that is pumped to a second equalization tank and then through a hydrocyclone installed in the line from the LS-1 discharge pump to LS-2. The leachate and shallow groundwater flow entering LS-1 was adjusted to a pH of 9.4 using potassium hydroxide (KOH) and then treated with a flocculent and coagulant to make the sand bed filter efficient in solids removal and to create a filter solid that rapidly releases water. This removes the majority of the solids before the process flow enters the line feeding LS-2 and reduces the calcium and magnesium content entering the Filter Building to a level the process can tolerate.

During full operation, the Settling Vat filter process flow showed signs of colloidal iron (or something that caused an iron-like color) and fine suspended solids remaining after all treatment. The process flow from the Settling Vat Effluent Filters, which feeds either the Irrigation System or the AOP$^+$ unit, continued to show a significant amount of fine suspended solids (TSS) and color. This was thought to be mostly colloidal iron. To address this, the Parties retained the services of a consulting process chemist who evaluated methods to flocculate, coagulate, or otherwise remove the remaining TSS and color from the Physical

Treatment System process effluent. Although this may not be a problem for the Irrigation System, it would not be suitable for processing in the AOP^+ unit. This unit relies on the transmissivity of light to operate efficiently. Therefore, this Settling Vat effluent filter process flow TSS and color would have interfered with the AOP^+ unit operation, reduced its effectiveness and increase its operating costs. After the modifications mentioned, most of the TSS and discoloration was removed.

System Chemistry Upgrade

The filter solids produced by the metal chelation process were thin, gelatinous, and very slow to release water. This caused the sand bed filter at LS-1 and the Filter Building to become ineffective and overloaded with solids that would not properly dewater. To address this problem, the Parties had the process chemistry reviewed by the consulting chemist to determine if the addition of flocculants and coagulants might improve the performance of the existing system without significant modification.

Samples were collected from several points during system operation. Each source was chemically characterized for critical components. Then chemical precipitation programs were evaluated to remove metals including Iron, Manganese, and Total hardness (combined calcium and magnesium). A series of coagulants and flocculants were evaluated in conjunction with metal precipitation to enhance solids settling and filter solids dewatering.

Table 5 - Baseline Chemistry

Sample point	Total iron	Mn	SO4	TH	TA	TDS	pH	ORP
LS1-RW	42.2	13	100	950	750	1873	6.45	72
PWDR-1	17.2	14	24	720	620	1210	6.61	71
S1S-RW	7.15	12	5	300	170	568	6.56	4
Leachate	14.1	1	110	580	1850	3815	6.92	2

Results reported as mg/l, unless noted otherwise
TH = total hardness = combined calcium and magnesium, as mg/l calcium carbonate
TA = total alkalinity, reported as mg/l of calcium carbonate
ORP = Oxidation Reduction Potential

Table 6 - LS-1 Inlet Flow Test Results

Test	Iron	Mn	TH
Baseline	42.2	13	950
pH elevation to 8.8 with NaOH	1.07	11.1	760
Inc. ORP by 500 mV, Adj. pH to 9.2	0.06	1.4	670
Inc. ORP + 350 mV, Add 125 ppm ACH, Adj pH to 9.3	0.06	0.0	500
Inc. ORP by + 350 mV: Add 125 ppm ACH, Adj pH to 9.5			450
Inc. ORP by + 350 mV, Add 125 ppm ACH, Adj pH to 9.9			430

Note: ORP=Oxidation-Reduction Potential

Buffering capacity exhausted at pH 9.5. Incremental addition of sodium hydroxide generates strong increase in pH. No carbonate alkalinity left to buffer pH or react with calcium.

Molarity calculation:

2. Moles Total hardness = 9.5×10^{-3} moles
3. Moles carbonate ion = 7.2×10^{-3}

One mole of carbonate reacts with one mole of hardness: Insufficient carbonate present to precipitate all of the hardness.

Table 7 - PWDR-1 Pilot Test Results

Test	Iron	Mn	TH
Baseline	17.2	14	720
Increase ORP by + 350 mV, Add 125 ppm ACH, Adj pH to 9.5	0.22	0.1	380

Table 8 - SIS Recovery Wells Pilot Test Results

Test	Iron	Mn	TH
Baseline	7.15	12	300
Increase ORP by + 350 mV, Add 125 ppm ACH, Adj pH to 9.7	0.0	0.0	200

Note: Insufficient alkalinity to remove all hardness

Table 9 – Leachate Pilot Test Results

Test	Iron	Mn	TH
Baseline	14.1	1	580
Increase ORP by + 350 mV, Add 250 ppm ACH, Adj pH to 9.43	0.26	0.2	260

Table 10 - Leachate Response to Oxidation with Bleach

ml 6.5% NaOCl	pH	ORP	Notes
0	7.24	459	
1.5		436	ORP declines–counter to expectation – should increase
2.5	7.49	417	Foam – ammonia off-gassing
3.5	7.62	399	Ammonium chloride ? chloroamines?
6.0	7.75	397	Water color lightening
9.0	7.8	409	
11.0	7.61	441	pH declines – acidic reaction
12.0	7.15	669	Break point : ORP increases radically

Note: The leachate water chemistry is significantly different then the PDWR-1 chemistry with respect to Alkalinity and Total Dissolved Solids. This has implications for calcium precipitation and filter solids dewatering:

Table 11 - Leachate and Groundwater Average Constituent Levels Test Results

Source	Iron	TDS	Hardness	Alkalinity
Leachate	14.1 ppm	3815	580	1850
PDWR-1	17.2 ppm	1210	720	620

Note: The iron concentration may actually be higher in the leachate at the point of generation, and some of the iron is depositing in the pipeline during transport. Iron and calcium carbonate deposition in leachate collection systems is commonplace

Impact on Hardness Removal

As the blend of water changes, the ratio of alkalinity to hardness changes. Alkalinity is a measure of all the dissolved species that react with acid, but for practical purposes it is composed of three ions, Hydroxide (OH^{-1}), bicarbonate (HCO_3^{-1}) and carbonate (CO_3^{-2}). As pH increases, bicarbonate ion converts to carbonate ion. Above pH 9.2, all of the carbonate alkalinity is present as bicarbonate. When the system adds KOH to increase pH, it is converting bicarbonate to carbonate alkalinity. One carbonate ion is required to react with one calcium ion or one magnesium ion.

$$Ca^{+2} + CO_3^{-2} >> CaCO_3$$

Calcium does not react with bicarbonate HCO_3^{-1}. Calcium carbonate is an equilibrium reaction, when equilibrium is attained the precipitation of calcium (and magnesium) self-arrests. Thus hardness will never be reduced to zero using precipitation alone. When the ratio of leachate to PWDR-1 water is high, there is sufficient alkalinity available to react with the hardness, and hardness removal efficiency is high. When the relative amount of PWDR-1 water increases, calcium precipitation is adversely impacted.

Filter Solids Quality

The leachate contains biological matter. If biological material reacts with inorganic coagulants like ferric chloride or aluminum based compounds to improve flocculation and dewatering, it produces poor quality filter solids. Low molecular weight, high charge density organic coagulants like epiamines would work well, but require extensive mixing and tend to be more expensive than inorganic coagulants.

A treatment chemical was used to remove Iron and Manganese at LS-1 and the Filter Building. It is designed to chelate dissolved metals and simultaneously flocculate the chelated materials to make them filterable. If the dose of this compound is constant, there will be instances of temporary overdosing when the metal concentration declines. Metal concentration will vary as the blend of groundwater and leachate sources varies. If the compound is temporarily overdosed, the resultant filtered solids will have excess polymer. The excess polymer creates gelatinous filter solids that are difficult to filter and dewater.

Revisions to the Treatment Program

After review, a basic program of oxidation with hydrogen peroxide, addition of polyaluminum chloride (inorganic coagulant), pH elevation with KOH to 9.4 and flocculation with anionic polyacrylamide was specified in order to effectively remove iron and manganese, reduce total hardness and produce large, rapidly settling floc that will dewater easily at both sand bed filters. In addition, polyaluminum chloride is injected immediately before the main process filters in the Filter Building to improve their effectiveness.

The UV Oxidation system is protected from calcium carbonate precipitation by taking two steps. First phosphoric acid is used to adjust the influent pH to 6.5 to keep all the alkalinity as non-reactive bicarbonate ion. Second, a polymaleic acid based inhibitor is injected before the air stripper to prevent calcium carbonate and calcium sulfate deposition in the downstream system.

Oxidizing Agent Selection

An oxidizing agent is required to abstract electrons from manganese, and convert divalent manganese to tetravalent manganese. The tetravalent manganese is subsequently precipitated as insoluble manganese dioxide.

$$Mn^{+2} - 2e^{-} > Mn^{+4} \qquad Mn^{+4} + O_2 > MnO_2$$

Leachate has a high demand for oxidizing agent. This is due to the oxidizer reacting with non-target compounds (such as ammonia) and forming ammonium compounds. Manganese oxidation (and subsequent precipitation) will not be effective until the extraneous organic demand is satisfied and free oxidizer residual is generated. The oxidation-reduction potential (ORP) actually declines until the organic demand is satisfied, then it accelerates rapidly. Hydrogen peroxide was evaluated as an oxidizer. Hydrogen peroxide reacts with non-target organic matter in the leachate and is preferred because it does not have the potential to create chlorinated disinfection by-products, which may be regulated compounds, and is already in use in the Filter Building and AOP^{+} systems.

System Control and Automation:

The chemical addition is automated using pH and ORP control. The polyaluminum chloride dose is controlled by proportional flow control. The flocculent dose is controlled manually by the operator's visual observation of filter solids quality.

Backwash Treatment

Treating the backwash water with anionic polyacrylamide causes the solids to floc immediately, dewater rapidly, and yield a clean filtrate. The injection point is located in the discharge line as it exits the filter. This injection point was selected to maximize mixing and contact time. In addition, injecting a polyaluminum chloride (PAC) based coagulant into the influent line leading to the main process filters increases their effectiveness significantly. The injection rate is approximately 30 ppm, based on a 50% concentration of the PAC. In addition, an anionic polymer is also injected in the filter backwash water. This polymer dose is 10 ppm. The objective is to create larger particles, improve filter drainage, reduce the rate that backpressure increases and extend filter run time between backwashing.

Calcium Carbonate Scale Control

The downstream system components, most notably the air stripper and catalyst recovery unit (CRU) on the AOP$^+$ unit, are subject to fouling due to deposition of calcium carbonate scale. The CRU requires frequently cleaning when the AOP$^+$ system is in use. The calcium carbonate scale problem is being managed by injecting a deposit control agent blended specifically to inhibit calcium carbonate. A blend of sequestering agents and dispersants is injected into the influent line ahead of the air stripper. This is injected at 3 ppm as 100% active product.

Iron Removal

The system will continue to use the metal chelant product in conjunction with pH elevation for removing iron and manganese at the Filter Building. In addition, Sulfuric acid was being used to lower the pH in the AOP$^+$ system. This was changed to phosphoric acid, because sulfuric acid dissolves to hydrogen ions and sulfate ion. The sulfate ions react with calcium to form calcium sulfate, which could foul the CRU and air stripper. To simplify the filter solids dewatering process at LS-1, it was decided to eliminate the addition of metal chelant at that location and perform all of the metals removal at the Filter Building where it is easier to manage the resulting filtered solids. Finally the laboratory testing shows the metals removal is optimal at a pH of 9.4, so the LS-1 and Filter Building process pH will be operated at 9.4 rather than 9.25.

Settling Vat Effluent Filters Upgrade

When processing in the AOP$^+$ unit, the flow is filtered through a 1-micron filter cartridge. Tests indicated that cartridge was plugging off after approximately 15-hours of use. To correct this, the Project Managers installed two bag filters that can be operated in series or as a paired system. When discharging to the irrigation system, the filters are operated as a paired system with 50-micron filter bags so the bags can be changed without shutting the system down. During this operation, the 1-micron filter is bypassed. When discharging to the AOP$^+$ unit, the filters are operated in series as pre-filters to the 1-micron filter unit. The inlet filter is fitted with a 25-micron bag, and the outlet filter is filtered with a 5-micron bag. This will capture the majority of the suspended solids and extend the operating life of the 1-micron filter.

Filtered Solids Handling

The Project Managers determined it would be necessary to dry and dispose of the filtered solids generated by the two new sand filter beds. To determine the requirements, a sample was collected and sent for hazardous waste characteristic testing, including a full TCLP metals and organics. Testing showed the solids did not exhibit any of the characteristics of hazardous waste. Therefore, the Parties requested permission to use the filtered solids as structural fill on the Riverdale Drive Landfill cap. This request has been approved.

Initial Component Testing

During the limited periods of time the system was operated after the fifth startup attempt, certain initial tests were conducted of the AOP+ system. While these tests were limited in scope and duration they contribute to understanding important aspects of the Remedial System operation.

AOP$^+$ Testing

During late September and early October 2014, the Project Managers conducted a series of short duration tests of the AOP$^+$ system. The objectives of the tests were to determine the treatment capabilities of the system and how the pH, quantity of oxidizer and presence of TiO_2 influenced the process flow concentration of 1,4-dioxane. A theoretical oxidizer demand for a flow of 50 GPM with an inlet concentration of 3 PPM of 1,4-dioxane was determined to be 0.00025 Lbs./Gal or 18 Lbs. per 72000 Gallons. That correlated to 8% stroke setting on the H_2O_2 dosing pump.

A series of tests were conducted varying the amount of H_2O_2, at various pH settings, both with and without TiO_2. All the tests except for one were limited to 1-hour duration because of the problems experienced with the plugging of the 1-micron AOP$^+$ pre-filter. A single test was run for a 2-hour duration to see if additional time for the process to stabilize would have any effect.

The following table presents the 1,4-dioxane results from those initial test runs:

Table 12 - AOP$^+$ Test Results

Date	Source	H_2O_2	TiO_2	pH	Result	% Destruction
9/27/14	PWDR-1	N/A	N/A	N/A	2880	N/A
	SISRW	N/A	N/A	N/A	2210	N/A
	LS-1RW	N/A	N/A	N/A	484	N/A
	LS-1 LCHT	N/A	N/A	N/A	135	N/A
9/30/14	AOP$^+$ IN	N/A	N/A	N/A	3170	N/A
	AOP$^+$ OUT	8	NO	5.5	1170	63.1%
	AOP$^+$ OUT	16	NO	5.5	1420	55.2%
	AOP$^+$ OUT	24	NO	5.5	1210	61.8%
	AOP$^+$ OUT	0	NO	5.5	1280	59.6%
10/2/14	AOP$^+$ IN	0	NO	5	2970	N/A
	AOP+ OUT	0	NO	5	977	67.1%
	AOP$^+$ OUT	8	YES	5	527	82.3%
	AOP$^+$ OUT	8	YES	4	481	83.8%
	AOP$^+$ OUT	8	NO	3	62.6	97.9%
10/10/14	AOP$^+$ IN	N/A	N/A	N/A	3060	N/A
	AOP$^+$ OUT	8	NO	4	124	95.9%
	AOP$^+$ OUT	16	NO	4	390	87.3%
	AOP$^+$ OUT	8	NO	3	15.8	99.5%
	AOP$^+$ OUT	8	YES	4	433	85.8%
	AOP$^+$ OUT	16	YES	4	411	86.6%
	AOP$^+$ OUT	8	YES	3	387	87.4%
	AOP$^+$ OUT	16	YES	3	405	86.8%

Because the run times were limited by the fouling of the 1-micron pre-filter due to the fact that the system chemistry was not finalized at the time, it was determined that further testing of the AOP$^+$ unit would be necessary. The test results indicated that 1,4-dioxane was not reduced to the <10 ug/L RASA treatment standard. Because the unit operates based upon the transmissivity of light, less than optimal system chemistry could limit the unit's effectiveness. It appeared the effectiveness of the unit is reduced by the presence of TiO_2, which the Manufacturer prescribes be added as a catalyst. This is most likely due to the reduction in transmissivity that results when the catalyst is added. When operating with TiO_2 in the system, the process flow is cloudy white in color as it passes through the light source.

It was decided further testing of the AOP^+ unit should be deferred until the primary treatment system (Natural Treatment System) was more fully tested and operated.

Capture Zone Monitoring

Transducers were installed in the wells as agreed in the Remedial Monitoring and Effectiveness Evaluation Plan (RMEEP), as revised. This included OW-DR-2, OW-DR-3, OW-DR-4, PW-6D, and OW-LFS-2, which are located on the landfill, and PW-15D and PW-16D located across the Randleman Reservoir on property within the Randleman Reservoir buffer. There was an existing transducer in PW-DR-1. During the 4th quarter, during limited operation of all of the recovery wells, the transducers indicated a significant draw down and good hydraulic control in all monitored wells, including two located across the Reservoir. With the exception of OW-DR-3 that has historically been unresponsive to pumping, all monitored wells showed influence when operating the recovery wells and the deep groundwater well. The Project Managers intend to relocate the OWDR-3 transducer to PW-6I to collect more useful data.

PHASE 3-JULY 2015 THROUGH CONSTRUCTION COMPLETION

During the third quarter of 2015 the Parties implemented certain chemical and mechanical refinements to improve system performance. Following the completion of Phase 2 of construction, the Parties began testing of the system components to determine long-term operating capabilities. During this initial testing it was determined that, although the system was capable of operating on a sustained basis when treating the deep and shallow groundwater, the amount and type of sludge produced when leachate was incorporated into the flow exceeded the capacity of the present solids and sludge handling equipment, and caused solids to form and deposit in pipes, pumps and equipment.

Clarifier Upgrade

To address the higher than expected amount of solids separating from the groundwater and leachate during processing, the Parties initially installed enhanced filtration with the addition of the Filter Building. When the system was restarted after that modification was installed, several variations of system chemistry were tested to determine whether the solids could be kept in solution until they could be deposited on a set of large dual media filters. Although this approach showed some improvement, it did not prove to be adequate to ensure stable long term operation of the system.

As a result, the Parties retained the services of Hazen and Sawyer in the summer of 2015 to conduct on Site testing and recommend physical and chemical changes to improve system stability and prevent fouling of pumps, valves, pipes and other components. Hazen and Sawyer issued their report in September 2015 and recommended that a Clarifier be installed before flow enters the Filter Building and that additional sludge handling equipment be added to the system. In addition, they recommended changes to system chemistry. A copy of the Hazen and Sawyer report is provided in Attachment 11.

The Parties approved the plans for the Clarifier modification, and construction commenced in early January 2016. Prior to commencing construction, a full set of the plan drawings for the proposed modifications was provided to NCDEQ. Construction consisted of installing a Clarifier immediately behind the Filter Building. The process piping was modified to direct flow from all groundwater and leachate sources to the Clarifier inlet.

The Clarifier is a conical bottomed cylindrical vessel approximately 18-feet in diameter and 15-feet high. It has an internal mixing zone where ferric chloride and hydrated lime are added to the flow and thoroughly mixed before entering the settling zone where the precipitate that forms is settled. The settled material is moved to the center of the Clarifier by a set of rakes where it is pumped to the solids handling equipment.

The clarified process flow overflows from the Clarifier into the Aeration Tank (T-600) in the Filter Building. The remaining portions of the treatment system were not modified.

Sludge Handling Modification

With the amount of sludge being produced by the Clarifier, the sand filtration that was being used to handle solids would no longer be adequate. In the Clarifier system, sludge is pumped from the bottom of the Clarifier by a set of progressive cavity pumps which transfer it to one of the two sludge dewatering boxes mounted on elevated stands behind the Maintenance Building. The progressive cavity pump in service draws the sludge from the bottom of the Clarifier. At this point the sludge is very thin; therefore, a polymer is added at the suction of the progressive cavity pump which further coagulates the sludge and release water as it travels to the dewatering box.

Once it arrives in the dewatering box, the sludge is retained by filter screens that line the dewatering box while the water drains to a sump which is pumped to the Clarifier Equalization Tank. The Equalization Tank receives that flow along with the backwash flow from the dual media filters in the Filter Building. The combined flows are pumped back to the Clarifier inlet. Each sludge dewatering box holds approximately 30 cubic yards of dewatered sludge. Once one dewatering box is full, flow is directed to the other box and the full box is allowed to sit until all the free water has drained. At that time, the box is tilted up and the low end is opened allowing the sludge to fall into a concrete basin. The sludge is tested quarterly for TCLP metals, and if it is below the limits, it used for structural fill on the landfill cap. If not, it disposed of as required by state regulations.

System Chemistry Modifications

With the Clarifier and Sludge Handling Upgrades installed, it is no longer necessary to attempt to retain the solids in solution until they reach the Filter Building. As a result, it is no longer necessary to add any of the chemicals that had been added at LS-1 or the Filter Building. Testing performed by Hazen and Sawyer indicated that the solids and sludge could be effectively removed at the Clarifier with the addition of lime to raise the pH and ferric chloride to flocculate the resulting precipitate. This eliminated all the existing chemical additions with the possible exception of the sequestering agent added at the Air Stripper.

During the Clarifier Upgrade the Parties installed two 6,500 gallon tanks in the Maintenance Building to hold the hydrated lime and ferric chloride These tanks are enclosed in separate containment structures which are designed to contain the volume of each tank should a leak occur.

PROCESS FLOW DESCRIPTION

The mechanical treatment process is control by a Siemens SIMATIC 300 PLC system. Burkert automatic pneumatic valves direct flow paths, while Endress-Hauser flow meters, level transducers, pH meters, and pressure gauges provide real-time data to the PLC. The system can be controlled from any of the four HMI's, as well as from remote locations.

LIFT STATION 1

Six leachate collection sumps (LCHT-1, 2, 3, 4, 5, and NIS-SUMP) and four groundwater recovery wells (RW-LFS1, RW-LFS2, RW-SIS1, and RW-NIS1) pump contaminated groundwater and leachate with submersible pneumatic pumps. These pumps are driven by compressed air from LS-1 and discharge to the collection manifold in LS-1. The process flow flows into a 500-gallon equalization tank (T-121). The water is then pumped to Lift Station 2.

LIFT STATION 2

Three groundwater water wells (RW-SIS2, 3, and 4) pump contaminated groundwater with submersible pneumatic pumps. These pumps are driven by compressed air from LS-2, and discharge to the collection manifold in LS-2. The deep groundwater recovery well (PWDR-1) pumps contaminated groundwater into the LS-2 manifold by means of an electric submersible pump. These two flow streams combine with the flow from LS-1, as well as an optional recycled process water line, then divert directly to the Clarifier.

CLARIFIER

The Clarifier is a conical bottomed cylindrical vessel approximately 18-feet in diameter and 15-feet high. It has an internal mixing zone where ferric chloride and hydrated lime are added to the flow and thoroughly mixed before entering the settling zone where the precipitate that forms is settled. The settled material is moved to the center of the Clarifier by a set of rakes where it is pumped to the solids handling equipment. The clarified process flow overflows from the Clarifier into the Aeration Tank (T-600) in the Filter Building.

SLUDGE HANDLING EQUIPMENT

In the Clarifier system, sludge is pumped from the bottom of the Clarifier by a set of progressive cavity pumps which transfer it to one of the two sludge dewatering boxes mounted on elevated stands behind the Maintenance Building. The progressive cavity pump in service draws the sludge from the bottom of the Clarifier. At this point the sludge is very thin; therefore, a polymer is added at the suction of the progressive cavity pump which further coagulates the sludge as it travels to the dewatering box.

Once it arrives in the dewatering box, the sludge is retained by filter screens that line the dewatering box while the water drains to a sump which is pumped to the Clarifier Equalization Tank. The Equalization Tank receives that flow along with the backwash flow from the dual media filters in the Filter Building. The combined flows are pumped back to the Clarifier inlet. Each sludge dewatering box holds approximately 20 cubic yards of dewatered sludge. Once one dewatering box is full, flow is directed to the other box and the full box sits until all the free water has drained. At that time, the box is tilted up and the low end is opened allowing the sludge to fall into a concrete basin. The sludge is tested quarterly for TCLP metals, and if it is below the limits, it used for structural fill on the landfill cap. If not, it disposed of as required by state regulations.

FILTER BUILDING

The Clarifier overflows to a 2,800-gallon coarse bubble diffusion aeration tank (T-600). From T-600, the water flows into a 500-gallon equalization tank (T-601). The process flow then flows through two parallel duel-media filters (F-604A/B). The upper media is a pumice type material called Filter-AG. The lower media is a layer of fine garnet. The duel media filters are backwashed from a 2,000-gallon storage tank (T-603). Following the filters the process water flows through the Air Stripper (AS-605) and is pumped back to LS-2.

EFFLUENT TREATMENT SYSTEM PROCESS FLOW

After the flow re-enters LS-2, it discharges into a 6,000-gallon settling tank (T-301), which contains an underflow and overflow baffle. The process flow is then pumped though a pair of bag filters (F-307A/B) that can operate in series or in parallel. Phosphoric or sulfuric acid is then injected, at a variable rate to adjust the pH to approximately 7.0. Following the pH adjustment, the process flow passes to one of three 2,000-gallon holding tanks (T-400, 410, 420).

From any of the three T-400 tanks, the treated water can be pumped to the Natural Treatment system, or re-cycled back to the Filter Building. The Natural Treatment System irrigation feed line can be injected with nutrients if necessary from a 2,000-gallon fertigation tank (T-580). Hydraulically operated solenoid valves control which of the sixteen irrigation zones in the Irrigation System is fed with the Physical Treatment System process effluent. Process flow diagrams are included in Attachment 3.

EXPLANATION OF SIGNIFICANT DIFFERENCES

The items listed below represent the more significant differences between the information contained in the PCR and what is included in the final as-built Remedial Treatment System.

ITEMS NOT INSTALLED THAT WERE IN THE PCR

Constructed Treatment Wetlands

In the remedial design presented in the PCR, a constructed treatment wetlands (CTW) was included to biologically destroy VOCs and reductively de-chlorinate the cVOCs. This was thought necessary because of a concern that if left untreated and applied to the phytoremediation soils, the level of chlorides in the soil would increase, and this could develop to levels that would become phytotoxic and affect tree health. The later pilot studies appeared to contradict this earlier assumption. When the Parties began to look into the available supporting research, they discovered a significant body of work was available, most of which was published after the Remedy Recommendation Document was prepared. This research pointed to successes in cVOC removal by several mechanisms, including air stripping and biodegradation processes in the Landfill soils due to metabolic processes that are unique in methane-rich soil environments, such as exist at Landfills.

Because there was evidence the CTW was not necessary, the Project Managers explored the effect eliminating the CTW might have on the remedy. Eliminating it provides a simplified treatment process. It removes several control variables and makes control of the phytoremediation irrigation less complex. In addition, the more effective removal of the CoCs and metal salts provided by the entire Physical Treatment system except for the AOP^+ unit would significantly improve the quality of the irrigation water and reduce the accumulation of CoCs and metal salts in the soils. This had the potential to extend the period in which the Natural Treatment System could be irrigated each year. Eliminating the CTW also reduced costs by a significant amount and did not increase the potential environmental risk at the Site or the anticipated duration of the remedial action. Therefore, it was decided to request a change in the remedy, and TM E-3 was prepared and submitted to NCDENR. TM E-3 was verbally approved by NCDENR, and the CTW was eliminated from the remedial treatment system design.

One main benefit that resulted from the elimination of the CTW is the improved quality of the irrigation water. At the time the PCR was submitted, it was planned for the CTW to receive extracted groundwater and leachate without significant pretreatment. The flow from LS-1 and LS-2 was to be sent to the CTW without prior treatment and the cVOCs and VOCs would be biodegraded, resulting in a significantly higher concentration of chloride salts in the irrigation water. With the elimination of the CTW, various chemical and physical processes, including aeration, air stripping, flocculation, metals chelation and filtration, are applied to the irrigation water prior to it being used for irrigation. This results in the levels of metal salts, including chlorides, being much lower than anticipated when the PCR was submitted. The much lower levels of metal salts and chlorides accumulated in the soils during startup testing have confirmed this.

AOP UNIT ELIMINATION

As discussed above, in the original design of the remedial treatment system, it was envisioned that there would be a need for a backup system to be used in the event of a catastrophic loss of the phytoremediation system. To provide the backup system, the Parties acquired an AOP^+ unit to treat 1,4-dioxane and other CoCs to levels sufficient to allow discharge to the POTW. After numerous expensive repair efforts, the Parties retained the services of Arcadis to provide an independent qualified expert to design an appropriate testing protocol and then to operate and test the AOP^+ unit to determine if it could meet the pretreatment limits established by the POTW. Arcadis provided an engineer who had extensive experience operating advanced oxidation systems. The testing was conducted during August 2016. The tests indicated that given the high concentrations of 1,4-dioxane (approximately 3,000 ug/L) entering the unit, and other characteristics of the extracted groundwater and leachate entering the unit, including high concentrations of radical scavengers (bromide levels of 6-10 mg/L), the AOP$^+$ unit, as presently configured, could not achieve the POTW pretreatment limits. Based on the observed conditions and the analytical data, Arcadis estimated that to install a unit that could meet the discharge limits would require approximately 5 times the existing UV-lamp power, or roughly 1,000 KW. Not only would such a unit be impossible to operate due to the heat it would generate, but at 50 GPM, the fluid would boil inside the unit, removing any cooling for the lamps. This would result in damage that would disable the unit. Arcadis also identified several significant additional long term operating issues with the PhotoCat that are detailed in the report. A copy of the Arcadis report is attached as Attachment 7.

Because the AOP$^+$ unit cannot consistently treat effluent to the required levels established in the City's Pretreatment Permit, the Parties are not allowed to discharge any treated effluent to the POTW. As discussed above, the Parties have explored alternative technologies that might improve or replace the AOP$^+$ unit but have not identified a suitable enhancement or replacement.

The Parties recognize that having a backup unit would address concerns that may exist about the catastrophic loss of the tree stand. However, the tree stands have existed on the Landfill cap for 9 years and have yet to experience significant tree loss. They are under the day-to-day supervision of a licensed forester, and the phytoremediation system is managed by an expert who conducts soil and tree tissue samplings to ensure the health of the entire stand. The tree species planted are native North Carolina species including Loblolly, Virginia and Southern Pine and Eastern Red Cedar, which were selected for their resistance to disease, long life expectancy, and tolerance of the Landfill cap soil conditions. Because of the experience gained over the past 9 years with the phytoremediation system, and the lack of suitable and available alternative technologies, the Parties submitted TM-E10 to request, among other things, that an alternate backup system to the PhotoCat not be required at this time. TM-E10 was subsequently approved by NCDEQ and, therefore, a backup system will not be installed at this time.

ITEMS INSTALLED THAT ARE NOT IN THE PCR

Tree Species Upgrade

It was determined certain tree species do far better than others in the existing soil conditions. In addition, certain discoveries during the 2009 and 2010 pilot tests have resulted in the conclusion that certain alterations to the design of the system seemed prudent. First, it was noted certain tree species seemed to be more tolerant of the Site conditions than others. For example, the loblolly pine (a conifer) is thriving at the Site, whereas most of the hardwoods are struggling. In replacing the trees that had died, it was necessary to determine alternative species to those that struggle, and yet not use the same species throughout the tree stand. Two alternative species of pines were identified that are similar to the loblolly pine, but sufficiently different to make them excellent candidate species (e.g. salt-tolerant Virginia pine).

The Parties also determined is that the original plan to use a mixed tree stand of conifers and deciduous trees is unnecessary and may adversely affect the system's capacity to handle irrigation flow in winter. The deciduous trees are among the species that have struggled to survive. They have been much more susceptible to disease and damage from insects, deer and fungi than the conifers. Therefore, the deciduous trees have been inter-planted with conifer trees so the tree stand will naturally mature with all zones planted in conifer trees.

During the 2009 and 2010 pilot studies to determine a mass balance of 1,4-dioxane, there were some unexpected indications that certain of the original assumptions may not have been what we were experiencing in the field. It was found there was no indication of the accumulation of phytotoxic levels of inorganic salts in the soils even though the plots were dosed with untreated groundwater directly from PWDR-1 having much higher salt levels than what is expected from the Physical Treatment system process flow.

During the same study, several months after the study ended, the soils were tested for cVOCs. It was determined that, like the metal salts, the cVOCs had not accumulated in the soils. The conclusion was there are several processes that degrade the cVOCs in the soils other than tree uptake, and there was no evidence of excessive chloride salt accumulation that might result in phytotoxicity. As a result, the Natural Treatment System can sustain higher levels of cVOC input than originally estimated.

Irrigation Logic

In the original plans, the Natural Treatment System was to be flushed to remove salt accumulation during the winter months. It was anticipated that salts could accumulate during the summer when transpiration rates are high and any inorganic constituents derived from the irrigation water are left behind in the root-zone soil. Flushing was to be done using City water. However, there was a major concern about bringing a City water line into the treatment system enclosures. The location the system occupies is at the low point in the City water system. Pressures at the Site have been measured above 160 psig. A leak inside an unattended structure at that pressure would have the potential to produce major electrical and electronic component damage resulting in a long recovery time, and a substantial cost. This was judged too great a risk.

When the Parties developed the original salt-flushing plan, the recent extensive modifications to the pretreatment system were not considered. With the addition of the more robust pretreatment systems including aeration, flocculation, filtration and settling, the quality of the Settling Vat process flow is considerably more suitable to use for flushing salts from the Landfill soil cap. Flush water that is low in metal salts (significantly below phytotoxic levels) is needed to flush any accumulated salts into the waste layer below the Landfill cap.

The design was modified to use Settling Vat process flow filter water for salt flushing. The only difference between the Settling Vat process flow and the City water is the presence of a small amount of residual CoCs and all the 1,4-dioxane. Even during the most dormant periods of tree uptake, the other degradation mechanisms continue to provide effective treatment of some or all the 1,4-Dioxane. The result is that any water infiltrating below the Landfill cap would be of significantly better quality than the extracted leachate or groundwater. Assuming the capture zone is effective, which has been confirmed during the recent testing, using Settling Vat process flow to flush salts from the soils should present no risk to the environment and will contribute to the mass reduction of contaminants at the Site, even during periods of low evapotranspiration. Hence, the system was modified to allow the system to use Settling Vat process flow to flush the accumulated salts during the winter months. Modifying the control logic to allow saturation of the lower moisture probes in the zone being flushed and operating the upper and middle probes above their free drainage set points accomplished this. The control system is designed to preclude the use of anything other than Settling Vat process flow when operating in this mode.

Filter Building

The original plans presented in the PCR did not include the Filter Building. This building is necessary to add the more robust filtration necessary to remove the metal salts and aeration needed to strip methane, VOCs and oxidize metals. There was not sufficient space available in the Effluent Treatment System Enclosures.

Clarifier

The original plans presented in the PCR did not include the Clarifier. The Clarifier was installed to address the higher than expected amount of solids produced when the groundwater and leachate is treated. It is a conical bottomed cylindrical vessel approximately 18-feet in diameter and 15-feet high. It has an internal mixing zone where ferric chloride and hydrated lime are added to the flow and thoroughly mixed before entering the settling zone where the precipitate that forms is settled. The settled material is moved to the center of the Clarifier by a set of rakes where it is pumped to the solids handling equipment. The clarified process flow overflows from the Clarifier into the Aeration Tank (T-600) in the Filter Building.

Sludge Handling Equipment

In the Clarifier system, sludge is pumped from the bottom of the Clarifier by a set of progressive cavity pumps which transfer it to one of the two sludge dewatering boxes mounted on elevated stands behind the Maintenance Building. Once the sludge arrives in the dewatering box, it is retained by filter screens that line the sides of the dewatering box while the water drains to a sump which is pumped to the Clarifier Equalization Tank. Each sludge dewatering box holds approximately 30 cubic yards of dewatered sludge. Once one dewatering box is full, flow is directed to the other box and the full box sits until all the free water has drained. At that time, the box is tilted up and the low end is opened allowing the sludge to fall into a concrete basin.

HEALTH AND SAFETY MODIFICATIONS

Tank Vent System

In LS-1, LS-2 and the Effluent Treatment System Enclosures, the tanks provided by the Manufacturer vented inside the containers. The environment inside the containers is not designed for use with flammable or toxic atmospheres, so the tank vents were routed outside the containers. A check of the original drawings indicated this was not specified in the bid specifications, Physical Treatment System PCR or the bid proposals.

Because the enclosures for LS2 and the Physical Treatment System were divided into three separate enclosures for ventilation purposes, each would have had a separate electrical classification. As explained in a separate report (*Atmospheric Classification of Seaboard Site Enclosures* Gary D. Babb, P.G. and James C. LaRue, February, 2012), any spaces in which leachate is present in its raw form must be evaluated for the risk of accumulation of methane gas at or above the lower explosive limit (LEL). This required that the classification be determined by the regulations of the U.S. Department of Labor Occupational Safety and Health Administration (OSHA). These regulations are found in 29 CFR Subtitle B Part 1910, Subpart S beginning at §1910.307. Several modifications have been necessitated by the presence of leachate in the treatment system influent, which raises the possibility that methane gas concentrations could exceed the LEL inside the Enclosures, particularly in the headspaces of tanks. This would have required that the electrical ratings of all equipment within those spaces meet Class 1 Division 1 (explosion-proof) requirements. Originally, there were three separate ventilation structures LS-1, LS-2 and the Physical Treatment System,[1] and each of these areas could have seen raw untreated leachate during operation. As a result, all electrical equipment in these spaces should have been rated accordingly. Instead, the Project Managers sealed the headspaces of all tanks and force ventilated them outside the Enclosures. In addition, new man-door openings were installed in both walls in Enclosure 5 allowing all the spaces in LS-2 and the Effluent Treatment System Enclosures to be evaluated as a single space for ventilation and interior air quality purposes. When the Parties added the Filter Building, it became a forth space for ventilation purposes. As a result, the design specified that all tanks be vented outside the building, and that all tank headspaces be swept with air from outside the building. In addition, the air stripper and aeration tank exhaust are vented outside the building.

In all four tank ventilation systems, the headspace of the tanks is ventilated with air drawn from outside the container by an explosion proof vacuum pump. This pump draws a suction on the tank vent header and exhausts into a header with a lower explosive limit (LEL) sensor. The LEL sensor provides a signal to the vacuum pump controller. The vacuum pumps run at a low speed until LEL begins to rise. They begin to ramp up when LEL reaches 10% based on methane. They are ramped up so that when LEL reaches 25% based on methane, they are running at 100% and continue to do so until the LEL is reduced to 10% or less.

Enclosure Egress

After the eight Enclosures were installed, it was determined the egress provided by the Manufacturer did not comply with the OSHA requirements (29 CFR 1910.36). Exit routes must meet the following design and construction requirements:

(1) Each exit route must be a permanent part of the workplace.

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[1] Enclosures 1,2, 3 and 4 were considered a separate structure, Enclosure 5 was another separate structure and Enclosures 6 and 7 were the third separate structure for ventilation purposes. The LS-1 structure in Enclosure 8 was also a separate structure for ventilation purposes.

(2) Construction materials used to separate an exit from other parts of the workplace must have a one-hour fire resistance-rating.
(3) An exit is permitted to have only those openings necessary to allow access to the exit from occupied areas of the workplace, or to the exit discharge.
(4) At least two exit routes must be available in a workplace to permit prompt evacuation of employees and other building occupants during an emergency.
(5) The exit routes must be located as far away as practical from each other so that if one exit route is blocked by fire or smoke, employees can evacuate using the second exit route.
(6) The street, walkway, refuge area, public way, or open space to which an exit discharge leads must be large enough to accommodate the building occupants likely to use the exit route.
(7) Employees must be able to open an exit route door from the inside at all times without keys, tools, or special knowledge.
(8) The capacity of an exit route must be adequate to support the maximum permitted occupant load for each floor served.

As a result, it was necessary to remove the double doors supplied and replace them with 1-hour fire rated double doors that could be operated in an emergency from the inside on Enclosures 1, 3, 5, 6, 7 and 8. This complied with the OSHA requirements.

External Alarm System

During an inspection by the Guilford County Fire Marshal, it was requested that the Parties install an external audio and visual alarm indication at LS-1, LS-2, and the Filter Building. Therefore, there is audio and visual alarm indication installed at those locations, which will provide notification to first responders whenever there is an alarm condition.

Chemical Tank Shielding

When supplied by the Manufacturer, the chemical storage tanks were unshielded. As they sat above their associated containment vessels, they represented a potential hazard to operating personnel. As a result, shielding was placed around the acid and caustic storage tanks.

The Manufacturer installed injection quills made of polypropylene. As the material would tend to degrade over time when exposed to the CoCs, the Parties also took the opportunity during the construction of the Filter Building to replace them with ones made of Kynar with Hastaloy springs and ball check valves.

Certified Industrial Hygenist Testing

In order to ensure that the atmospheres inside the enclosures and surrounding selected outside areas are in compliance with the U.S. and North Carolina Departments of Labor regulations for employee exposure to chemicals in the working environment, the Parties retained the services of Matrix Health and Safety Consultants, LLC (Matrix), who provided a North Carolina Certified Industrial Hygenist (Mr. C. Britt Wester, CIH) to inspect and sample the atmospheres at the Site.

The CIH inspected the Site during the period from February 21, 2017 to February 22, 2017 and collected the requisite atmospheric samples. This period of time was selected because the system had been in continuous operation in a configuration considered representative of normal operations. A copy of the Matrix report is included as Attachment 10 to this report. As noted, none of the samples collected contained contaminants at levels that exceed the "permissible exposure limit" (PEL) for the contaminant in occupied working environments.

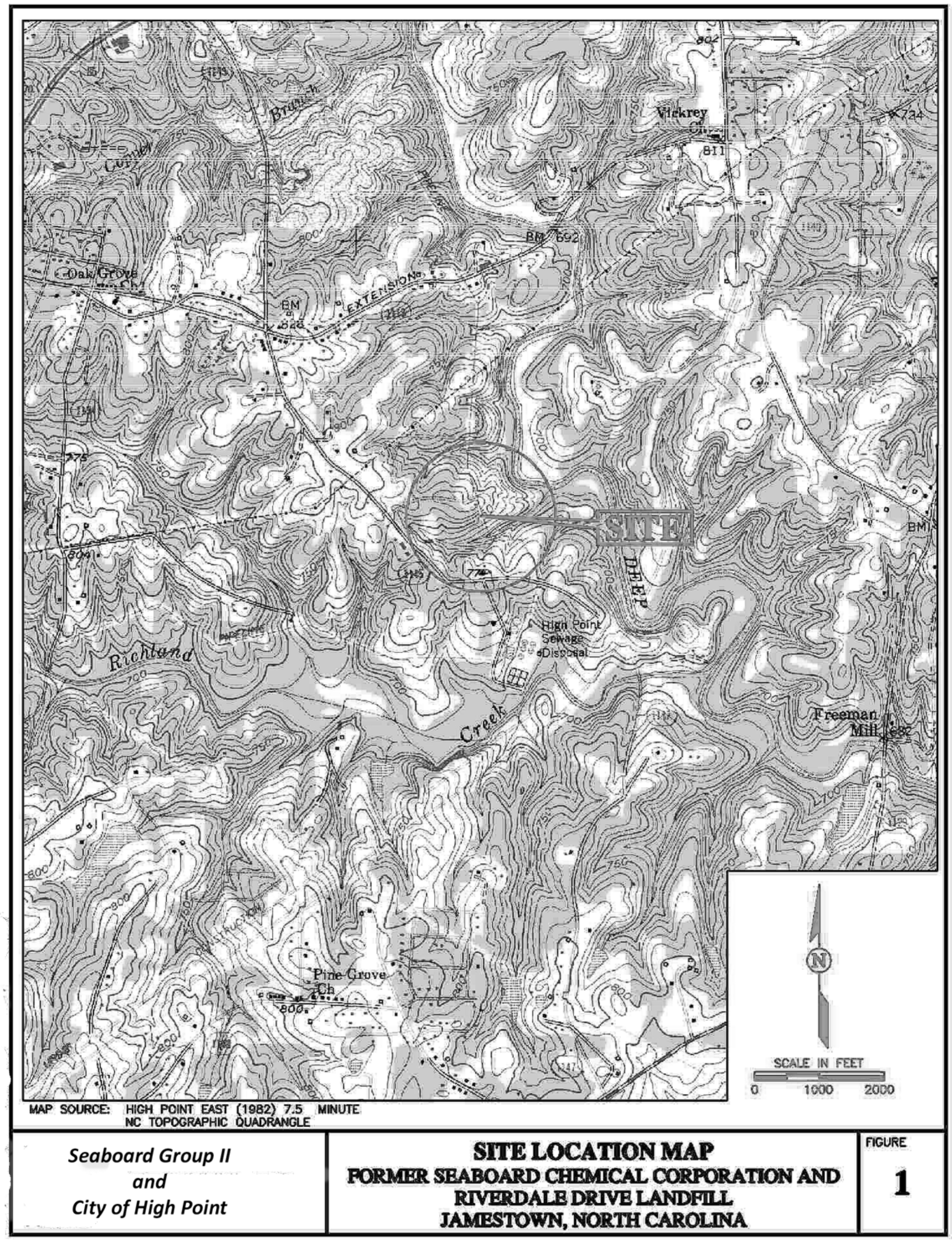
CONCLUSION

The Remedial Treatment System components have been constructed, and with certain exceptions described in this report, are substantially consistent in function, performance and operation with those presented in the PCR; and they address all the remedial objectives for the Site. Construction of the Remedial Treatment System, although taking longer than expected, progressed relatively well considering the overall complexity of the project, the failure of the AOP$^+$ unit to function properly, the necessity to address higher levels of certain CoCs and metal salts in the groundwater and leachate and the unique nature of the remedy.

The construction of the Remedial Treatment System is now complete, and the Parties have begun the process of pre-operational testing of the system components. The most significant modifications from the Remedial Treatment System proposed in the PCR were the elimination of the constructed treatment wetland (CTW), which the Parties determined would neither contribute to the effectiveness of the remedy nor be necessary to achieve the remedial objectives originally proposed in the PCR, and the elimination of the AOP$^+$ unit, which despite the best efforts of the Parties could not be rendered capable of meeting the established City POTW pre-treatment limits. In addition, the PCR proposed a less robust and flexible Physical Treatment System, which upon initial startup proved unable to provide the requisite level of treatment. All the modifications to the Remedial Treatment System, except for the elimination of the CTW, have been necessitated by the need to correct manufacturing defects or deficiencies in equipment, enhance or improve the overall treatment system destruction and removal efficiency, provide additional metal salts removal or provide flow path flexibility to produce a suitable Physical Treatment System process effluent. All modifications to the RASA Statement of Work were submitted to NCDENR in ten Technical Memoranda (TM). These ten TM were approved by NCDENR and are included in Attachment 5.

ATTACHMENT 1

FIGURES



MAP SOURCE: HIGH POINT EAST (1982) 7.5 MINUTE NC TOPOGRAPHIC QUADRANGLE

Seaboard Group II
and
City of High Point

SITE LOCATION MAP
FORMER SEABOARD CHEMICAL CORPORATION AND RIVERDALE DRIVE LANDFILL
JAMESTOWN, NORTH CAROLINA

FIGURE
1

Figure 1 - General Site Location

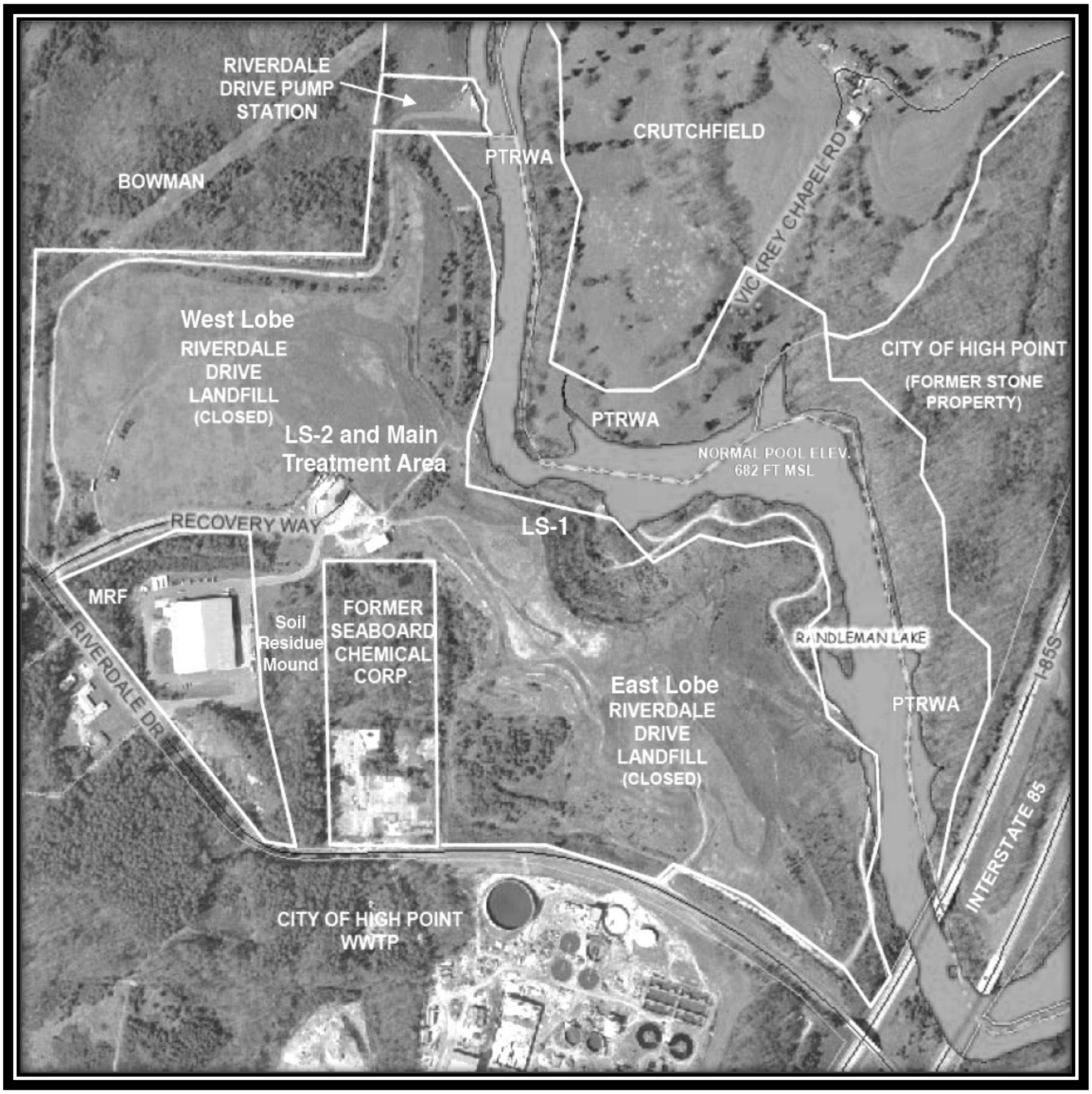


Figure 2 - Site Layout


SITE MAP AND MONITORING LOCATIONS
FORMER SEABOARD CHEMICAL/RIVERDALE DRIVE LANDFILL
JAMESTOWN, NORTH CAROLINA
LEGEND
Monitoring Well (Bedrock)
Monitoring Well (Saprolite/PWR)
Leachate Monitoring Well
Recovery Well (Saprolite/SB)
Surface Water Sample
Surface Water and Piezometer Sample
Intermittent Stream
10 Foot Elevation Contour Interval
Road
682 Ft Contour (Normal Pool Elevation of Lake)
Randleman Lake
Parcel Boundary
Note: Source of 2008 Aerial Photography Guilford County, NC
0
150
300 Feet
N
I-85N
Crutchfield Property
Randleman Lake
Riverdale Drive Landfill
Southern Intermittent Stream
Former Seaboard Chemical Facility
Eastside WWTP
Soil Residue Mound
Former Burn Pits Area
Material Recycling Facility
Northern Intermittent Stream (Piped)
RIVERDALE DR
111699 Figure2.mxd 06/09/10 LCR

Figure 3 - Site Layout with Burn Pits and Monitoring Wells

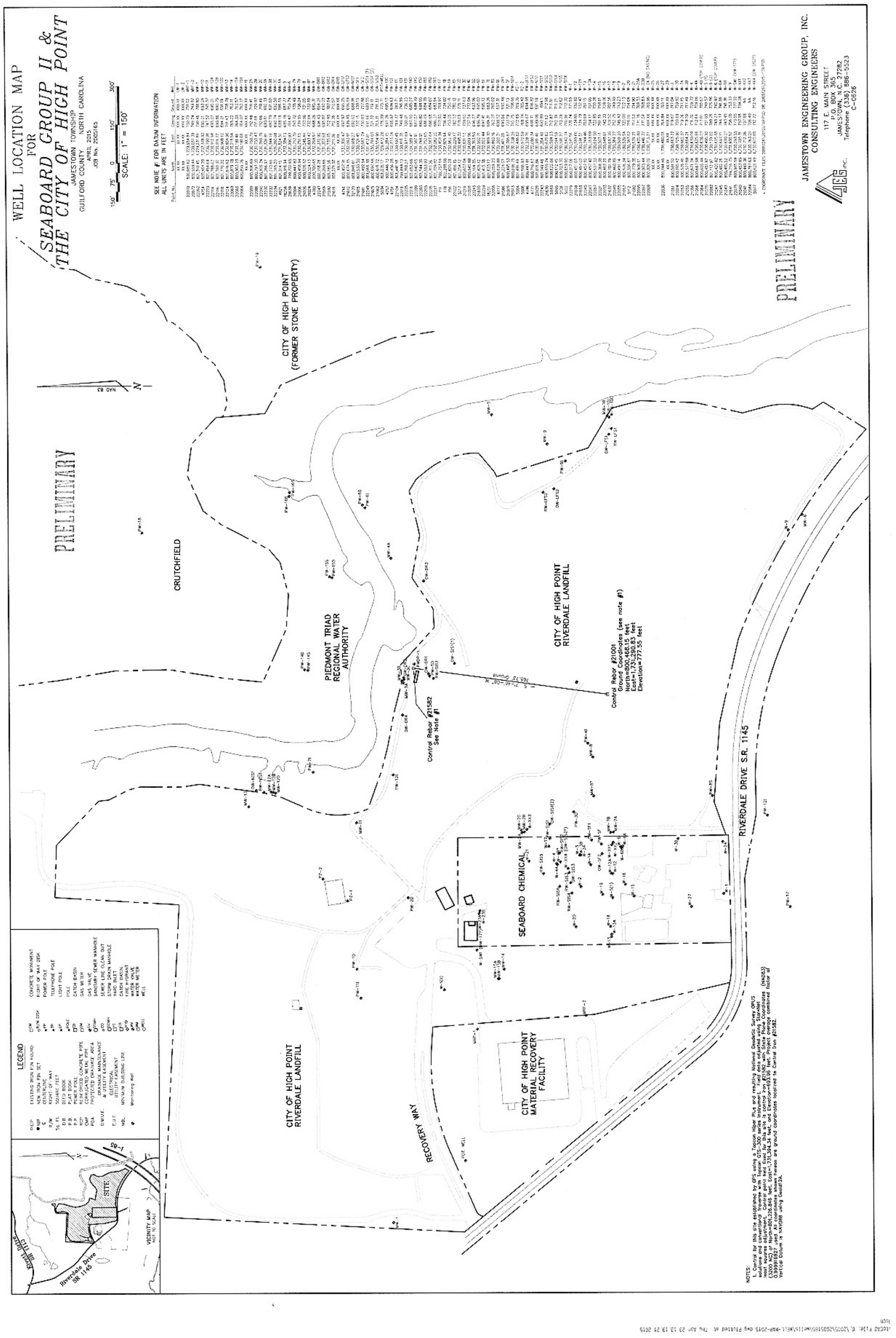


Figure 4 - Monitoring Well Locations

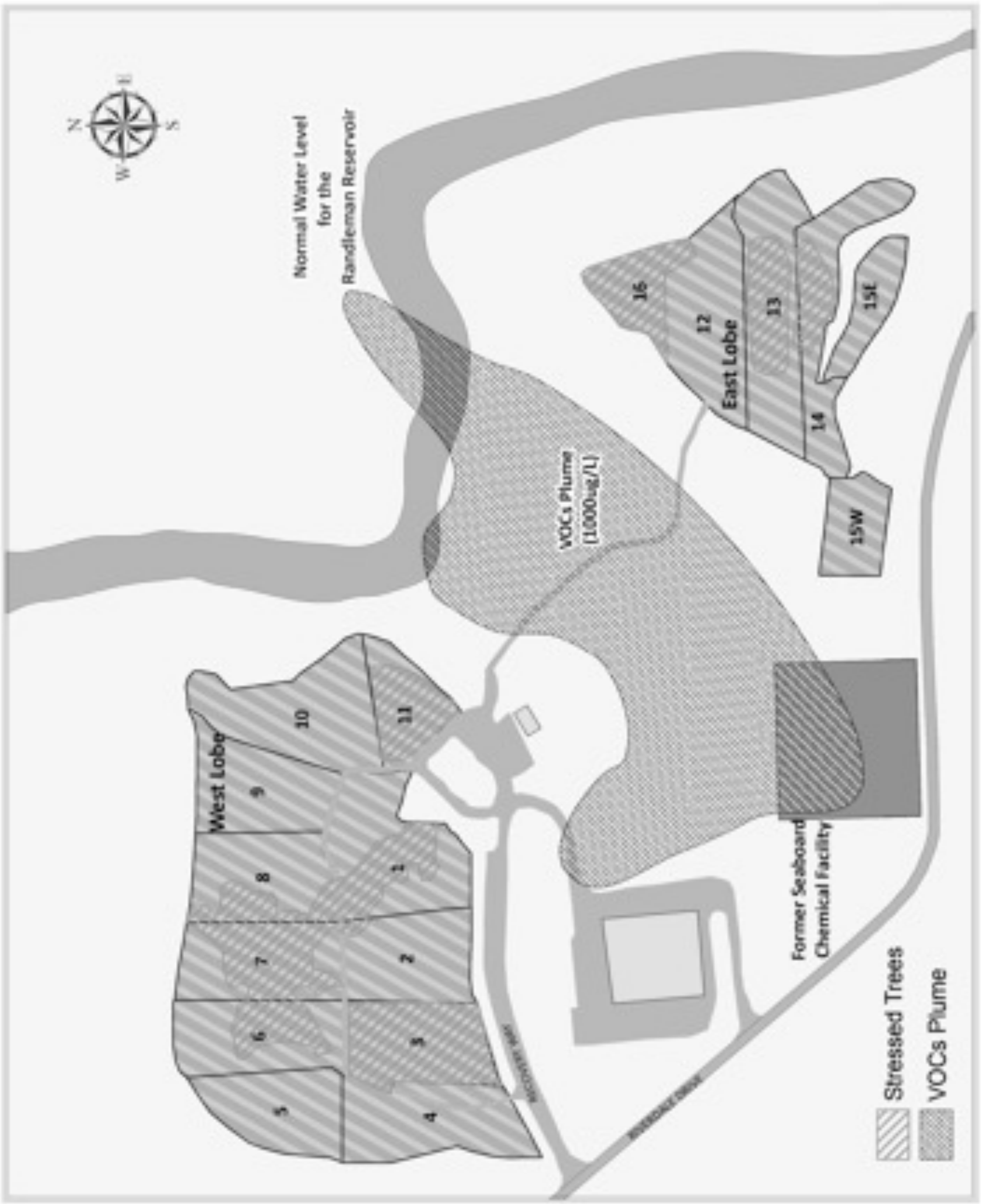


Figure 5 - Site Irrigation Zones

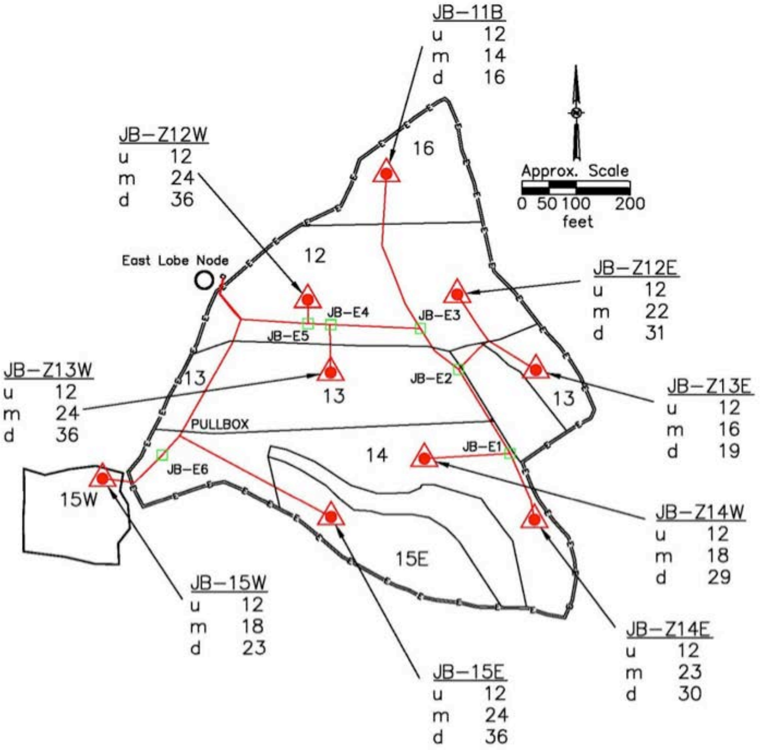


Figure 6 - East Lobe Probe Locations

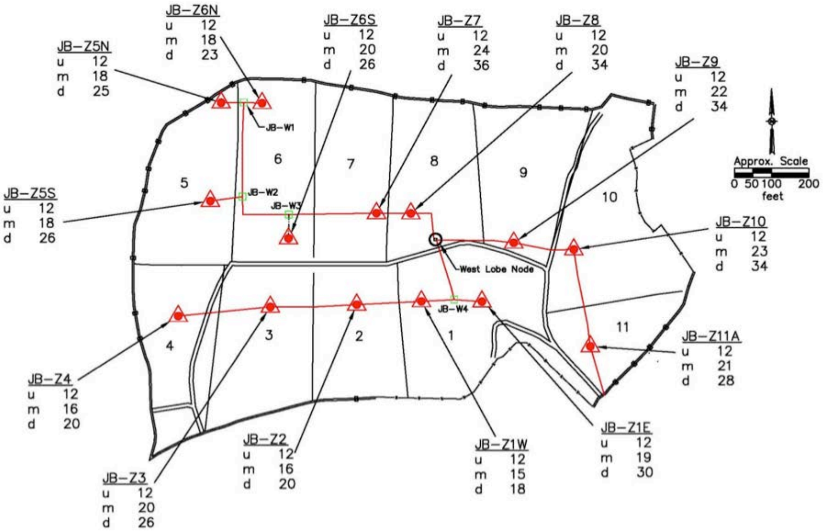


Figure 7 - West Lobe Probe Locations

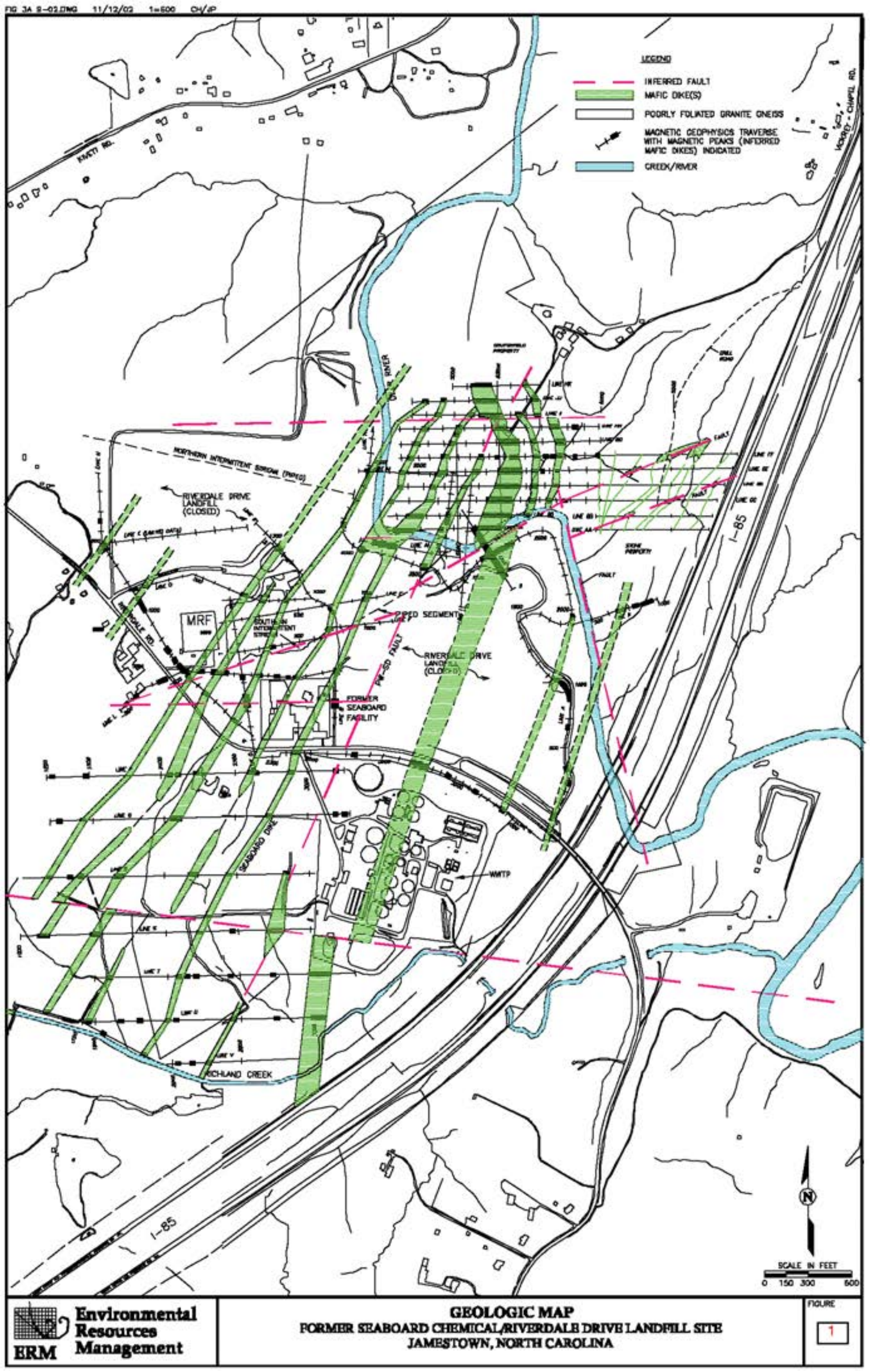


Figure 8 - Geologic Map

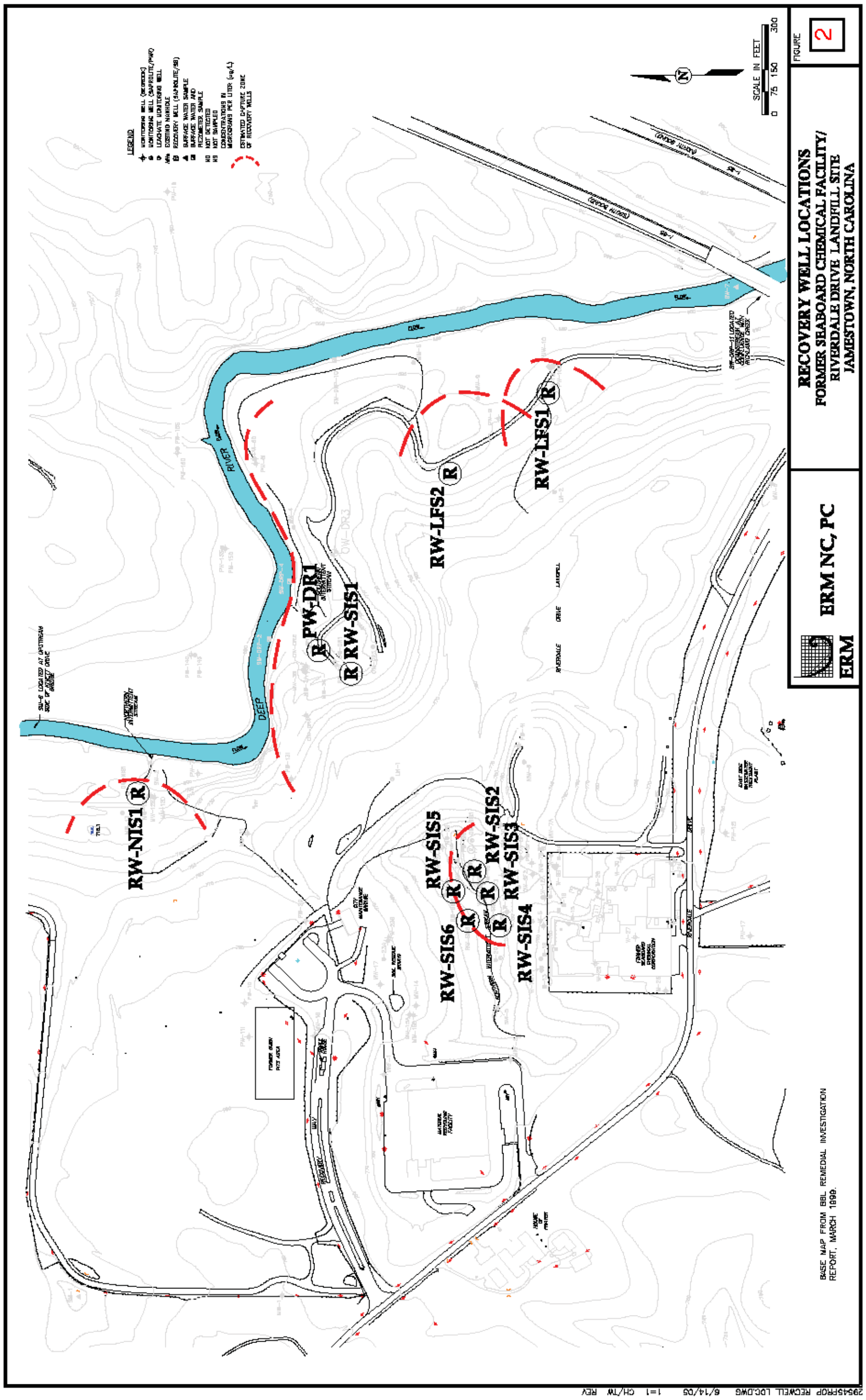


Figure 9 - Recovery Well Locations

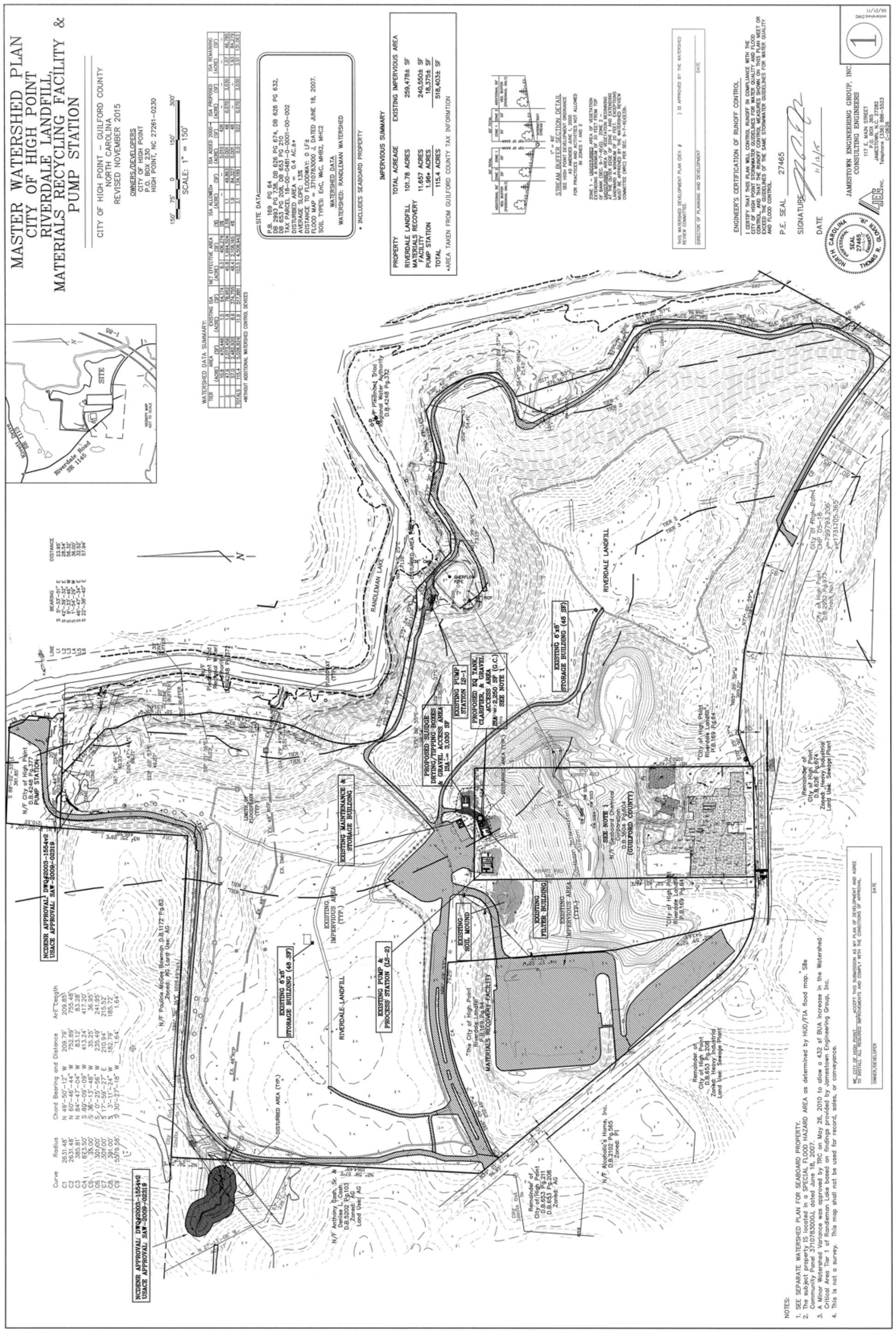


Figure 10 - Site Layout

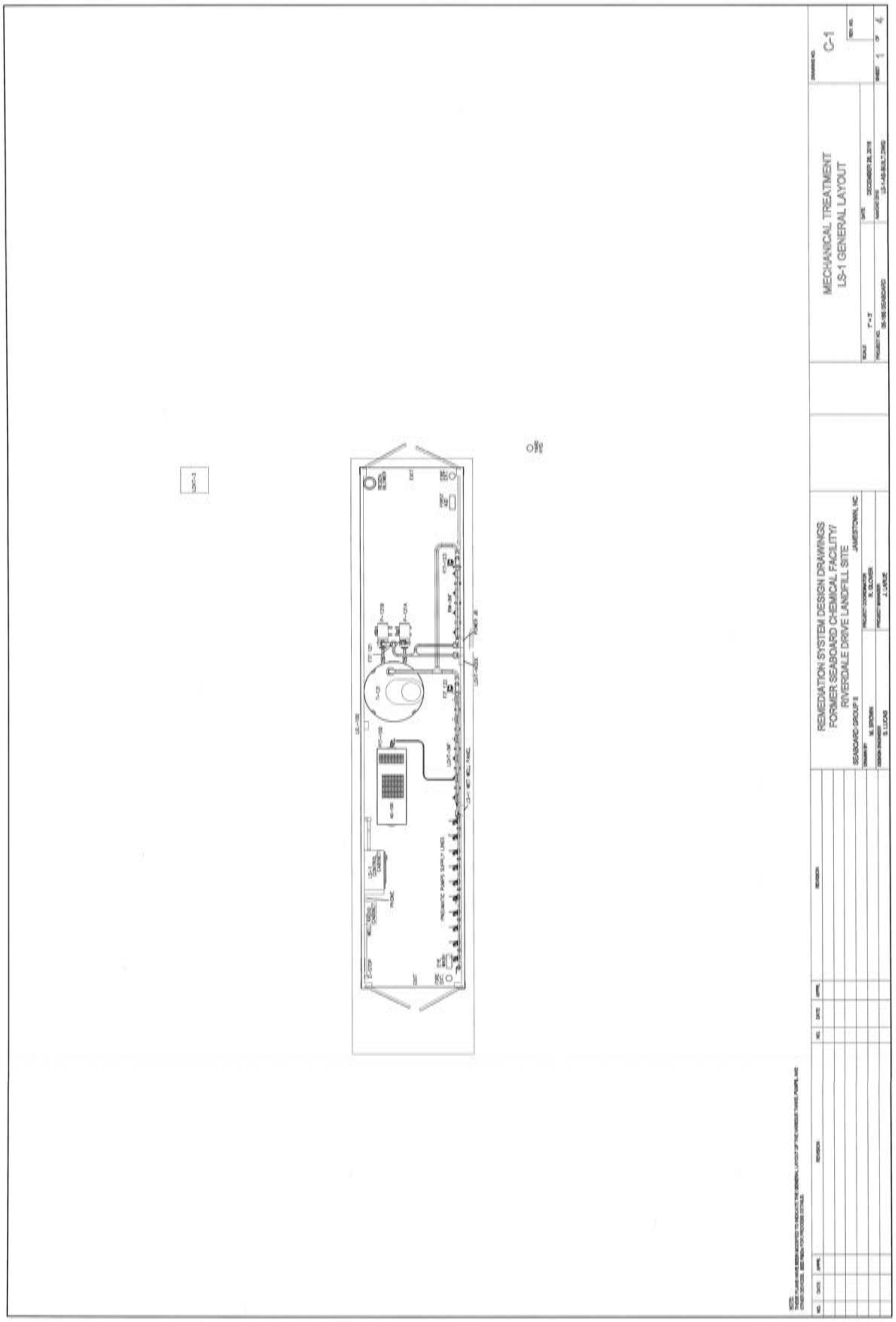


Figure 11 - LS-1 Layout

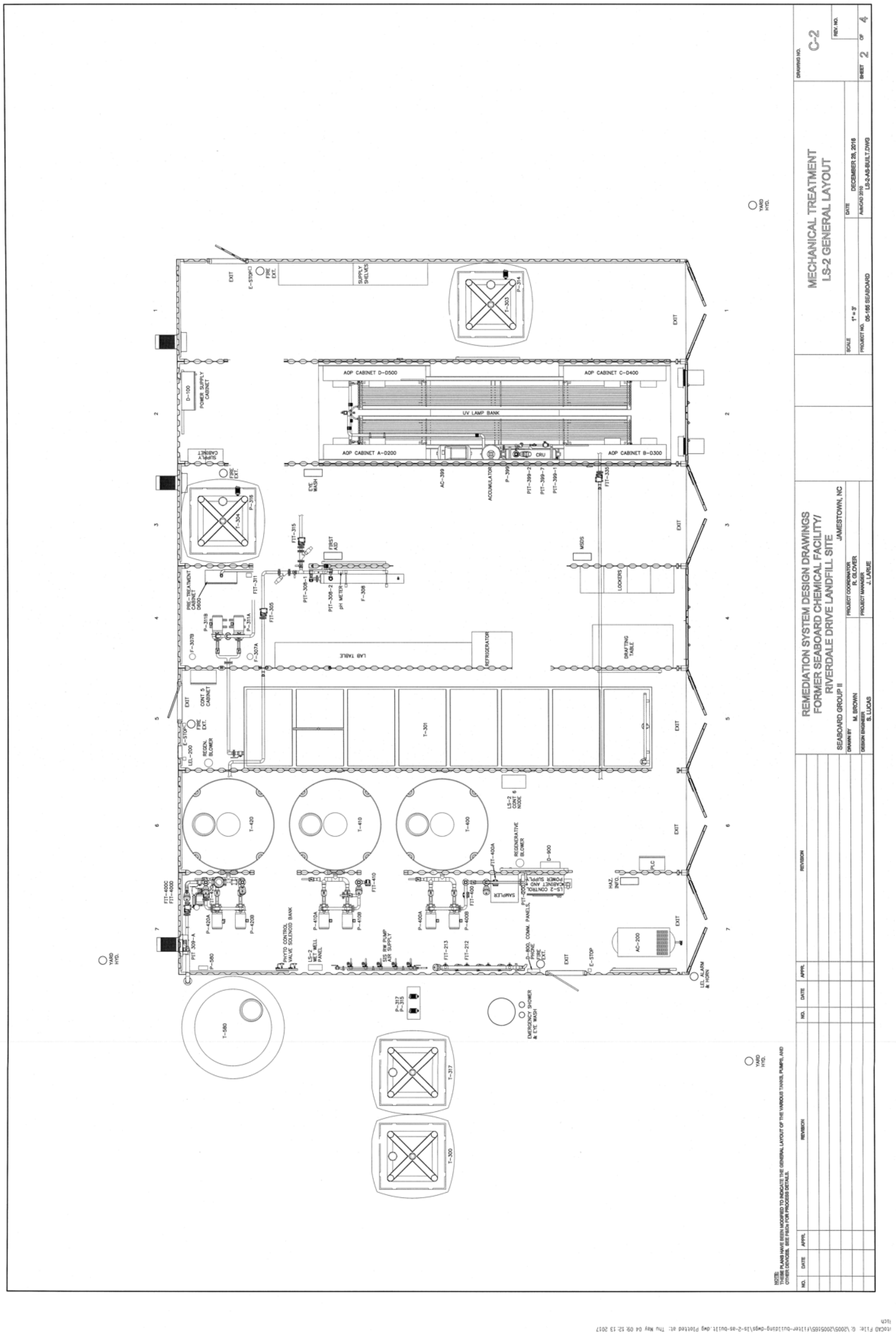


Figure 12 - LS-2 and Effluent Treatment System Layout

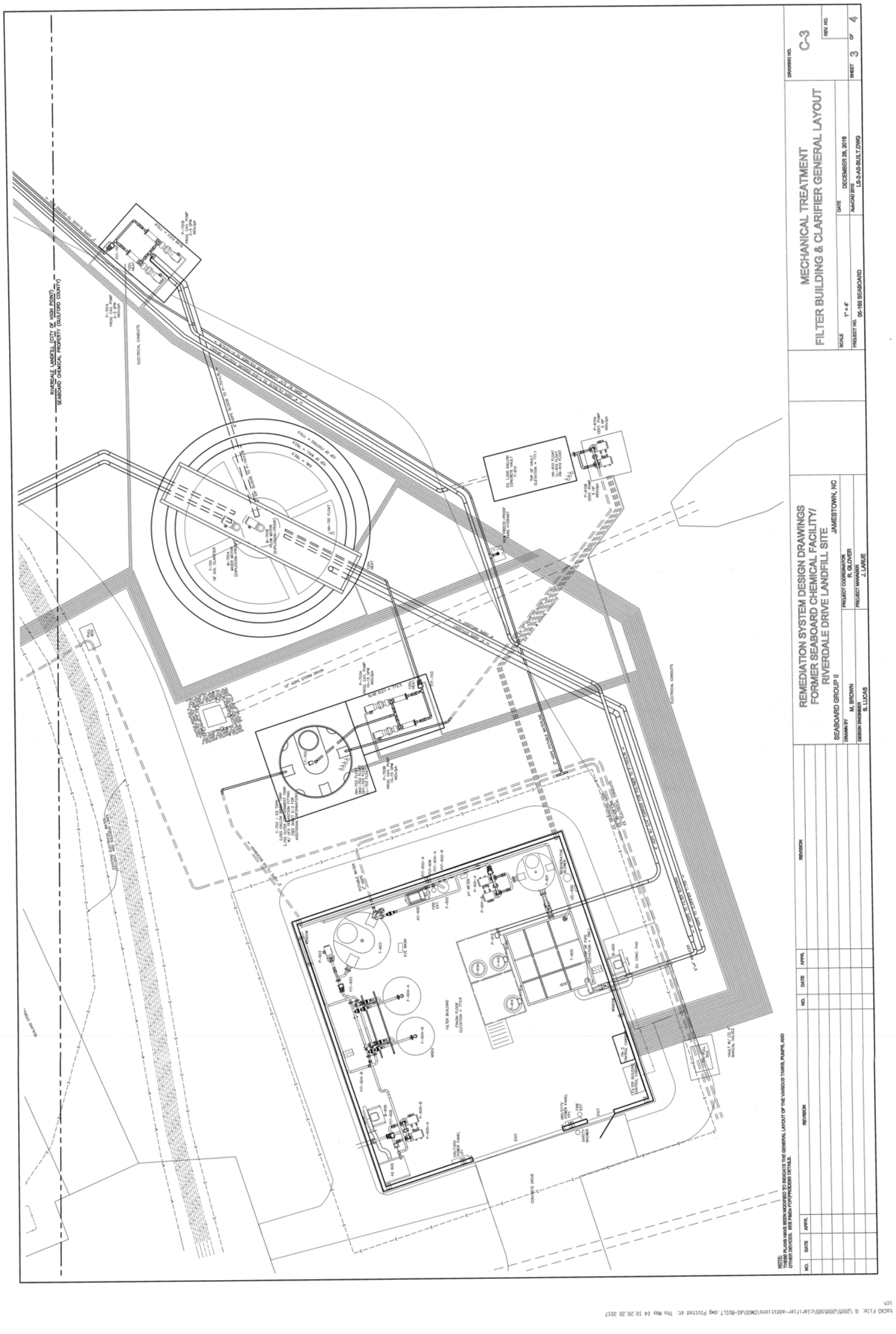


Figure 13 - Filter Building Layout

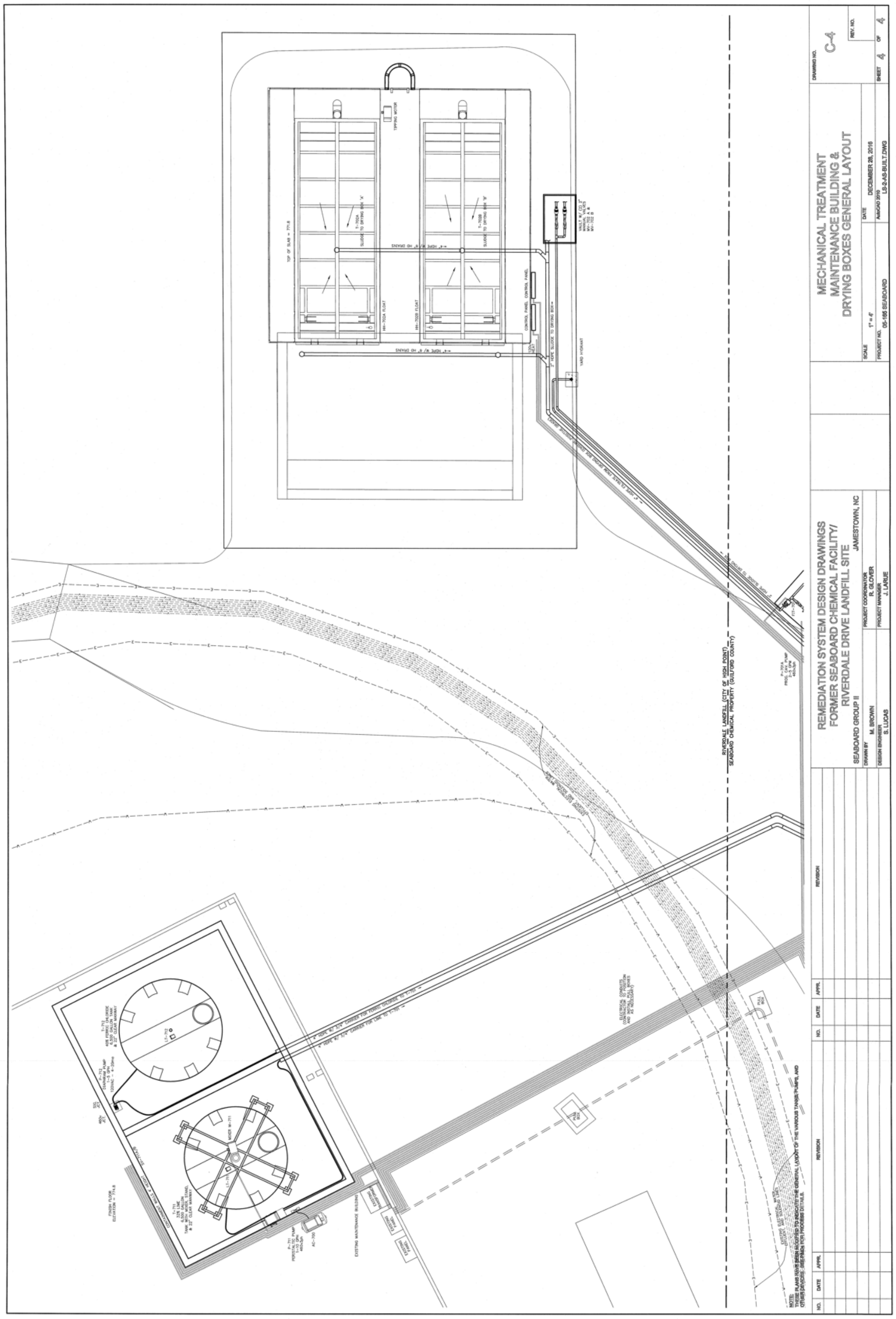
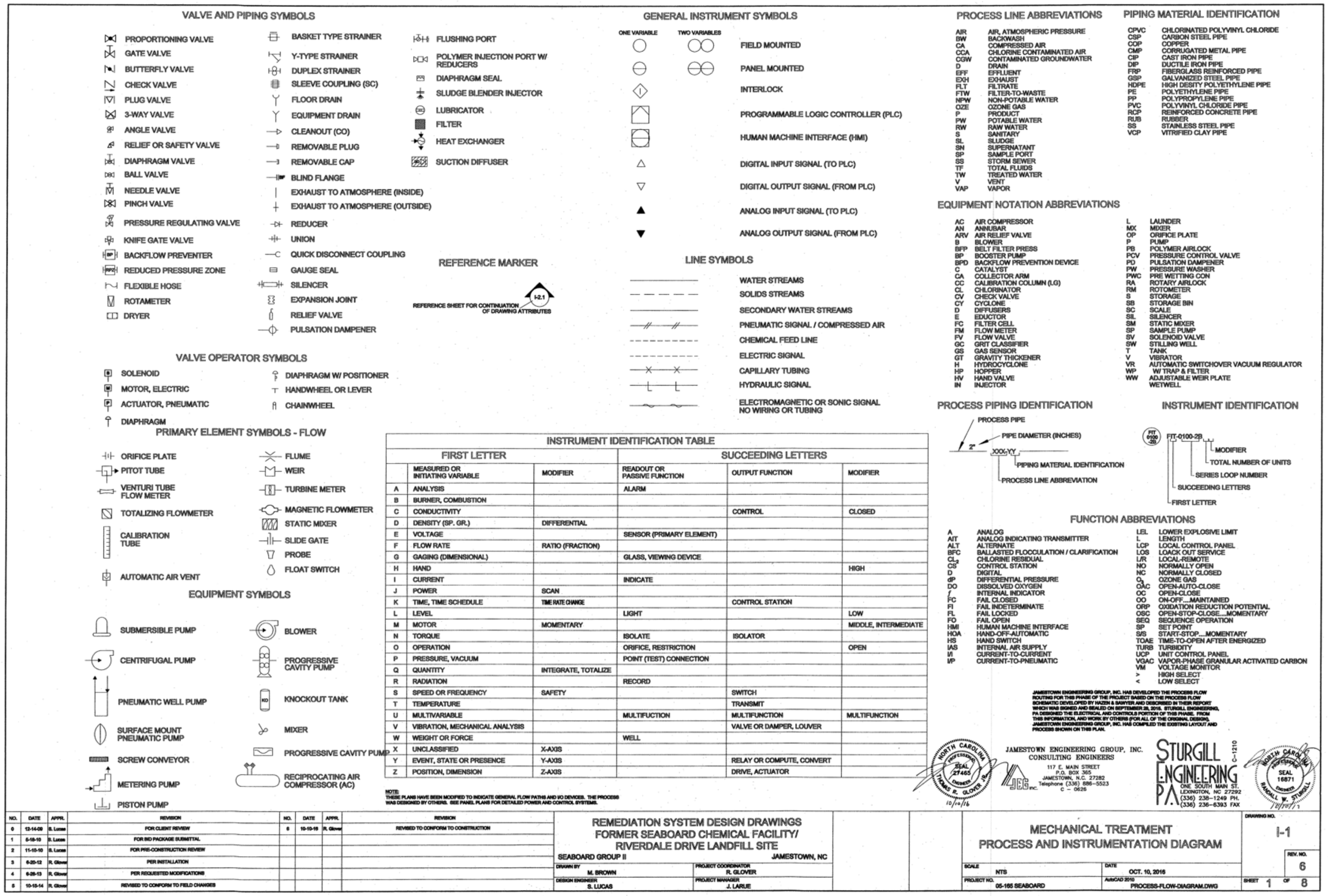


Figure 14 - Maintenance Building and Sludge Handling System

ATTACHMENT 2

PROCESS FLOW DIAGRAMS



INSTRUMENT IDENTIFICATION TABLE

	FIRST LETTER		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION				
C	CONDUCTIVITY			CONTROL	CLOSED
D	DENSITY (SP. GR.)	DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G	GAGING (DIMENSIONAL)		GLASS, VIEWING DEVICE		
H	HAND				HIGH
I	CURRENT		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME RATE CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	MOTOR	MOMENTARY			MIDDLE, INTERMEDIATE
N	TORQUE		ISOLATE	ISOLATOR	
O	OPERATION		ORIFICE, RESTRICTION		OPEN
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED OR FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECHANICAL ANALYSIS			VALVE OR DAMPER, LOUVER	
W	WEIGHT OR FORCE		WELL		
X	UNCLASSIFIED	X-AXIS			
Y	EVENT, STATE OR PRESENCE	Y-AXIS		RELAY OR COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z-AXIS		DRIVE, ACTUATOR	

NOTE:
THESE PLANS HAVE BEEN MODIFIED TO INDICATE GENERAL FLOW PATHS AND I/O DEVICES. THE PROCESS WAS DESIGNED BY OTHERS. SEE PANEL PLANS FOR DETAILED POWER AND CONTROL SYSTEMS.

PROCESS LINE ABBREVIATIONS

AIR	AIR, ATMOSPHERIC PRESSURE
BW	BACKWASH
CA	COMPRESSED AIR
CCA	CHLORINE CONTAMINATED AIR
CGW	CONTAMINATED GROUNDWATER
D	DRAIN
EFF	EFFLUENT
EXH	EXHAUST
FLT	FILTRATE
FTW	FILTER-TO-WASTE
NPW	NON-POTABLE WATER
OZE	OZONE GAS
P	PRODUCT
PW	POTABLE WATER
RW	RAW WATER
S	SANITARY
SL	SLUDGE
SN	SUPERNATANT
SP	SAMPLE PORT
SS	STORM SEWER
TF	TOTAL FLUIDS
TW	TREATED WATER
V	VENT
VAP	VAPOR

PIPING MATERIAL IDENTIFICATION

CPVC	CHLORINATED POLYVINYL CHLORIDE
CSP	CARBON STEEL PIPE
COP	COPPER
CMP	CORRUGATED METAL PIPE
CIP	CAST IRON PIPE
DIP	DUCTILE IRON PIPE
FRP	FIBERGLASS REINFORCED PIPE
GSP	GALVANIZED STEEL PIPE
HDPE	HIGH DESITY POLYETHYLENE PIPE
PE	POLYETHYLENE PIPE
PP	POLYPROPYLENE PIPE
PVC	POLYVINYL CHLORIDE PIPE
RCP	REINFORCED CONCRETE PIPE
RUB	RUBBER
SS	STAINLESS STEEL PIPE
VCP	VITRIFIED CLAY PIPE

EQUIPMENT NOTATION ABBREVIATIONS

AC	AIR COMPRESSOR	L	LAUNDER
AN	ANNUBAR	MX	MIXER
ARV	AIR RELIEF VALVE	OP	ORIFICE PLATE
B	BLOWER	P	PUMP
BFP	BELT FILTER PRESS	PB	POLYMER AIRLOCK
BP	BOOSTER PUMP	PCV	PRESSURE CONTROL VALVE
BPD	BACKFLOW PREVENTION DEVICE	PD	PULSATION DAMPENER
C	CATALYST	PW	PRESSURE WASHER
CA	COLLECTOR ARM	PWC	PRE WETTING CON
CC	CALIBRATION COLUMN (LG)	RA	ROTARY AIRLOCK
CL	CHLORINATOR	RM	ROTOMETER
CV	CHECK VALVE	S	STORAGE
CY	CYCLONE	SB	STORAGE BIN
D	DIFFUSERS	SC	SCALE
E	EDUCTOR	SIL	SILENCER
FC	FILTER CELL	SM	STATIC MIXER
FM	FLOW METER	SP	SAMPLE PUMP
FV	FLOW VALVE	SV	SOLENOID VALVE
GC	GRIT CLASSIFIER	SW	STILLING WELL
GS	GAS SENSOR	T	TANK
GT	GRAVITY THICKENER	V	VIBRATOR
H	HYDROCYCLONE	VR	AUTOMATIC SWITCHOVER VACUUM REGULATOR W/ TRAP & FILTER
HP	HOPPER	WP	ADJUSTABLE WEIR PLATE
HV	HAND VALVE	WW	WETWELL
IN	INJECTOR		

FUNCTION ABBREVIATIONS

A	ANALOG	LEL	LOWER EXPLOSIVE LIMIT
AIT	ANALOG INDICATING TRANSMITTER	L	LENGTH
ALT	ALTERNATE	LCP	LOCAL CONTROL PANEL
BFC	BALLASTED FLOCCULATION / CLARIFICATION	LOS	LOACK OUT SERVICE
CL_2	CHLORINE RESIDUAL	L/R	LOCAL-REMOTE
CS	CONTROL STATION	NO	NORMALLY OPEN
D	DIGITAL	NC	NORMALLY CLOSED
dP	DIFFERENTIAL PRESSURE	O_3	OZONE GAS
DO	DISSOLVED OXYGEN	OAC	OPEN-AUTO-CLOSE
f	INTERNAL INDICATOR	OC	OPEN-CLOSE
FC	FAIL CLOSED	OO	ON-OFF....MAINTAINED
FI	FAIL INDETERMINATE	ORP	OXIDATION REDUCTION POTENTIAL
FL	FAIL LOCKED	OSC	OPEN-STOP-CLOSE....MOMENTARY
FO	FAIL OPEN	SEQ	SEQUENCE OPERATION
HMI	HUMAN MACHINE INTERFACE	SP	SET POINT
HOA	HAND-OFF-AUTOMATIC	S/S	START-STOP....MOMENTARY
HS	HAND SWITCH	TOAE	TIME-TO-OPEN AFTER ENERGIZED
IAS	INTERNAL AIR SUPPLY	TURB	TURBIDITY
I/I	CURRENT-TO-CURRENT	UCP	UNIT CONTROL PANEL
I/P	CURRENT-TO-PNEUMATIC	VGAC	VAPOR-PHASE GRANULAR ACTIVATED CARBON
		VM	VOLTAGE MONITOR
		>	HIGH SELECT
		<	LOW SELECT

JAMESTOWN ENGINEERING GROUP, INC. HAS DEVELOPED THE PROCESS FLOW ROUTING FOR THIS PHASE OF THE PROJECT BASED ON THE PROCESS FLOW SCHEMATIC DEVELOPED BY HAZEN & SAWYER AND DESCRIBED IN THEIR REPORT WHICH WAS SIGNED AND SEALED ON SEPTEMBER 28, 2016. STURGILL ENGINEERING, PA DESIGNED THE ELECTRICAL AND CONTROLS PORTION OF THIS PHASE. FROM THIS INFORMATION, AND WORK BY OTHERS (FOR ALL OF THE ORIGINAL DESIGN), JAMESTOWN ENGINEERING GROUP, INC. HAS COMPILED THE EXISTING LAYOUT AND PROCESS SHOWN ON THIS PLAN.

SEAL 27465
THOMAS R. GLOVER JR.
10/10/16

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SEAL 16871
RANDALL W. STURGILL
10/10/16

NO.	DATE	APPR.	REVISION	NO.	DATE	APPR.	REVISION
0	12-14-09	S. Lucas	FOR CLIENT REVIEW	6	10-10-16	R. Glover	REVISED TO CONFORM TO CONSTRUCTION
1	5-18-10	S. Lucas	FOR BID PACKAGE SUBMITTAL				
2	11-10-10	S. Lucas	FOR PRE-CONSTRUCTION REVIEW				
3	6-20-12	R. Glover	PER INSTALLATION				
4	6-28-13	R. Glover	PER REQUESTED MODIFICATIONS				
5	10-15-14	R. Glover	REVISED TO CONFORM TO FIELD CHANGES				

REMEDIATION SYSTEM DESIGN DRAWINGS
FORMER SEABOARD CHEMICAL FACILITY/
RIVERDALE DRIVE LANDFILL SITE
SEABOARD GROUP II JAMESTOWN, NC
DRAWN BY M. BROWN
PROJECT COORDINATOR R. GLOVER
DESIGN ENGINEER S. LUCAS
PROJECT MANAGER J. LARUE

MECHANICAL TREATMENT
PROCESS AND INSTRUMENTATION DIAGRAM
SCALE NTS
DATE OCT. 10, 2016
PROJECT NO. 05-165 SEABOARD
AutoCAD 2010 PROCESS-FLOW-DIAGRAM.DWG
DRAWING NO. I-1
REV. NO. 6
SHEET 1 OF 8

itoCAD File: G:\2005\2005165\PIDs\process-flow-diagram\process-flow-diagram-10-10-16.dwg Plotted at: Tue Oct 11 13:37:03 2016
lich

Figure 15 - Process Flow Diagram Information 1

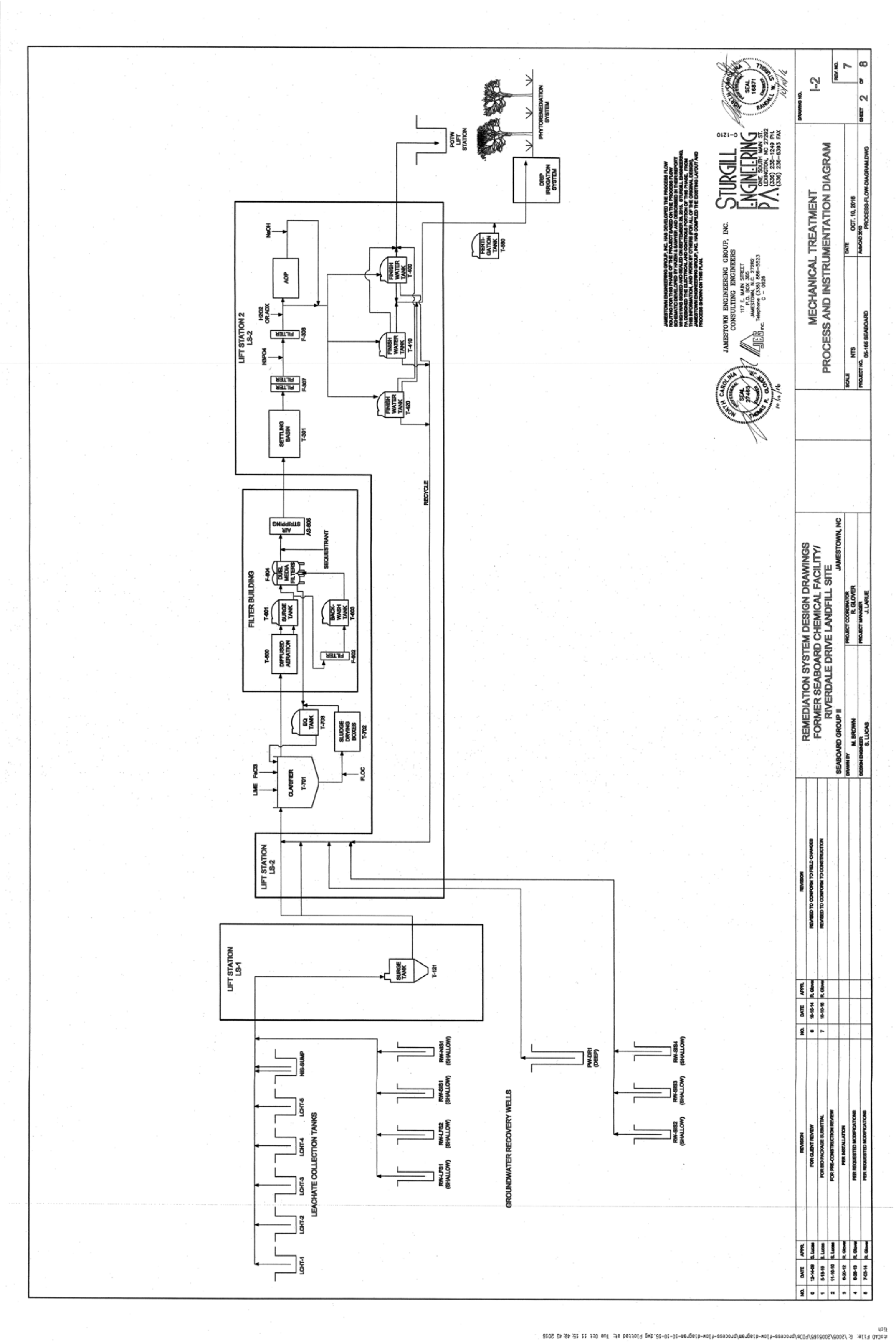

Figure 16 - Overall Process Flow 2

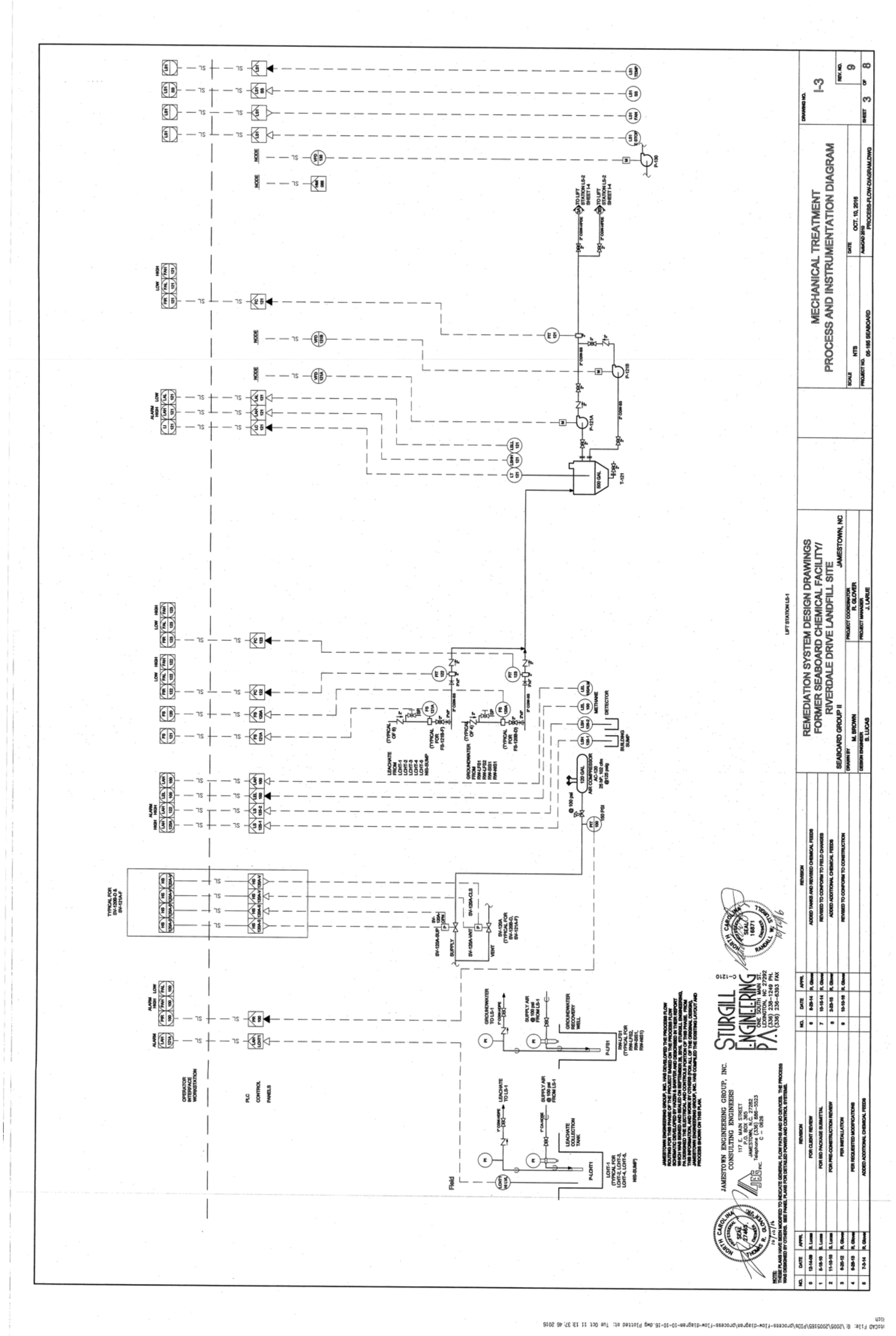

Figure 17 – Physical Treatment System Flow Diagram-3

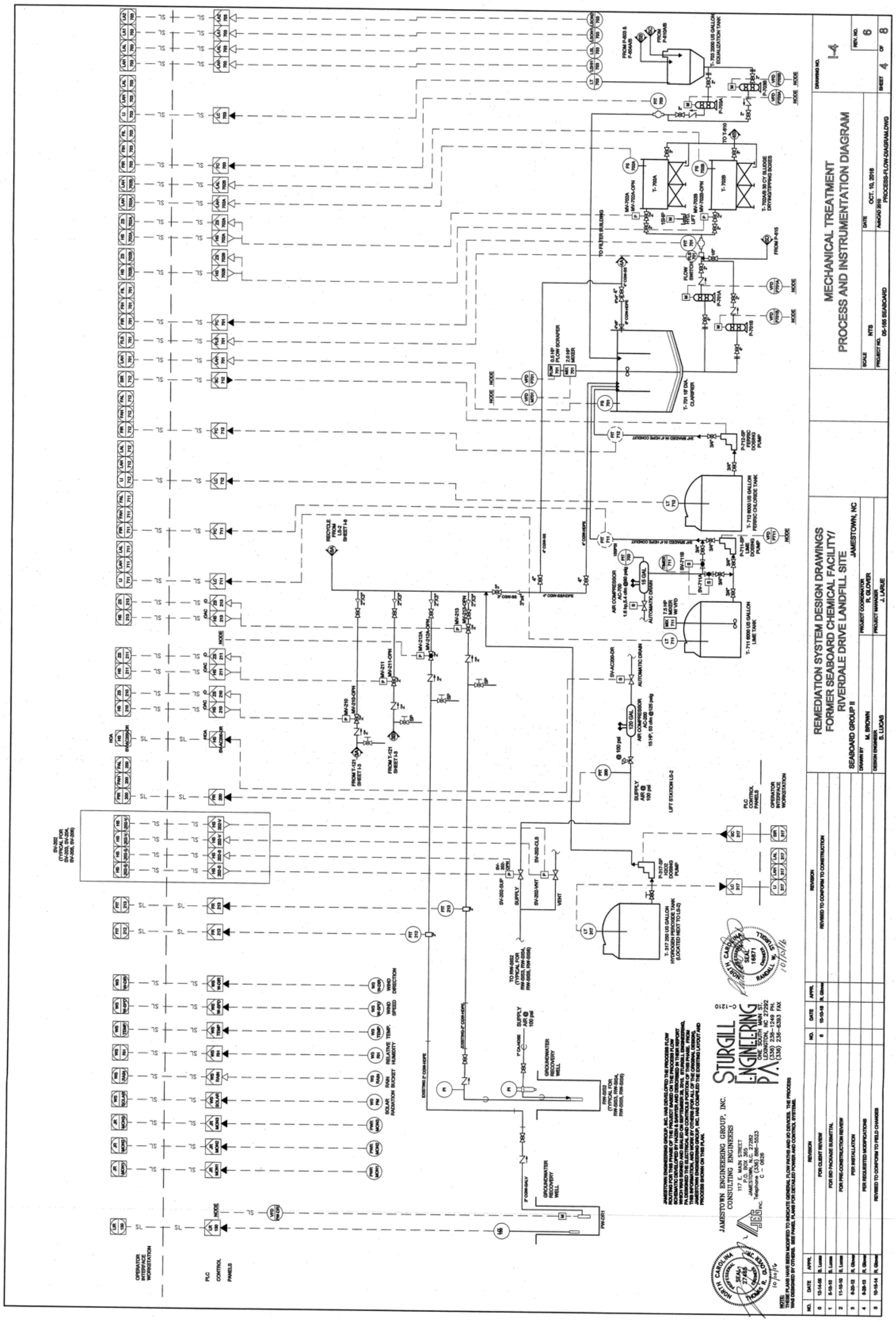

Figure 18 - Physical Treatment System Flow Diagram-4

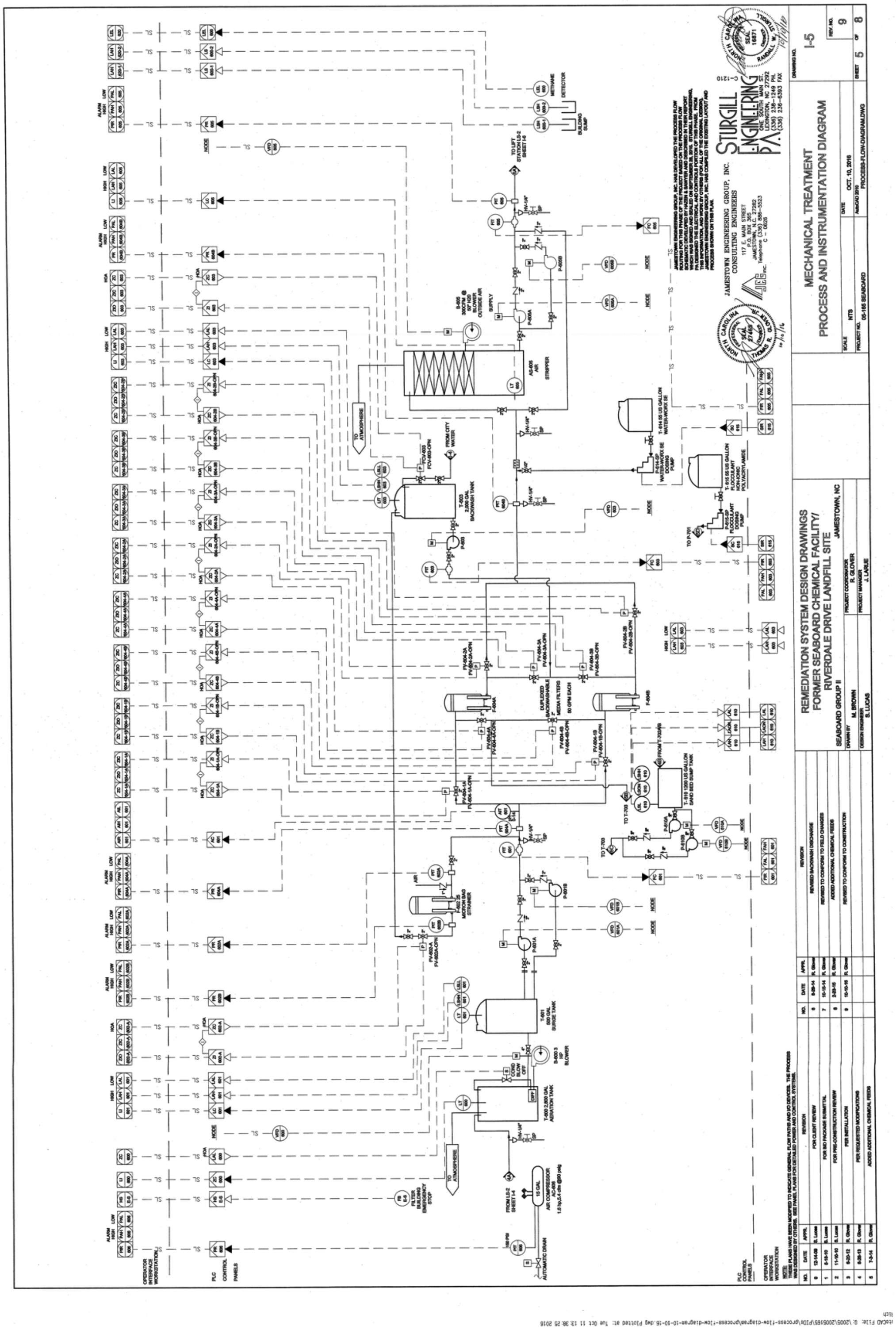

Figure 19 - Physical Treatment System Flow Diagram-5

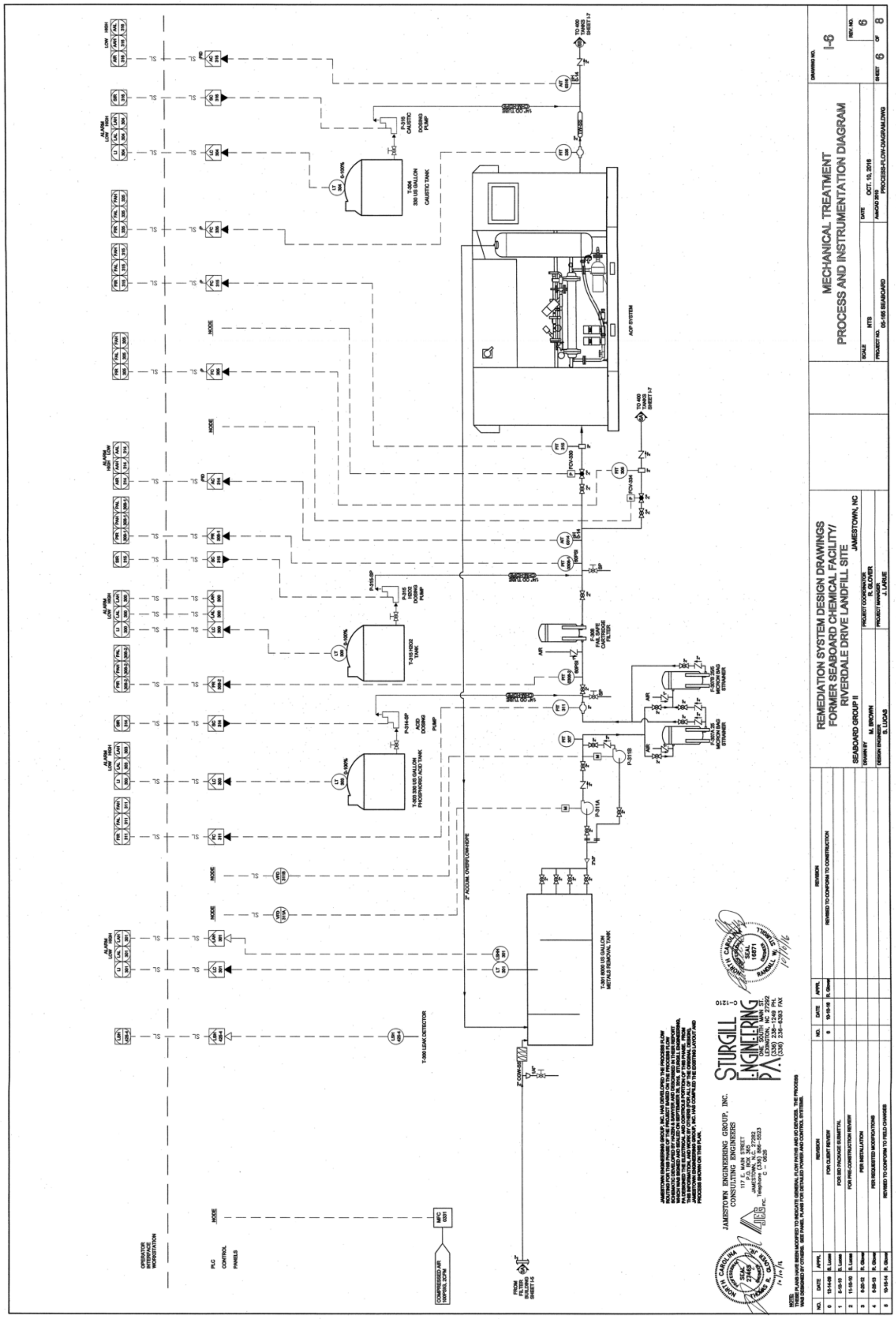

Figure 20 - Physical Treatment System Flow Diagram-6

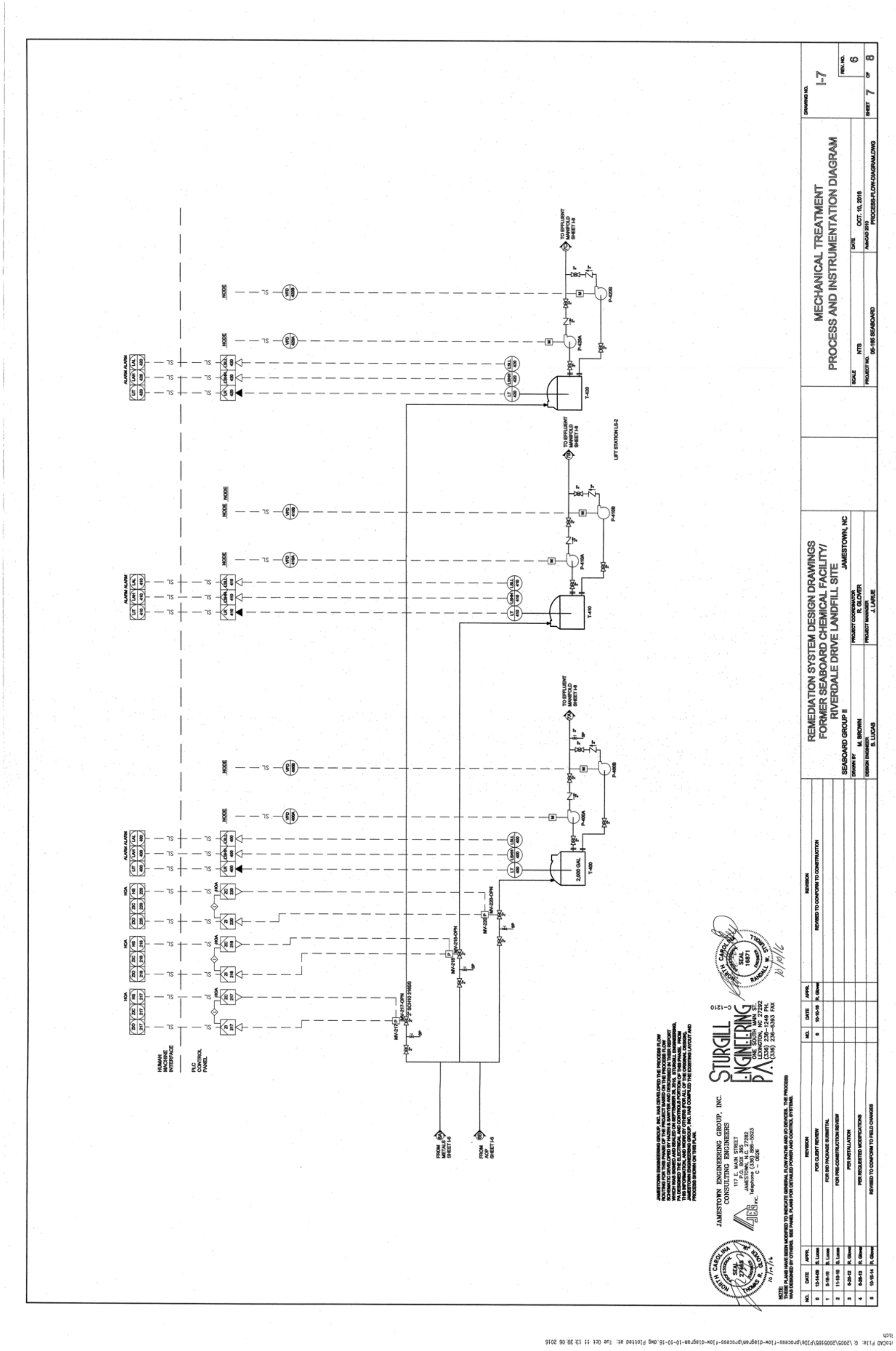

Figure 21 - Physical Treatment System Flow Diagram-7

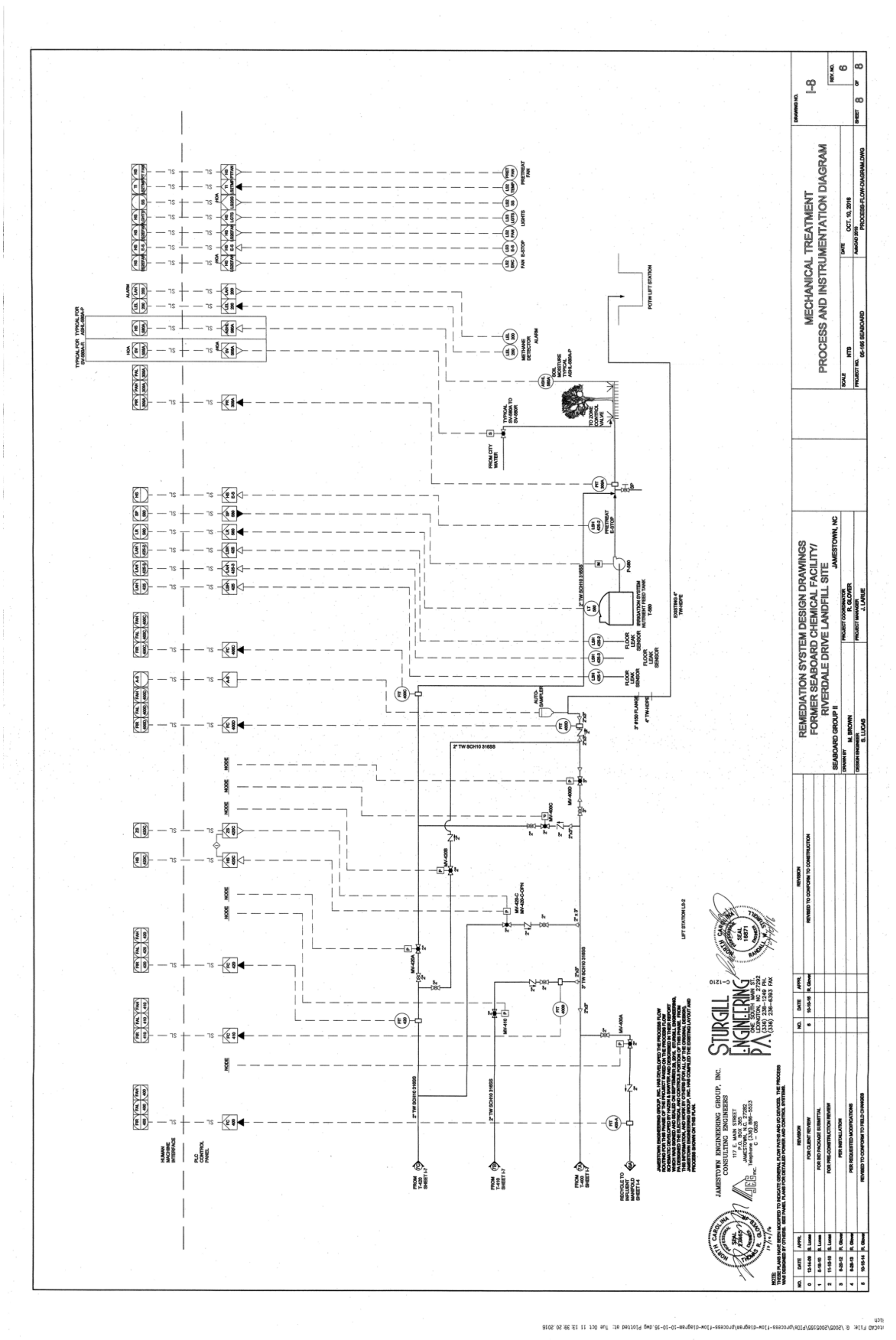

Figure 22 - Physical Treatment System Flow Diagram-8

ATTACHMENT 3

LIST OF CONTAMINANTS OF CONCERN

CONTAMINANTS OF CONCERN									
			Detected		Exposure Limit in PPM				
Contaminant	ISCS Number	CAS Number	G.W	LCH	REL	PEL	TWA	RTECS	Other
Volatile Organic Compounds:									
1,1,1,2-Tetrachloroethane	1486	630-20-6	X	X	*	*	*	KI845000	See NIOSH Appendix C
1,1,1-Trichloroethane	0079	71-55-6	X	X	350	350	*	KJ29750	See NIOSH Appendix C
1,1,2-Trichloroethane	0080	79-00-5	X	X	10	10	*	KJ31500	See NIOSH Appendix C
1,1-Dichloroethane	0249	75-34-1	X	X	100	100	*	KI017500	See NIOSH Appendix C
1,1-Dichlororethene	0083	75-35-4	X	X	*	*	*	KV92750	See NIOSH Appendix A
1,2,3-Trichloropropane	0683	96-18-4	X	X	10	50	50	TZ92750	See NIOSH Appendix A
1,2-Dibromoethane	0045	106-93-4	X	X	0.045	20	20	KH92750	See NIOSH Appendix A
1,2-Dichloroethane	0249	75-34-3	X	X	100	100	100	KI017500	See NIOSH Appendix C
1,2-Dichloropropane	0441	78-87-5	X	X	*	75	75	TX96250	See NIOSH Appendix A
1,4-Dioxane	0041	123-91-1	X	X	1	100	100	JG82250	See NIOSH Appendix A
2-Butanone	0179	78-93-3	X	X	200	200	200	EL64750	
4-Methyl-2-Pentanone	0511	108-10-1	X	X	50	100	100	SA92750	
Acetone	0087	67-64-1	X	X	250	1000	1000	AL31500	
Benzene	0015	71-43-2	X	X	0.1	1.0	1.0	CY14000	See NIOSH Appendix A, E, and F
Bromomethane	1378	74-96-4	X	X	*	200	200	KH64750	See NIOSH Appendix D
Carbon Tetrachloride	0024	56-23-5	X	X	2.0	10	10	FG49000	See NIOSH Appendix A

CONTAMINANTS OF CONCERN									
			Detected		Exposure Limit in PPM				
Contaminant	ISCS Number	CAS Number	G.W	LCH	REL	PEL	TWA	RTECS	Other
Chlorobenzene	0642	108-90-7	X	X	*	75	75	CZ01750	See NIOSH Appendix D
Chloroethane	0132	75-00-3	X	X	*	1000	1000	KH75270	See NIOSH Appendix C
Chloroform	0027	67-66-3	X	X	2.0	50	*	FS91000	See NIOSH Appendix A
Chloromethane	0419	740-87-3	X	X	*	100	100	PA63000	See NIOSH Appendix A
Cis-1,2-Dichloroethene	0436	540-59-0	X	X	200	200	200	KV93600	See ISCS Listing
Cis-1,4-Dichloro-2-Butene	*	1476-115	X	X	*	*	*	EM4900000	Not Listed and no limits established
Ethylbenzene	0268	100-41-4	X	X	100	100	100	DA07000	
Methylene Chloride	0058	75-09-2	X	X	*	25	25	PA80500	See NIOSH Appendix A
Tetrachloroethene	0076	127-18-4	X	X	*	100	100	KX38500	See NIOSH Appendix A
Toluene	0078	108-88-3	X	X	100	200	100	XS52500	
Trans-1,2-Dichloroethene	0436	156-60-5	X	X	200	200	200	KV9400000	Not Listed, Limits from Other Sources
Trichloroethene	0081	79-01-6	X	X	*	100	100	KX45500	See NIOSH Appendix A, C
Vinyl Chloride	0082	75-01-4	X	X	*	1.0	1.0	KU96250	See NIOSH Appendix A
Xylenes (Total)	0084 *	97-47-6	X	X	100	100	100	ZE24500	Based on Ortho, See Meta (0085 and Para 0086)
Semi-Volatile Organic Compounds:									
4-Methylphenol	0031	106-44-5	X	X	2.3	5.0	5.0	GO647500	
Acenapthene	1674	83-32-9	X	X	*	10	10	AB1000000	EPA Priority Chemical, TWA Based on PAH
Acetophenone	*	98-86-2	X	X	*	*	10	AM525000	Not Listed and no limits established, ACGIH TWA Only

CONTAMINANTS OF CONCERN									
			Detected		Exposure Limit in PPM				
Contaminant	ISCS Number	CAS Number	G.W	LCH	REL	PEL	TWA	RTECS	Other
Benzoic Acid	*	65-85-0	X	X	*	*	*	DG087500	Not Listed and no limits established
Bis(2-Ethylhexyl)Phthalate	0271	117-81-7	X	X	5.0	5.0	5.0	TI0350000	See NIOSH Appendix A, Units mg/m^3
Dibenzofuran	*	132-64-9	X	X	*	*	*	HP4430000	Not Listed and no limits established
N-Nitrosodimethylamine	0525	62-75-9	X	X	*	*	*	LU5950000	Regulated 29CFR1910.1016. See Appendix E
Naphthalene	0667	91-20-3	X	X	10	10	10	QJ0525000	Units mg/m3
Phenol	0070	108-95-2	X	X	5.0	5.0	5.0	SJ3325000	Units mg/m3
Pesticides:									
Alpha-BHC	0795	319-84-6	X	X	0.5	0.5	0.5	GV3500000	Based on Lindane Units mg/m^3
Beta-BHC	0796	319-85-7	X	X	0.5	0.5	0.5	GV4375000	Based on Lindane Units mg/m^3
Delta-BHC	*	319-86-8	X	X	0.5	0.5	0.5	GV4550000	Based on Lindane Units mg/m^3
Heptachlor	0743	76-44-8	X	X	0.5	0.5	0.5	PC0700000	Units mg/m^3
Heptachlor Epoxide	*	1024-573	X	X	0.5	0.5	0.5	PB9450000	Units mg/m^3
Metals:									
Antimony	0775	7440-36-0	X	X	0.5	0.5	0.5	CC4025000	Units mg/m^3
Barium	1052	7440-39-3	X	X	0.5	0.5	0.5	CQ837000	Units mg/m^3
Chromium	0020	7440-47-3	X	X	1.0	0.5	1.0	GB4200000	See NIOSH Appendix C, Units mg/m^3
Lead	0052	7440-92-1	X	X	0.05	0.05	0.05	OF7525000	See NIOSH Appendix C, Units mg/m^3
Nickel	0062	7440-02-0	X	X	0.015	1.0	1.0	QR595000	See NIOSH Appendix C, Units mg/m^3

CONTAMINANTS OF CONCERN									
			Detected		Exposure Limit in PPM				
Contaminant	ISCS Number	CAS Number	G.W	LCH	REL	PEL	TWA	RTECS	Other
Thallium	0077	7440-28-0	X	X	0.1	0.1	0.1	XG3425000	Units mg/m^3
Vanadium	0107	12604-58-9	X	X	1.0	1.0	1.0	LK2900000	Units mg/m^3
Zinc	0208	1314-13-2	X	X	5.0	5.0	5.0	ZH4180000	Units mg/m^3
Notes: NIOSH references from Pocket Guide to Chemical Hazards NIOSH Publication No. 2010-168c unless otherwise noted. * indicates to see remarks THIS INFORMATION IS PROVIDED FOR INFORMATION PURPOSES ONLY. THE CURRENT EXPOSURE LIMITS SHOULD BE CHECKED BEFORE USE.									

Table 13 - Contaminants of Concern

ATTACHMENT 4

PILOT STUDY ANALYTICAL DATA

				VOCs EPA Method 8260																														Dioxane		Metals		TOC
	Sample ID	Date	Time	1,1,1-Trichloroethane	1,1,2,2- Tetrachloroethane	1,1,2-Trichloroethane	1,1-Dichloroethane	1,1-Dichloroethene	1,2-Dichloroethane	2-Butanone (MEK)	4-methyl-2-pentanone	Acetone	Benzene	Bromodichloromethane	Bromoform	Bromomethane (Methyl bromide)	Carbon Disulfide	Chlorobenzene	Chloroethane	Chloroform	Chloromethane (Methyl Chloride)	Cis-1,2-Dichloroethene	Dibromochloromethane	Ethylbenzene	Methylene Chloride	Napthalene	Tetrachloroethene	Toluene	Trans 1,2-Dichloroethene	Trichloroethene	Vinyl Acetate	Vinyl Chloride	Xylene	1,4-Dioxane	Total	Fe	Mn	
				ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L		ug/L	ug/L	ug/L	ug/L	mg/L	mg/L	
Day 1	SEA-PUR-1-IN	3/18/09	1600	729	ND	ND	1570	652	72.6	ND	ND	ND	72.7	ND	ND	ND	ND	2380	383	ND	ND	3070	ND	ND	43.9	ND	ND	163	ND	ND	ND	414	59.4	2100	11,709.6	5.9	8.3	21.7
	SEA-PUR-1-AS	3/18/09	1600	ND	ND	ND	ND	ND	ND	8.2	ND	10.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.8	ND	ND	ND	ND	ND	ND	ND	ND	--	22.3	0.05	0.045	--
	SEA-PUR-1-EFF	3/18/09	1600	ND	ND	ND	ND	ND	ND	13	ND	187	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.8	ND	ND	ND	ND	ND	ND	ND	ND	171	374.8	--	--	20.6
Day 2	SEA-PUR-2-IN	3/19/09	1100	796	ND	ND	1670	633	75.3	ND	ND	ND	75	ND	ND	ND	ND	2590	183	ND	ND	3190	ND	ND	47.1	ND	ND	173	ND	ND	ND	448	62.1	--	9,942.5	5.4	8	--
	SEA-PUR-2-AS	3/19/09	1100	ND	ND	ND	ND	ND	ND	ND	ND	7.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND	1470	1,479.1	0.05	0.013	--
	SEA-PUR-2-EFF	3/19/09	1100	ND	ND	ND	ND	ND	ND	6.8	ND	74	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.1	ND	ND	ND	ND	ND	ND	ND	ND	829	911.9	--	--	--
	SEA-PUR-2a-AS	3/19/09	1315	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	1840	1,840.0	--	--	--
	SEA-PUR-2a-EFF	3/19/09	1315	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--		--	--	963	963.0	--	--	--
	SEA-PUR-2b-IN	3/19/09	1600	935	ND	ND	1990	745	95.3	ND	ND	ND	88.1	ND	ND	ND	ND	3210	445	ND	ND	3880	ND	ND	44.9	ND	ND	188	ND	ND	ND	508	75.1	--	12,204.4	6.3	7.8	--
	SEA-PUR-2b-AS	3/19/09	1600	ND	ND	ND	ND	ND	ND	ND	ND	20.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND	2130	2,152.4	0.05	0.01	--
	SEA-PUR-2b-EFF	3/19/09	1600	ND	ND	ND	ND	ND	ND	6.4	ND	46.8	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2	ND	ND	2.9	ND	ND	ND	ND	ND	1650	1,708.1	--	--	--
Day 3	SEA-PUR-3-AS	4/7/09	1430	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1300	1,300.0	--	--	--
	SEA-PUR-3-EFF	4/7/09	1425	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	44.5	44.5	--	--	--
	SEA-PUR-3a-AS	4/7/09	1530	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1400	1,400.0	--	--	--
	SEA-PUR-3a-EFF	4/7/09	1530	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	98.3	98.3	--	--	--
	SEA-PUR-3b-IN	4/7/09	1630	826	ND	5.2	1680	676	83.7	ND	ND	545	72.1	ND	ND	ND	ND	2340	423	3	17.2	3060	ND	19.7	11.2	5.2	21.9	197	19.7	6.6	ND	478	91.6	--	10,582.1	5.3	8.1	--
	SEA-PUR-3b-AS	4/7/09	1630	ND	ND	ND	2	ND	ND	6	ND	28	ND	ND	68.7	ND	ND	6.5	ND	ND	ND	5.5	2.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1470	1,589.6	0.025	ND	--
	SEA-PUR-3b-EFF	4/7/09	1630	ND	ND	ND	1.6	ND	ND	ND	ND	167	ND	ND	ND	2.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	229	400.2	--	--	--
Day 4	SEA-PUR-4-IN	4/8/09	1330	901	ND	ND	1850	822	95.4	ND	ND	1940	92.9	ND	ND	ND	ND	2820	508	ND	ND	3770	ND	17.6	41.9	8.6	18.9	187	20.9	7.9	18.2	583	82	--	13,785.3	5.5	7.7	--
	SEA-PUR-4-AS	4/8/09	1330	ND	ND	ND	ND	ND	ND	ND	ND	230	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.8	ND	ND	ND	ND	ND	ND	ND	ND	1830	2,063.8	ND	0.44	--
	SEA-PUR-4-EFF	4/8/09	1330	ND	ND	ND	ND	ND	ND	ND	ND	159	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.6	ND	ND	ND	ND	ND	ND	ND	ND	443	603.6	--	--	--
Day 5	SEA-PUR-5-AS	4/16/09	1000	3.7	2.1	ND	12.8	ND	1.6	ND	8.1	58.1	ND	6.1	19.8	ND	ND	22.5	1.9	45.4	4.3	16.4	13.7	ND	ND	ND	ND	ND	1.3	ND	ND	ND	ND	1350	1,567.8	--	--	--
	SEA-PUR-5-EFF	4/16/09	1000	3.2	ND	ND	11.5	ND	1.5	ND	ND	192	ND	2	11.4	3.7	ND	ND	1.7	36.7	3.1	ND	4.9	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	194	465.7	--	--	--
	SEA-PUR-5a-EFF	4/16/09	1130	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	308	308.0	--	--	--
	SEA-PUR-5b-EFF	4/16/09	1250	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	87.7	87.7	--	--	--
	SEA-PUR-5c-EFF	4/16/09	1445	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	522	522.0	--	--	--
	SEA-PUR-5d-IN	4/16/09	1700	878	ND	3	1880	722	77.7	219	29.9	102	81.6	ND	11.2	ND	ND	1780	296	2.8	ND	3790	3.1	17.5	2540	ND	12.2	147	77.4	10.3	ND	383	75.2	2240	15,378.9	--	--	--
	SEA-PUR-5d-EFF	4/16/09	1700	7.4	ND	ND	25.4	ND	2.8	45	ND	175	ND	ND	17.4	4.5	ND	1.9	2.1	31.8	2.7	2.6	1.9	ND	49.3	N	ND	ND	ND	ND	ND	ND	ND	250	619.8	--	--	--
Day 6	SEA-PUR-6-EFF	4/28/09	1115	ND	ND	ND	ND	ND	ND	15	ND	440	ND	ND	ND	53	ND	ND	ND	3.3	2.8	ND	ND	ND	1.9	ND	ND	ND	ND	ND	ND	ND	ND	<5.0	516.0	--	--	--
	SEA-PUR-6a-IN	4/28/09	1325	960	ND	ND	1700	1000	90	ND	ND	ND	90	ND	ND	ND	ND	2800	560	ND	ND	3600	ND	17	15	ND	19	170	13	ND	ND	560	73	1600	13,267.0	--	--	--
	SEA-PUR-6a-EFF	4/28/09	1315	3.3	ND	ND	9.5	ND	1.2	13	ND	380	ND	2	22	10	1.5	ND	ND	2.5	6.2	ND	11	ND	3.8	ND	ND	ND	ND	ND	ND	ND	ND	16	482.0	--	--	--
	SEA-PUR-6b-EFF	4/28/09	1545	4.1	ND	ND	12	ND	1.6	14	ND	340	ND	ND	29	8.8	ND	ND	ND	ND	ND	ND	ND	ND	1.8	ND	ND	ND	ND	ND	ND	ND	ND	85	496.3	--	--	--
	SEA-PUR-6c-EFF	4/28/09	1705	4.1	ND	ND	13	ND	2	11	ND	230	ND	ND	2.8	4.2	ND	ND	ND	ND	ND	ND	ND	ND	1.1	ND	ND	ND	ND	ND	ND	ND	ND	100	368.2	--	--	--
Day 7	SEA-PUR-7-IN	4/29/09	100	760	ND	ND	1600	680	87	260	ND	ND	87	ND	26	ND	ND	1800	340	ND	ND	3300	ND	18	1800	ND	14	150	100	17	ND	370	68	1900	13,377.0	--	--	--
	SEA-PUR-7-EFF	4/29/09	1015	4.5	ND	ND	13	ND	1.8	32	11	390	ND	1.9	22	17	2	ND	ND	1.9	8.1	ND	14	ND	24	ND	ND	ND	ND	ND	ND	ND	ND	58	601.2	--	--	--
	SEA-PUR-7a-EFF	4/29/09	1230	2.9	ND	ND	11	ND	1.7	25	ND	440	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	8.1	ND	ND	ND	ND	ND	ND	ND	ND	33	521.7	--	--	--
Day 8	SEA-PUR-8-IN	5/12/09	1630	1100	<20.0	<20.0	2220	1160	112	<100.0	<100.0	<100.0	104	<20.0	<20.0	<20.0	<20.0	3290	592	<20.0	29.7	4680	<20.0	<20.0	82.4	ND	<20.0	201	<20.0	<20.0	23.2	654	82.4	2750	17,080.7	6.5	7.4	--
	SEA-PUR-8-AS	5/12/09	1630	5.7	1.1	<1.0	21	<1.0	3.7	13.3	<5.0	79	<1.0	3.4	36.3	<1.0	<1.0	42.7	3.2	4.6	1.6	30.4	8.4	<1.0	3.1	ND	<1.0	<1.0	3	<1.0	<1.0	<1.0	<1.0	--	260.5	--	--	--
	SEA-PUR-8-EFF	5/12/09	1630	<5.0	<5.0	<5.0	12.1	<5.0	<5.0	<25.0	<25.0	399	<5.0	<5.0	75.6	15.7	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	16.2	ND	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<2.0	518.6	0.091	ND	--
Day 9	SEA-PUR-9-IN	5/13/09	1645	1220	<10.0	<10.0	2800	1300	130	<50.0	<50.0	90.1	121	<10.0	<10.0	<10.0	<10.0	4180	672	<10.0	33.1	5640	<10.0	22.8	15	ND	20.8	233	14.5	<10.0	25.8	733	108	3030	20,389.1	7.1	7.4	--
	SEA-PUR-9-AS	5/13/09	1645	8.3	<1.0	<1.0	29.6	5.3	3.8	<5.0	<5.0	7	1.4	<1.0	<1.0	<1.0	<1.0	70.1	4.1	<1.0	<1.0	71.3	<1.0	<1.0	<1.0	ND	<1.0	2.8	<1.0	<1.0	<1.0	2.3	<1.0	--	206.0	--	--	--
	SEA-PUR-9-EFF	5/13/09	1645	4.7	<1.0	<1.0	17.1	<1.0	2.2	8.9	<5.0	367	<1.0	<1.0	58.2	19.5	<1.0	<1.0	1.2	<1.0	1.6	<1.0	1.1	<1.0	<1.0	ND	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<2.0	481.5	0.12	ND	--

Bold Day - Includes landfill leachate in influent

Red Day - Operation included 3rd rack of lamps in PhotoCat

Results highlighted for easier reading
-- = Not sampled
SEA - Seaboard
PUR - Purifics
IN - Influent
AS - After air stripper
EFF - Effluent

ND- Non detect

Table 14 -Pilot Study Analytical Data

ATTACHMENT 5

TECHNICAL MEMORANDUMS

Technical Memorandum No. E-1

To:	Mr. Vance Jackson
From:	Mr. Jim LaRue
CC:	Randy C. Smith Gary Babb Chris Thompson
Date:	January 4, 2011
Subject:	Monitoring Well Abandonment

After your December 14, 2010 meeting with Mr. Tom Wilson and Mr. Gary Babb, Seaboard Group II and the City of High Point (collectively the Parties) have revised Technical Memorandum Number E-1 to reflect the abandonment of the monitoring wells mutually agreed to at that meeting. Attached is a list of monitoring wells that the Parties propose to abandon at the former Seaboard Chemical Corporation site and closed Riverdale Drive Landfill (collectively the Site). These wells have been selected based on our belief that they have no present or future purpose for monitoring any of the operable units at the Site, or in determining the effectiveness of the remedy. As a result, the Parties feel that they should be plugged and permanently abandoned in accordance with the procedure outlined in 15A NCAC 02C.0214.

The Parties propose to conduct the abandonment procedure on these wells at a convenient time during the next year. Prior to proceeding we ask that you review the list of proposed wells and provide written authorization to proceed. If you have any questions, or if we may be of any assistance, please feel free to contact Mr. Jim LaRue at 281-431-3571 or Mr. Tom Wilson at 704-541-8345.

Thank you,

James C. LaRue
Oversight Consultant

Attachments

TECHNICAL MEMORANDUM

TO: VANCE JACKSON, P.E.

FROM: SEABOARD GROUP II AND CITY OF HIGH POINT

SUBJECT: TECHNICAL MEMORANDUM NO. E-2

DATE:

Seaboard Group II and City of High Point (Parties) hereby request that the construction schedule contained in the Remedial Action Settlement Agreement (RASA) Scope of Work be modified. Due to circumstances beyond the Parties control, certain key components of the mechanical treatment system will not be available for delivery at the times originally anticipated.

Specifically, the order for the PhotoCat[1] advanced oxidation system was entered on April 28, 2010 with the issue of Purchase Order 1047 in the amount of $1,511,600 for the entire PhotoCat system including the advanced oxidation system, the organics separation system, the metals removal system and the air stripper system. That order had an original estimated construction schedule of 26 weeks.

That order was followed by Purchase Order 1047A in the amount of $497,000 for Lift Station Number 1. That lift station was to be incorporated into the PhotoCat system and the construction schedule was extended to 26 weeks from August 18, 2010. Originally the system was scheduled for delivery on October 26, 2010 and this modification extended the delivery until February 16, 2011. This would have been in ample time to finish the construction by the March 28, 2011 deadline.

Unfortunately, as construction has progressed the vendor has experienced several delays on equipment deliveries beginning with the shipping containers that house the systems. This was addressed by changing the specified type of container and delivery on schedule was still thought possible. However, recently there have been additional delays in equipment deliveries that have placed the anticipated delivery of the finished system to the site around April 15, 2011.

The Parties request that the construction schedule in the scope of work be extended to reflect completion of construction by July 31, 2011 to allow for the delays in component deliveries. This will allow for delivery and setup to be finished according to the revised schedule even if there are other minor delays affecting construction completion. This places the completion of the period to test and correct deficiencies in the system at 6 months after July 31, 2011 or January 31, 2012.

The Parties respectfully request that you approve this extension to the construction schedule, and modification to the Scope of Work in the RASA. If there are any questions,

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[1] PhotoCat is a registered trademark of Purifics ES, Inc. of London, Ontario, Canada.

or if we may be of any assistance on this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

James C. LaRue, Oversight Consultant
For the Parties

TECHNICAL MEMORANDUM

TO: VANCE JACKSON, P.E.
NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES.

FROM: SEABOARD GROUP II AND CITY OF HIGH POINT

SUBJECT: TECHNICAL MEMORANDUM NO. E-3

DATE:

Seaboard Group II and the City of High Point (hereinafter the Parties) submit this Technical Memorandum Number E-3 to revise the Scope of Work (SOW) for the remedy at the former Seaboard Chemical Corporation site and the City of High Point closed Riverdale Drive Landfill (collectively referred to as the Site).

The Parties submitted a conceptual remedial design to the North Carolina Department of Environment and Natural Resources (NCDENR) in a document entitled "Remedy Recommendation Document." which was approved by the North Carolina Division of Waste Management (NCDWM) on September 27, 2005. The remedial action program for the Site is now being conducted under a Remedial Action Settlement Agreement (RASA), dated December 29, 2008, with NCDENR Division of Waste Management, and is based upon the design concepts presented in the Remedy Recommendation Document.

Appendix A of the RASA contains the Declaration and Order (Docket 08-SF-249). Attachment A to that Declaration and Order is the Scope of Work (SOW) for the remedy at the Site agreed to at the time the RASA was executed. Section 4 of the SOW provides that within 120 days of the approval of the Pre-construction Report for the natural treatment system the Parties shall commence construction of the constructed treatment wetlands and phytoremediation system.

As the remedy has progressed through the completion and submission of the Mechanical Treatment System and Phytoremediation Preconstruction Reports, new information has been developed that indicates certain changes in the remedy seem to be appropriate. More specifically, the Parties have come to believe that the constructed treatment wetlands are not a necessary part of the remedy, and would like to eliminate them from the process.

Following the research and design work done by the Parties leading up to the preparation of the Remedy Recommendation Document, several published studies were conducted to evaluate the effectiveness of phytoremediation systems in the treatment of chlorinated volatile organic compounds (cVOCs). Those recent studies have lead to a better understanding of the fate of cVOCs in a phytoremediation system. Attached to this memorandum is a report, prepared by the Parties consultants (recognized phytoremediation experts), describing the recent research, discussing the fate mechanisms that degrade cVOCs and the lines of evidence that support this requested change.

In addition to the recent research, during the latter part of 2009, and over the growing season during 2010, two pilot study plots were dosed with groundwater extracted from the main extraction well (PW-DR1) at the Site. That activity was to pilot test the concept that 1,4-Dioxane could be phytoremediated, and would be taken up by the trees and not leached below the root zone. This information was presented in Attachment A to the Phytoremediation Pre-construction Report submitted to NCDENR during October of 2010.

One of the conclusions of that research was that the trees, in fact, did take up the groundwater, and a bromate tracer was used to establish that during the dosing of the pilot plots the groundwater was not leached below the root zone. This was a significant finding and lead to further investigation of the fate of compounds other than 1,4-Dioxane.

The Parties determined that during the dosing of the pilot plots with untreated groundwater, there was no evidence of excess buildup of cVOCs in the soil. Even though the tree stand was dosed with groundwater that contained untreated levels of cVOCs, there was no evidence of plant damage. To confirm that the cVOCs were degraded, soil samples were collected and analyzed. The result of that sampling is described in the attached report. In summary, the testing revealed that the cVOC levels in the soils had in fact declined significantly, leaving only trace concentrations of two cVOCs in the root zone. Since it was established that the cVOCs had not leached into the waste layer below the root zone, as confirmed by the bromate tracer in the pilot study, one or a combination of the fate mechanisms discussed in the attached report must have degraded them.

It was also noted that the concentration of the cVOCs applied to the test plots was considerably higher (approximately 100 times higher) than the level that would be present after the groundwater and leachate is pretreated by air stripping. That, coupled with the fact that the full scale system will be operated for six months applying water to the deciduous trees, and six months applying water to the conifer trees, thereby allowing additional time for the degradation of accumulated cVOCs, lead to the conclusion that if all of the extracted groundwater and leachate was air stripped there was no need for a constructed treatment wetlands (CTW) before the phytoremediation system.

In the original remedial design the CTW was included to reductively dechlorinate the cVOC compounds. The thinking at the time was that if left untreated and applied to the phytoremediation soils the level of chlorides in the soil would increase. This would increase to levels that would become phytotoxic and affect tree health. The pilot study seemed to contradict the earlier assumption. When the consultants began to look into the available supporting research, they discovered that a significant body of work was available, most of which was published after the Remedy Recommendation Document was prepared, and pointed to successes in cVOC removal in phytoremediation systems by several mechanisms.

Since there was evidence that the CTW was not necessary, the Parties explored the effect eliminating them might have on the remedy. First, it provides a simplified treatment process. It removes several control variables and makes the control of the phytoremediation irrigation less complex. It reduces cost by a significant amount, and does not negatively impact the environment. Since the application of the groundwater and leachate will be controlled by a system designed to preclude leaching below the root zone of the trees, as is required for the 1,4-Dioxane, there is no increased risk of causing leaching as a result of this change. Generally, the Parties felt that there was sufficient justification to request the change in the remedy, and that the proposed change improved the process, reduced cost, and did not increase the potential environmental risk at the Site. All modifications to an approved remedy have one concern in common. What if it results in a reduced effectiveness and allows a greater impact on the environment? As the Parties considered this question, they realized that this remedy is somewhat unique. In this instance, any impact can be eliminated quickly by simply diverting flow from the natural treatment system to the mechanical treatment system. Because this remedy was approved with two parallel treatment processes that operate independently, if cVOC levels were to begin to become elevated, the flow could simply be diverted to the mechanical treatment system while a solution is developed. If there were to be a need to construct the CTW at some later date, the system being installed has all of the components necessary to make that a relatively simple task that can be accomplished fairly quickly and, most significant, without adverse impact to the conformance with the remedial goals. All of the plans and specifications for the CTW were approved by NCDENR in the Mechanical Treatment System Preconstruction Report, and construction could begin immediately. The necessary controller capacity and piping is included in the present design for the lift stations and treatment processes being installed. As a result it would be relatively easy to install the CTW at a later date without interrupting the operation of the mechanical treatment system.

As a result of these findings the Parties would like NCDENR to approve a modification to the remedy for the Site to eliminate from the natural treatment system the CTW. The modified treatment system would send the extracted groundwater and leachate through the free organics removal system and metals removal system as was always intended. The original plan was to divert the flow at this point to the CTW if capacity was available. If not, the flow would be directed to the air stripper and then to the advanced oxidation system (PhotoCat).

In the proposed modification the groundwater and leachate would follow the same treatment sequence as before, but the entire flow leaving the metals removal system would all be directed, initially, to the air stripper. After air stripping the flow will be sent to the phytoremediation system if capacity is available, or to the PhotoCat[1] and discharged to the City of High Point Eastside Wastewater Treatment Plant if capacity is not available. In effect, this would be using the air stripper as an alternative treatment technology to the CTW when discharging to the phytoremediation system. Testing performed in 2010 by the Parties indicates that the treatment efficiency of the air stripper is approximately equal to that expected with the CTW for cVOCs.

The Parties propose to monitor the cVOC levels in the soil and divert flow from the air stripper inlet to the phytoremediation system if testing of the soils supports higher cVOC dosing rates. This will have the effect of maximizing the treatment capacity of the phytoremediation system. This will require that the Parties monitor the cVOC levels in the soil as they stabilize and increase the flow of untreated water until equilibrium is achieved. The attached report includes a proposed sampling plan intended to monitor the cVOC concentrations in the soils.

Section 5B of the SOW provides that amendments or modifications to the SOW, to the implementation schedule set forth in the SOW or the reports or plans submitted pursuant to the SOW shall be implemented through Technical Memoranda submitted by the Responsible Parties and approved in writing by the NCDENR Division of Waste Management. The Parties feel that the requested change in the approved remedy is a modification to the plans submitted in the Pre-construction Report, which was submitted pursuant to Section A1 of the SOW. The Parties request approval of this modification to the proposed remedy. If there are any questions, or if we may be of any assistance on this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

James C. LaRue
Oversight Consultant

Attachment

4. cc Jackie Drummond, NCDENR
5. Chris Thomson, City of High Point
6. Dave Roberson, SGII
7. Gary Babb, City of High Point
8. Randy Smith, SGII
9. Steve Earp, Esq. City of High Point
10. Amos Dawson, Esq., SGII
11. Tom Wilson, ERM-NC
12. Ari Ferro, URS Corporation
13. Chris Cuomo, ERM-NC

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[1] PhotoCat is a registered trademark of Purifics ES, Inc. of London, Ontario, Canada.

TO: VANCE JACKSON, P.G.

FROM: SEABOARD GROUP II AND CITY OF HIGH POINT

SUBJECT: TECHNICAL MEMORANDUM NO. E-4

DATE:

Seaboard Group II and City of High Point (Parties) hereby request that the construction schedule contained in the Remedial Action Settlement Agreement (RASA) Scope of Work, as modified by earlier Technical Memoranda, be further modified. Due to circumstances beyond the Parties control, certain key components of the mechanical treatment system will not be available for delivery at the times originally anticipated.

Specifically, the order for the PhotoCat[1] advanced oxidation system was entered on April 28, 2010 with the issue of Purchase Order 1047 in the amount of $1,511,600 for the entire PhotoCat system including the advanced oxidation system, the organics separation system, the metals removal system and the air stripper system. That order had an original estimated construction schedule of 26 weeks.

That order was followed by Purchase Order 1047A in the amount of $497,000 for Lift Stations Numbers 1 and 2. The LS-2 lift station was to be incorporated into the PhotoCat system, and LS-1 was a separate stand-alone structure. As a result, the construction schedule was extended to 26 weeks from August 18, 2010. Originally the system was scheduled for delivery on October 26, 2010 and this modification extended the delivery until February 16, 2011. This would have been in ample time to finish the construction by the original March 28, 2011 deadline.

Unfortunately, as construction has progressed the vendor has experienced several delays on equipment deliveries beginning with the shipping containers that house the systems. This was addressed by changing the specified type of container and delivery on schedule was still thought possible. However, recently there have been additional delays in equipment deliveries that have placed the anticipated delivery of the finished system to the site around July 31, 2011.

In addition, the requirements of the North Carolina Modular Building Regulations have been determined to be applicable to the installation of all structures at the Site. This meant that the Guilford County and City of High Point Building Permits were to be evaluated and issued in accordance with those rules. This required that a structural and electrical engineer certify the design, and those applications were submitted with the required certifications. Unfortunately, this delayed the installation of the electrical distribution system, the concrete pads and the structures. The delay in the pads has further delayed the project, as they must be poured and finished and allowed to cure for

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[1] PhotoCat is a registered trademark of Purifics ES, Inc. of London, Ontario, Canada.

two weeks before the containers are placed. The permits have been obtained at this time and the concrete pouring will commence on or before July 1, 2011.

The Parties request that the construction schedule in the scope of work be extended to reflect completion of construction by September 30, 2011 to allow for the delays in component deliveries. This will allow for delivery and setup to be finished according to the revised schedule even if there are other minor delays affecting construction completion. This places the completion of the period to test and correct deficiencies in the system at 6 months after September 30, 2011 or March 31, 2012.

Attached for your review you will find a copy of the June 20, 2011 progress report from the key equipment supplier. As indicated by Purifics, ES, Inc. in this report in Section 2, the Parties have scheduled the Factory Acceptance inspection for July 6 and 7, 2011, and the first shipment of two sections of the mechanical treatment system structure, the LS-2 containers and the single stand-alone structure containing LS-1 will be shipped the week of July 11, 2011. That will be followed by a shipment of three sections of the PhotoCat structure during the week of July 18, 2011. This will be followed by a final shipment of two containers during the week of July 25, 2011. Therefore, by the end of July all of the containers should be on-site and the process of connecting the electrical, control and piping feeds can begin.

The Parties respectfully request that you approve this extension to the construction schedule, and modification to the Scope of Work in the RASA. If there are any questions, or if we may be of any assistance on this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

James C. LaRue, Oversight Consultant
Seaboard Group II

Gary D. Babb

Gary D. Babb, P.G., Oversight consultant
City of High Point

Attachment

TO: VANCE JACKSON, P.G.
JACKIE DRUMMOND
FROM: SEABOARD GROUP II AND CITY OF HIGH POINT
SUBJECT: TECHNICAL MEMORANDUM NO. E-5

DATE:

Seaboard Group II and City of High Point (Parties) hereby request that the construction schedule contained in the Remedial Action Settlement Agreement (RASA) Scope of Work, as modified by earlier Technical Memoranda, be further modified. Due to circumstances beyond the Parties control certain key components of the mechanical treatment system must be modified so that the system can be certified in order that the City of High Point and Guilford County Building Departments can issue the Certificates of Occupancy required to operate the units. At this time, the Parties have performed the modifications required, and await the recertification by the third-party certification agent before asking for the final inspection.

The requirements of the North Carolina Modular Building Regulations were determined to be applicable to the installation of all structures at the Site. This meant that the Guilford County and City of High Point Building Permits were required to be issued in accordance with those rules prior to commencing work. This required that a structural and electrical engineer certify the design, and those applications were submitted with the required certifications before construction commenced. As construction has progressed, certain changes have been necessary to the electrical wiring and components in the system. This requires that QPS, the third-party certification agent, inspect and reissue their certification prior to the Parties asking that the City of High Point and Guilford County inspect the system and issue the Certificates of Occupancy needed.

The Parties request that the construction schedule in the scope of work be extended to reflect completion of construction by December 31, 2011 to allow for these delays. All construction, as it relates to the system mechanical components and electrical modifications has been completed at this time. This placed the completion of the period to test and correct deficiencies in the system at 6 months after December 31, 2011 or June 30,2012.

The Parties respectfully request approval of this extension to the construction schedule, and modification to the Scope of Work in the RASA. If there are any questions, or if we may be of any assistance on this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

Gary D. Babb

James C. LaRue, Oversight Consultant
Seaboard Group II

Gary D. Babb, P.G., Oversight consultant
City of High Point

TO: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

ATTN: QU QI, P.G., HAZARDOUS WASTE SECTION
Jacyline Drummond, Solid Waste Section

From: SEABOARD GROUP II AND CITY OF HIGH POINT

Subject: TECHNICAL MEMORANDUM NO. E-6

DATE: JUNE 18, 2012

Seaboard Group II and City of High Point (Parties) hereby request that the construction schedule contained in the Remedial Action Settlement Agreement (RASA) Scope of Work, as modified by earlier Technical Memorandum E-5, be extended. Due to circumstances beyond the Parties' control, certain key components of the treatment system (System) have not been completed to the requirements of the contractual specifications, and full operation has not proved possible. This is not attributable to the mechanical or electrical components of the System installed by the Parties. Those portions of the System were completed in October of 2011.

At that time, the Parties and their contractors began to make preparations to place the System into operation. On October 25, 2011 they made their first effort to operate the System. Unfortunately, despite best efforts, that attempt was unsuccessful. A series of modifications were made to address the safety of the System, correct issues identified by the Building and Fire Code inspectors and bring all components into compliance with the North Carolina Building Code, including the Modular Building Code, and the National Electric Code ("NEC"), along with other regulatory requirements necessary for issuance of Certificates of Occupancy (COs) required before full operation could be attempted.

The requirements of the North Carolina Modular Building Code were determined to be applicable to the installation of all structures at the Site. This required that Guilford County and City of High Point Building Permits be issued in accordance with the applicable rules prior to commencing work, and that those agencies issue COs before the System was placed into full operation. A registered professional structural and electrical engineer were required to certify the design, and applications were submitted with the required certifications before construction commenced in early August 2011. As construction progressed, certain changes were necessary to the electrical wiring and components in the System. This required that QPS, the third-party certification agent, re-inspect and reissue its certification prior to the Parties requesting the City of High Point and Guilford County to re-inspect the system and issue the COs. Both Guilford County and the City of High Point issued the necessary COs by the end of January 2012.

Upon receiving the COs, the Parties began the process of starting up the System and testing its controls, interlock and alarms. It was determined at that time there were numerous defects and deficiencies in the control and instrumentation system (SCADA), that there were numerous pump and valve problems and several of the specified alarms and interlocks were not functional as they related to the lift stations or the PhotoCat system®[1]. The Parties promptly notified Purifics, the Manufacturer of the System and responsible for providing the controls and instrumentation software, of the defects and deficiencies in the System components and demanded immediate correction. This lead to numerous attempts by Purifics to correct these defects and deficiencies. In addition, the Parties retained an automation firm from North Carolina to assist in this effort. In spite of these diligent and persistent efforts by the Parties, Purifics has failed to correct the deficiencies and defects in the equipment and software it sold to the Parties. Because Purifics is based in Canada, it has proved very difficult for the Parties to expedite repairs.

For these reasons beyond the control of the Parties, the Parties respectfully request that the schedule in the Scope of Work for placing the System into full operation be extended from July 1, 2012, to December 31, 2012. All construction relating to the System's mechanical components and electrical distribution has been completed at this time, and the Parties have been issued the necessary COs to operate the System. The requested extension to December 31, 2012 will allow six additional months to effect correction of the Manufacturer's defects and deficiencies, test the System, perform the other tasks described in the Pre-constriction Report, and place the System into operation.

The Parties respectfully request approval of this extension to the construction schedule, and modification to the Scope of Work in the RASA. If there are any questions, or if we may be of any assistance this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

Gary D. Babb

James C. LaRue, Oversight Consultant
Seaboard Group II

Gary D. Babb, P.G., Oversight Consultant
City of High Point

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[1] PhotoCat is a registered trademark of Purifics ES, Inc. of London, Ontario, Canada

To: North Carolina Department of Environment and Natural Resources

ATTN: Qu Qi, P.G., Hazardous Waste Section
Jackie Drummond, Solid Waste Section

From: Seaboard Group II and City of High Point

Subject: Technical Memorandum No. E-7

Date: April 10, 2013

Seaboard Group II and City of High Point (Parties) hereby request that the construction schedule contained in the Remedial Action Settlement Agreement (RASA) Scope of Work, as modified by several earlier Technical Memoranda (including the most recent, TM E-6), be further extended. Despite their best efforts and due to circumstances beyond the Parties' control, certain key components of the treatment system (System) have not been completed due to requisite process changes that are in progress, making full operation impossible at this time.

As you are aware, this system has been subject to a series of delays in achieving sustained operation. The Parties retained an automation contractor in early 2012 and undertook the development of completely new hardware and software to manage the System process and provide the necessary alarm and interlock functions. This was addressed earlier in TM-E6, and was necessitated by the fact that the original equipment manufacturer, Purifics ES, Inc. of London, Ontario, Canada (Purifics), failed to provide a complete and fully functioning remedial system as specified in their proposal and in violation of their contractual obligations. Purifics has also refused to return to the project and complete their scope of work after repeated requests and demands.

At this time, the work has been completed by the new automation contractor. By December 31, 2012, as specified in TM E-6, all of the necessary automation software and hardware had been prepared, installed and tested, and the Parties commenced an initial startup. Because this System requires a phased startup, the initial testing required that city water be pumped through the system from Lift Station 1 (LS-1) to Lift Station 2 (LS-2) and then into the remaining components in the Effluent Treatment System. That test commenced in early January 2013. Unfortunately, that initial test revealed certain deficiencies in the control system requiring additional programming and testing. That work was authorized immediately and has now been completed.

While the System was shut down, the Parties decided to collect and analyze samples to determine the metals content of the leachate and groundwater to estimate the rate of sludge generation in order to anticipate the metals removal system maintenance requirements. Historically, the iron content of the leachate was reported to be in the 10- to 20-mg/l range. However, this sample event showed results much higher, in the 100- to 150-mg/l range. The Parties reviewed work done shortly after the Remedial Investigation was completed and the RI Report submitted to DENR to evaluate methods to address iron fouling in the lines running from LS-1 to LS-2. That work indicated sequestration, chelation and ion exchange treatment were not practical, but that aeration was an option worth considering. The option of doing nothing was also considered in that early work when the iron level was thought to be in the lower range (10- to 20-mg/l). It was concluded in the earlier work that a startup without any iron removal being performed at LS-1 was a viable concept in order to determine how long the system would operate without fouling of the LS-1 to LS-2 transfer piping. To ensure the lines could be reopened, provisions were installed to clean the LS-1 to LS-2 transfer lines.

The Parties undertook an investigation in March 2013 to determine:

1. What is the cause of the increased iron levels;
2. What needs to be done to reduce the iron levels before the transfer from LS-1 to LS-2;
3. What effect does the pH have on the iron levels;
4. What effect does aeration have on the VOCs in the transfer liquid; and

5. Does the iron in solution function effectively to drive a Fenton's reagent reaction and reduce some of the 1,4-Dioxane at LS-1?

To perform this evaluation, the Parties had samples of the leachate from the six leachate tanks (LCHT 1 through 5 and the NIS Sump), groundwater from the landfill recovery wells (RWLF) and SIS wells and groundwater from PWDR-1 collected and analyzed by a state certified laboratory. A pilot study was then performed to evaluate certain objectives of the investigation.

The conclusions from the investigation were as follows:

1. The cause of the increase in iron in the leachate was undetermined. There are several possible theories as to the causes, including that there was undetected sample dilution of the earlier leachate samples, or that there is some seasonal effect on the iron levels and several other possible causes. However, because finding the exact cause was not as important as determining how it should be addressed, the Parties deferred this portion of the study.
2. The pilot study revealed that aeration alone did not significantly reduce the iron levels in the LS-1 transfer liquid (a combination of leachate and the RWLFS and SIS wells). In fact, after two hours of aeration simulating fine bubble diffusion the iron was essentially the same as before aeration. However, it did reduce the VOC levels significantly. It also had very little effect on the BOD_5 or COD, but did have a positive overall effect on the VOC reduction. This will reduce the overall load on the air stripper in the Effluent Treatment System and increase the overall system destruction and removal efficiency (DRE).
3. The pilot study also revealed that a second aeration for two hours followed by filtration to 50 microns did have a significant effect on the iron and VOC levels. The only VOC remaining in the post filter process flow was acetone, and the iron was reduced to less than 0.25 mg/l. The study indicated that, other than to drive a Fenton's reaction, lowering the pH of the liquid had no positive effect. It also revealed that raising the pH had very little effect on the liquid. There was indication that a Fenton's reaction may have a beneficial effect in reducing the 1,4-Dioxane concentration at a lower pH.

These results indicate that aeration alone has little or no effect on the iron level in the LS-1 transfer water; however, aeration at LS-1 has a beneficial effect on the process. It does strip some of the VOCs and precludes the potential domination of the liquid characteristics by the leachate, potentially causing it to become anaerobic. However, to avoid fouling of the transfer piping from LS-1 to LS-2, it will be necessary to determine a method to flocculate and settle or filter the iron in the LS-1 transfer liquid before it enters the transfer piping. This piping consists of two 2" HDPE pipes that flow up-hill from LS-1 to LS-2, presenting an ideal condition for settling and iron deposition. The results also indicated that a second stage of aeration followed by filtration before the liquid is transferred into the Effluent Treatment System also have a beneficial effect on the process by further reducing the loading on the air stripper and eliminating most of the iron and solids from the process. This reduces the loading on the "Metals Removal Vat" in the Effluent Treatment System and on the air stripper and advanced oxidation process when in operation. The results also indicated that by using iron as a catalyst and lowering the pH of the liquid, titration with Hydrogen Peroxide will reduce 1,4-Dioxane by the Fenton's reaction process. This may become important if the mass of 1,4-Dioxane entering the system exceeds the treatment system's capacity to destroy it. However, the reduction seen in this crude experiment was about 65%, and considerably more study would be needed to refine the process. The data was collected only for reference in the event it is determined at some later date that it may be beneficial to address some of the mass of 1,4-Dioxane earlier in the process.

Up until this point, the Parties have considered that they were in the 6-month testing and evaluation period, and that regardless of all the difficulties and delays they would complete the drawdown test and capture zone test and be ready to submit the Completion Report by June 30, 2013. Unfortunately, within the past few days we have determined that goal does not appear to be achievable. We have been informed of extended delivery times for system components that will press the schedule and likely make full startup by July 1, 2013 unachievable. The oversight consultants have therefore informed the Parties that submission of TM E-7 is needed to request an additional extension of time. The exact duration of the necessary extension cannot be determined until we confirm the delivery dates for the long-lead components, but to be safe the Parties request the schedule be extended until December 31, 2013.

This delay is also caused by the components supplied by Purifics. All of the valves and instrumentation Purifics installed were either the Canadian or the European models, and the Manufacturers in North Carolina and their U.S.A. supply sources do not support those versions of the various components. Therefore, with every order it is necessary to either special order the component or to cross-reference and locate the U.S. equivalent. This has resulted in long lead times for modification or repair of several necessary components.

Some of the modifications are underway at this time. These include the installation of the aeration at LS-1, the installation of a new filter building near LS-2 and revisions to some piping to simplify and improve system flows. We have also modified the Metals Removal Vat to enhance solids removal and make it possible to add and properly mix treatment chemicals if that is necessary.

As documented herein, the Parties have used best efforts and expended substantial resources to remain on schedule. However, for reasons beyond the control of the Parties, the Parties must respectfully request that the schedule in the Scope of Work for placing the System into full operation be extended from July 1, 2013, to December 31, 2013. The requested extension to December 31, 2013 will allow six additional months to effect correction of the Manufacturer's defects and deficiencies, test the System, perform the other tasks described in the "Remedial Action Pre-Constriction Report" (ERM-NC, PC, December 28, 2009) and place the System into operation.

The Parties respectfully request approval of this extension to the construction schedule, and modification to the Scope of Work in the RASA. If there are any questions, or if we may be of any assistance this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

James C. LaRue, Oversight Consultant

Seaboard Group II

Gary D. Babb

Gary D. Babb, P.G., Oversight Consultant

City of High Point

To: North Carolina Department of Environment and Natural Resources

ATTN: Larry Stanley, Hazardous Waste Section
Jackie Drummond, Solid Waste Section

From: Seaboard Group II and City of High Point

Subject: Technical Memorandum No. E-8

Date: January 15, 2014

Seaboard Group II and City of High Point (Parties) hereby request that the Remedial Monitoring and Effectiveness Evaluation Plan (EEP), as included in the Remedial Action Preconstruction Report (PCR) as Attachment E, be revised as indicated in the attached document. After review by the Parties, it has been determined that the plan submitted with the PCR did not have the benefit of the data and information obtained since it was prepared. Therefore, some of the requirements were unnecessary, some were better addressed in a different manner, and some were not considered at all.

The Parties have prepared a revised EEP that takes into account this recent information, and modifies and expands the data collection and monitoring planned for the Site. It revises the groundwater and surface water monitoring to reflect the Randleman Reservoir having reached its normal pool, and collects water level data from additional locations, including from wells on properties north of the Site, to better monitor the capture zone for the contaminant plume.

The Parties respectfully request concurrence with this revised Remedial Monitoring and Effectiveness Evaluation Plan and modification to the Remedial Action Preconstruction Plan, Attachment E. If there are any questions, or if we may be of any assistance this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

Gary D. Babb

James C. LaRue, Oversight Consultant
Seaboard Group II

Gary D. Babb, P.G., Oversight Consultant
City of High Point

To: North Carolina Department of Environment and Natural Resources

ATTN: Larry Stanley, Hazardous Waste Section
Jackie Drummond, Solid Waste Section

From: Seaboard Group II and City of High Point

Subject: Technical Memorandum No. E-9

Date: May 29, 2014

Seaboard Group II and City of High Point (Parties) hereby request that the construction schedule contained in the Remedial Action Settlement Agreement (RASA) Scope of Work, as modified by several earlier Technical Memoranda (including the most recent, TM E-8), be further extended. Despite our best efforts, and due to circumstances beyond the Parties' control, certain key components of the treatment system (System) have not been completed due to delays in the delivery of certain components needed for the solids removal modifications in progress at this time.

As you are aware, this system has been subject to a series of delays in achieving sustained operation. The Parties experienced very high solids loading in the leachate and shallow groundwater recovered at the Site. To address the increase in solids the Parties performed several tests during operations to determine how the removal should best be addressed. That resulted in a process design change to add a hydrocyclone to the discharge line from LS-1 into the filter building, and another hydrocyclone before the filter in the backwash line for the large filters located in the filter building. The components for these modifications were ordered in early May and some have not yet been delivered.

In addition to the mechanical changes, there is a study being performed by chemist retained by the Parties to determine the proper pH to adjust the incoming groundwater and leachate to in order to facilitate the solids flocculation and filtration in the filter building. The preliminary indication is that the pH may need to be adjusted to 4.5, or lower, to allow adequate removal of metals. This study should be completed during June and the necessary equipment installed by the end of July.

Finally, the Parties have ordered all of the equipment needed to install the seven additional level transducers in the additional wells included in the modified Remedial Monitoring and Effectiveness Evaluation Plan (RMEEP). The suppliers have not shipped some of these parts to the Site at this time. The estimated delivery and modification completion is scheduled now for mid-August.

All of these delays have raised concerns that the schedule as approved in Technical Memorandum E-8 will not be achieved. The Parties will not have all the equipment installed until at least mid-August, and need time after that to test and stabilize the system as well as to collect sufficient data to be able to prepare and submit the Construction Completion Report. As documented herein, the Parties have used their best efforts and expended substantial resources to remain on schedule. However, for reasons beyond the control of the Parties, the Parties must respectfully request that the schedule in the Scope of Work for placing the System into operation be extended until December 31, 2014.

The Parties respectfully request approval of this extension to the construction schedule, and modification to the Scope of Work in the RASA. If there are any questions, or if we may be of any assistance this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

Gary D. Babb

James C. LaRue, Oversight Consultant

Gary D. Babb, P.G., Oversight Consultant

Construction Completion Report
Seaboard Group II and City of High Point

Seaboard Group II	City of High Point

To: North Carolina Department of Environmental Quality

ATTN: Joe Ghieold, Hazardous Waste Section
Jackie Drummond, Solid Waste Section

from: Seaboard Group II and City of High Point

subject: Technical Memorandum No. E-10

Date: November 14, 2016

Seaboard Group II and City of High Point (Parties) have determined that certain modifications to the remedial treatment system at the Seaboard Chemical Corporation and Riverdale Drive Landfill (Site) were necessary in order to improve the operating reliability, performance and solids handling. Those modifications are as follows:

CLARIFIER INSTALLATION

In prior Technical Memoranda, the Parties have addressed the higher than expected amount of solids separating from the groundwater and leachate during processing that foul the equipment and require frequent shutdowns for cleaning and repairs. To address this issue the Parties installed enhanced filtration with the addition of the Filter Building. When the system was restarted after that modification was installed several variations of system chemistry were tested to determine whether the solids could be kept in solution until they could be deposited on a set of large dual media filters. Although this approach showed some improvement, it did not prove to be adequate to ensure stable long term operation of the system.

As a result, the Parties retained the services of Hazen and Sawyer in the summer of 2015 to conduct on-site testing and recommend physical and chemical changes to improve system stability and prevent fouling of pumps, valves, pipes and other components. Hazen and Sawyer issued their report in July 2015 and recommended that a Clarifier be installed before flow enters the Filter Building and that additional sludge handling equipment be added to the system. In addition, they recommended changes to system chemistry. A copy of the Hazen and Sawyer report was submitted to the North Carolina Department of Environmental Quality (DEQ) in an earlier report.

The Parties approved the plans for the Clarifier modification, and construction commenced in early January 2016. Prior to commencing construction, a full set of the plan drawings for the proposed modifications was provided to DEQ. Construction consisted of installing a Clarifier immediately behind the Filter Building. The process piping was modified to direct flow from all groundwater and leachate sources to the Clarifier inlet.

The Clarifier is a conical bottomed cylindrical vessel approximately 18-feet in diameter and 15-feet high. It has an internal mixing zone where ferric chloride and hydrated lime are added to the flow and thoroughly mixed before entering the settling zone where the precipitate that forms is settled. The settled material is moved to the center of the Clarifier by a set of rakes where it is pumped to the solids handling equipment. The clarified process flow overflows from the Clarifier into the Aeration Tank (T-600) in the Filter Building. The remaining portions of the treatment system were not modified. A simplified flow diagram is attached.

SLUDGE HANDLING EQUIPMENT INSTALLATION

Sludge is pumped from the bottom of the Clarifier by a set of progressive cavity pumps which transfer it to one of the two sludge dewatering boxes mounted on elevated stands behind the Maintenance Building. The progressive cavity pump in service draws the sludge from the Clarifier.

At this point the sludge is very thin; therefore, a polymer is added at the suction of the progressive cavity pump which further coagulates the sludge as it travels to the dewatering box. Once it arrives in the dewatering box, the sludge is retained by filter screens that line the dewatering box while the water drains to a sump which is pumped to the Clarifier Equalization Tank. The Equalization Tank receives that flow along with the backwash flow from the dual media filters in the Filter Building. The combined flows are pumped back to the Clarifier inlet. Each sludge dewatering box holds approximately 20 cubic yards of dewatered sludge. Once one dewatering box is full, flow is directed to the other box. The full box is allowed to sit until all the free water has drained. At that time, the box is tilted up and the low end is opened allowing the sludge to fall into a concrete basin. The sludge is tested quarterly for TCLP metals, and if it is below the limits, it used for structural fill on the landfill cap. If not, it disposed of as required by state regulations.

AOP UNIT ELIMINATION

In the original design of the remedial treatment system it was envisioned that there was a need for a backup system to be used in the event of a catastrophic loss of the phytoremediation system. To provide the backup system the Parties requested proposals for an advanced oxidation system to treat 1,4-dioxane and other organic contaminants to levels sufficient to allow discharge to the City of High Point East Side POTW. After an onsite pilot test that appeared to show satisfactory destruction of 1,4-dioxane and other VOC and cVOC compounds, the Parties purchased a titanium dioxide catalytic advanced oxidation system, referred to as the PhotoCat, manufactured by Purifics ES, Inc. of London, Ontario, Canada. That unit was warranted by Purifics to treat 1,4-dioxane and the residual organics to consistently produce an effluent that would meet the pretreatment permit limits for discharge to the City of High Point East Side POTW.

Unfortunately, the Parties have determined that the PhotoCat unit is unable to meet the performance standards required under their contract and as warranted by Purifics. The PhotoCat and related equipment manufactured by Purifics were defective when delivered and failed to comply with the National Electric Code and other contractual requirements. After delivery and set up at the Site, Purifics was unable, after repeated attempts, to get the treatment system to operate as designed and warranted. Purifics failed to respond to the Parties’ demands to cure the many defects in the system. Consequently, the Parties hired qualified contractors to effect the necessary repairs to the system. The Parties spent over $700,000 to make the necessary repairs, including reprogramming the SCADA control system.

In April of 2015, the Parties filed a demand for arbitration against Purifics under the rules of the International Chamber of Commerce seeking recovery of the approximately $700,000 spent to repair and render operable the PhotoCat and related treatment system equipment manufactured by Purifics. The Parties also sought damages for failure of the PhotoCat to meet the warranted treatment standards. Alternatively, the Parties requested the Arbitrator to require Purifics to take back the PhotoCat and refund the purchase price to the Parties along with the costs of repair. Purifics denied and contested all of the Parties claims. An arbitration hearing was held in Greensboro NC during the last week of September 2016. A ruling by the Arbitrator on the Parties’ breach of contract and warranty claims is expected during the first quarter of 2017. Because the PhotoCat will not meet the pre-treatment standards for discharge to the POTW, it cannot be used as a backup system at the Site. Therefore, despite the Parties’ best efforts and the expenditure of millions of dollars, the Photocat unit is unable to be used as part of the treatment process at the Site.

After making the repairs necessary to render the system operable, the Parties conducted short-term test runs of the PhotoCat in the fall of 2014. These tests indicated that the PhotoCat unit was unable to achieve the necessary treatment limits for 1,4-dioxane of 3 ug/L to be suitable for discharge to the POTW. Further tests of the PhotoCat unit were delayed until the Clarifier modifications were installed. As soon as the Clarifier modifications were complete, the Parties retained the services of Arcadis to provide a qualified expert to design an appropriate testing protocol and then to operate and test the PhotoCat to determine if it could meet the treatment limits. Arcadis provided an engineer who had extensive experience operating advanced oxidation systems, including the Purifics PhotoCat. The testing was conducted during August 2016. The tests indicated that given the high concentrations of 1,4-dioxane (approximately 3,000 ug/L) entering the PhotoCat, and other characteristics of the extracted groundwater and leachate entering the unit, including high concentrations of radical scavengers (bromide levels of 6-10 mg/L), the PhotoCat unit, as presently configured, could not achieve the required treatment levels. Based on the observed conditions and the analytical data, Arcadis estimated that to install a unit that could meet the discharge limits would require approximately 5-times the existing UV-lamp power, or roughly 1,000 KW. Not only would such a unit be impossible to operate due to the heat it would generate, but at 50 GPM, the fluid would boil inside the unit, removing any cooling for the lamps. This would result in damage that would disable the unit. Arcadis also identified a number of significant additional long term operating issues with the PhotoCat that are detailed in the report. A copy of the Arcadis report is attached.

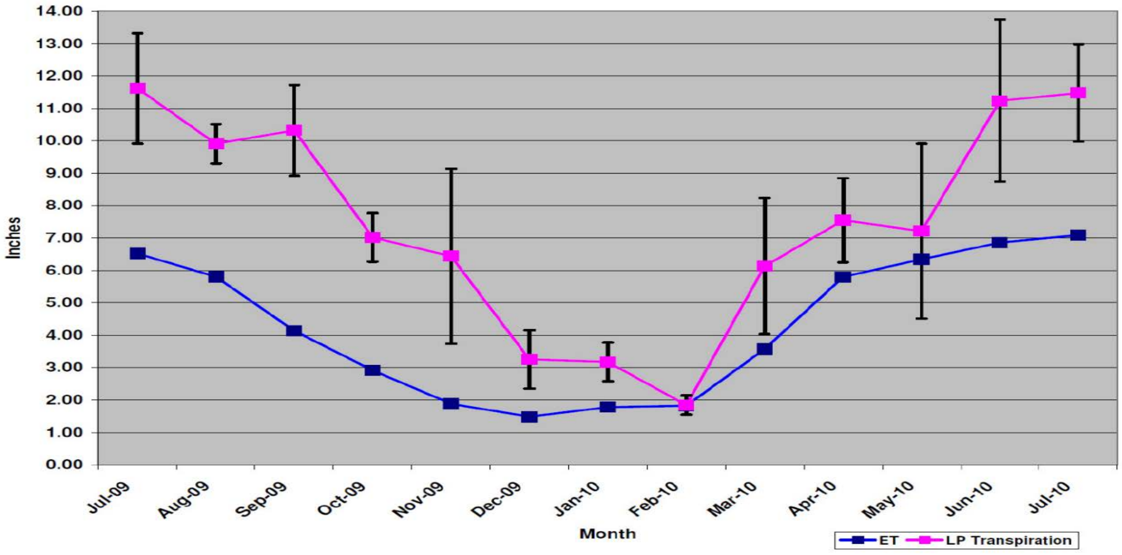
Because the effluent from the PhotoCat cannot be consistently treated to the required levels established in the City's Pretreatment Permit, it cannot be operated, and the Parties are not able to discharge any treated effluent to the City's POTW. The Parties have explored alternative technologies that might improve or replace the PhotoCat. However, the available alternative technologies are very limited due to the high levels of 1,4-dioxane in the groundwater and leachate and the presence of high levels of radical scavengers at this Site. At this time, the Parties have not been able to identify a suitable enhancement or replacement for the PhotoCat.

The Parties recognize that having a backup unit would address concerns that may exist about the catastrophic loss of the tree stand. However, the tree stands have existed on the landfill cap for 9 years and have yet to experience significant tree loss. They are under the day-to-day supervision of a licensed forester, and the phytoremediation system is managed by an expert who conducts soil and tree tissue samplings to ensure the health of the entire stand. The tree species planted are native North Carolina species including Loblolly, Virginia and Southern Pine and Eastern Red Cedar, which were selected for their resistance to disease, long life expectancy, and tolerance of the landfill cap soil conditions. As a result of the experience gained over the past 9 years with the phytoremediation system, and the lack of suitable and available alternative technologies, the Parties request that an alternate backup system to the PhotoCat not be required at this time. For the reasons discussed below, the Parties believe the most prudent course of action is to continuously operate the phytoremediation system over the next five years as the sole effluent treatment system.

The Parties submit that the following significant facts support using continuous operation of the phytoremediation system as the sole treatment method:

1. From conception, this remedial system has been designed as a containment remedy due to the presence of DNAPL in fractured bedrock. Accordingly, the primary objective has been to establish and maintain a capture zone that prevents the plume from reaching the Reservoir. It was determined that the best method to contain the plume is to continuously pump PW-DR-1 at a rate necessary to maintain a capture zone. This rate was predicted during an August 2002 aquifer test, and observations of groundwater drawdown during recent system operation confirm the design data developed during the 2002 aquifer testing. The drawdown pattern and extent of the capture zone observed from the permanently installed transducers support the findings of the aquifer testing and indicate hydraulic control of the contaminant plume is achieved using an extraction rate of 10 - 20 gpm at the PW-DR1 extraction well location. Given the drawdown indicated in deep monitoring wells on the north side of the Reservoir (PW-15D/PW-16D), the designed extraction system exceeds the anticipated performance, and the capture zone is expected to be effective in preventing the plume from reaching the Reservoir.

2. The City POTW has no treatment system that will remove, degrade or destroy 1,4-dioxane, which is present in the influent to the remedial treatment system at levels of 2 to 3 mg/L. This is roughly 1,000 times the North Carolina 2L groundwater standard of 3 ug/L and well above what can be discharged to the City's POTW. The best results during the PhotoCat testing reduced the influent levels of 1,4-dioxane by approximately 75%, and would not meet the treatment level necessary to discharge to the POTW.
3. There are two lobes of the landfill being used by the phytoremediation system. Tree stands are planted on the eastern and western lobes consisting of approximately 13,000-trees planted on 10-foot centers covering roughly 30-acres. The irrigation system is divided into fifteen drip-irrigation zones of approximately 2 acres each. Process effluent water is irrigated on one zone at a time year-round. To accomplish this, long subsurface drip lines are buried in the shallow landfill soil between the tree rows. Drip-emitters are spaced 1.2 to 1.5 ft. apart along each drip line and emit 0.4 to 0.6 gallons per hour each. There are approximately 3,500 drip-emitters per zone giving an irrigation rate per zone of 40 to 58 gpm. The average is 50 gpm, which represents a rate of 0.1 inch per day of irrigation flow applied stand-wide.
4. The irrigation water leaving the physical treatment system contains very low amounts of chlorinated ethenes and chlorinated ethanes, and all of the 1,4-dioxane. Recent testing has shown that the groundwater and leachate entering the system contains approximately 20,000 ug/L of total organics (VOC and cVOC). Of that, approximately 3,000 ug/L is 1,4-dioxane and 17,000 ug/L is other organics. That same testing, as well as earlier testing, showed that the total of the other organics in the physical treatment system effluent is less than 100 ug/L and the 1,4-dioxane remains unchanged. As a result, the destruction or removal efficiency of the physical treatment system for compounds other than 1,4-dioxane is greater that 99%, but it has no effect on the 1,4-dioxane. Nevertheless, including the 1,4-dioxane, the overall destruction or removal efficiency is roughly 85%
5. The compound 1,4-dioxane is miscible in water, not readily volatilized, highly mobile in soil and resistant to biodegradation. Fortunately, 1,4-dioxane is taken up by many tree species as readily is water. Once it is taken up by a tree, it trans-locates from the roots to the leaves and exits the tree through the stomata where it rapidly photo-degrades (half-life = 6.7 to 9.6 hours). There is minimal accumulation in the tree, resulting in no metabolism or toxicity.
6. The Parties have determined through pilot testing that there will be some periods of time during the winter months when the amount of irrigation water applied to the landfill cap will exceed the amount taken up by the trees. This excess irrigation is actually beneficial because it is necessary to flush any accumulated phytotoxic salts from the soil. The excess irrigation water will wet the upper layer of waste in the landfill, will be recaptured by the leachate collection system and shallow groundwater recovery wells, and then will be returned to the remedial treatment system for further treatment.



The above chart is a plot of the transpiration rate for loblolly pines which, as can be seen, roughly follows the plot of the reference evapotranspiration rate. Thus the removal of 1,4-dioxane, which is dependent on evapotranspiration, is less in the cold months.

To test the effectiveness of the phytoremediation process, during the summer of 2015 the Parties operated a pilot plot located on the west lobe of the landfill. The pilot plot was irrigated from May 2015 to September 2015. The results are as follows:

1,4-DIOXANE

Added via irrigation water: 57.6 g
Recovered: 0.14 g (0.24%) mostly in drainage water

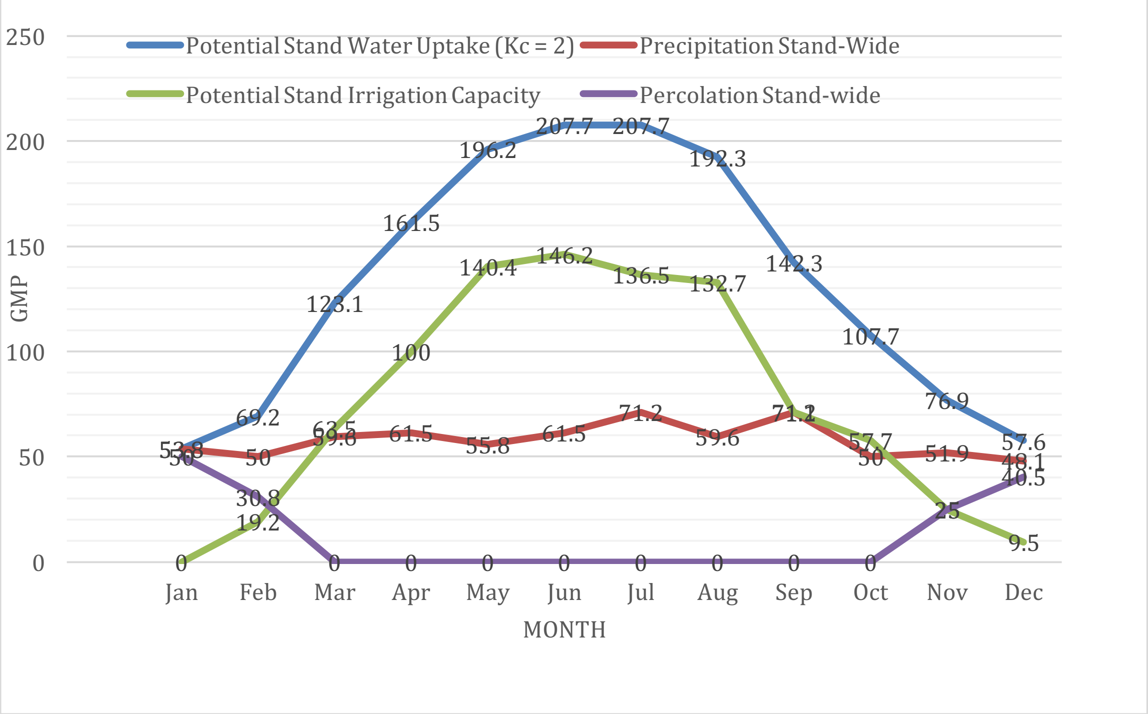
Result: Greater than 99% removal of 1,4-dioxane.

BROMIDE TRACER

Added via irrigation water: 238.4 g
Recovered: 249.2 g (104%); soils (80%), drainage water (20%)

Result: Other organics added via irrigation water were 100% removed.

The 1,4-dioxane removal was greater than 99% during the period when transpiration is high enough to take up the amount of irrigation water applied.



As indicated in the chart above, beginning in the late fall, stand-wide percolation begins to exceed transpiration. This continues through early spring, when transpiration once again exceeds percolation. During the period when percolation exceeds transpiration using the worst case pumping rate (50 gpm), the maximum amount of 1,4-dioxane that could be added to the soils and possibly leach into the upper landfill waste layer is as follows:

January	35.0 lbs.
February	20.7 lbs.
November	17.5 lbs.

December 27.0 lbs.
Total 100.2 lbs. or 24% of total (418 lbs.) applied annually.

7. An important point to consider is that regardless of the amount of 1,4-dioxane that the remedial system removes at any given time, the overall destruction and removal efficiency of the entire system is greater than 99% for all organic compounds during 8 months of the year and drops to 84.5% for 4 months of the year. By operating during the 4-month period when there is excess irrigation, not only do we maintain the capture zone, but we also remove or destroy 84.5% of the contamination captured and flush excess accumulated salts from the tree stand soils.
8. If the system were operated continuously at 50 gpm, it could process 26,280,000 gallons of water per year. If that influent contained 20 mg/L of total organic contamination, 3 mg/L would be 1,4-dioxane and 17 mg/L would be other VOC and cVOC compounds. During that 4-month period, the system would process 8,640,000 gallons, which would contain approximately 1,441.2 pounds of contamination. Of that, 100.2 pounds would be 1,4-dioxane; however, the other 1,341 lbs. of contaminants would be removed or destroyed by the physical treatment system regardless of transpiration rate.
9. The effect on the landfill hydraulics is monitored by permanently installed transducers. These transducers are placed on the landfill in monitoring wells that monitor key locations on the east and west lobes, as well as two wells located on the other side of the Reservoir. These allow monitoring of the landfill hydrology. In addition, the landfill is inspected weekly to detect leachate seeps or ponding of irrigation water.
10. In order to ensure that the effluent from the remedial treatment system cannot accidentally be discharged to the POTW, the Parties have disabled the valve actuator in the control system for the POTW discharge. The valve and line will remain in place in the event it becomes necessary to install an alternate backup system at some time in the future.

Because there is no known technology available at this time that will consistently reduce the 1,4-dioxane to a level suitable for discharge to the POTW, the Parties believe that continuously operating the phytoremediation system while keeping the effluent inside the extraction wells' capture zone is the best treatment alternative for the Site. The Parties request that they be allowed to operate the phytoremediation system for a period of five years, during which time the Parties will irrigate the tree stand with process effluent on a continuous basis. This will allow full evaluation of the phytoremediation system, including identification of and the time to mitigate any problems observed. Extensive data will be collected that will demonstrate the operating reliability and treatment levels of the physical system, treatment levels for the phytoremediation system and other important information. This data can be used to fully evaluate the need for a backup system at the time of the remedial action 5-year review, or at such earlier time DEQ determines necessary.

If there are any questions, or if we may be of any assistance this matter, please feel free to contact Jim LaRue at (281) 431-3571 or Gary Babb at (919) 325-0696.

Respectfully,

Seaboard Group II and City of High Point

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Gary D. Babb, P.G., Oversight Consultant

Gary D. Babb

City of High Point

Attachments Intentionally Omitted

ATTACHMENT 6

RASA STATEMENT OF WORK

RASA Statement of Work

All work performed pursuant to this Declaration and Order (the “Order”) shall comply with the remedial design and specifications in the “Remedial Recommendation Document” prepared by Seaboard Group II and the City of High Point and published for public notice and comment in the June 1, 2000 North Carolina Register (the “Remedy”) as approved by the Division for remediation of the Site, and shall be conducted in substantial compliance with the National Contingency Plan and the current Inactive Hazardous Sites Program “Guidelines for Assessment and Cleanup”.

Based upon the foregoing Findings of Fact and Declarations, **IT IS HEREBY ORDERED** that:

A. Within ninety (90) days after service of this Order, the Remediators shall begin implementation of the approved Remedy. The projected schedule set forth in the “Remedial Recommendation Document” shall be modified as set forth herein. The major components of the Remedy shall be implemented according to the following schedule commencing from the date of service of the Order:

   1. Within three hundred sixty (360) days of service of the Order, final design documents for construction of the remedy shall be submitted to the Division for concurrence. The report must contain at least the following information:

      a. The results of any additional site characterization or treatability studies performed since Division approval of the remedy

      b. A final engineering report, including a narrative description of process design, a summary of changes from the conceptual design approved in the remedy and final construction plans and specifications. However, the full scale phytoremediation preconstruction report shall be due within ninety (90) days of completion of the eighteen (18) month full scale field pilot study. The full scale field pilot study shall commence within thirty (30) days of the effective date.

      c. Copies of required registrations, permits, and approvals.

      d. A detailed performance monitoring and evaluation plan that has been developed to monitor the remedial action system as shown in the final design.

      e. An updated project schedule that includes estimated submittal dates for the Construction Completion Report, Progress Reports, and the Remedial Action Completion Report.

   2. Within one (1) year after notice to the Remediators of approval of the final design, the Remediators shall complete the construction of the hydroxyl ion oxidation system with the performance standard of <10 ug/l or other approved alternative system with equal or greater performance standards and all ancillary equipment and appurtenances necessary for its operation.

   3. The construction of the treatment wetlands located on the former Seaboard Chemical Corporation site and the phytoremediation system located on top of a portion of the landfill shall commence within ninety (90) days of the approval by the Division of the final construction plans and specifications for both the treatment wetlands and the full scale phytoremediation system (the “natural treatment systems”). The operation of the natural treatment systems as outlined in the “Remedy Recommendation Document” shall commence as soon as practicable after completion of construction. It is understood that the approved Remedy contemplates increased reliance on the natural treatment systems as they mature. The hydroxyl ion oxidation treatment process will provide supplemental treatment of extracted ground water and leachate prior to the natural processes becoming mature and fully effective, and to provide an alternative to the natural treatment

systems if they do not perform in accordance with the design estimates.

4. The Remediators have submitted to the Division for approval a Pre-remedial Groundwater and Surface Water Monitoring Plan containing the following elements:
    a. Monitoring objectives
    b. Ground water monitoring locations
    c. Surface water monitoring locations
    d. Analytical methods
    e. Quality control samples
    f. Monitoring and reporting schedule

    As soon as practical, but no later than one year after notice to the Remediators of approval of the Monitoring Plan, the Remediators shall complete pre-remedial ground water and surface water monitoring activities and submit a pre-remedial monitoring report to the Division.

    Within one hundred and eighty (180) days after completion of construction of the hydroxyl ion oxidation system with the performance standard of <10ug/l or other approved alternative system with equal or greater performance standards and ancillary equipment and appurtenances, the Remediators shall commence operation of the hydroxyl ion oxidation system with the performance standard of <10 ug/l or other approved alternative system with equal or greater performance standards.

B. Any requests for modifications of the approved Remedy and the implementation schedule set forth herein must be submitted in writing to the Division, and may not modify the schedule set forth in this Order, be incorporated into the approved Remedy, or implemented unless and until approved in writing by the Division.

C. During the period of construction of the remedial action systems, the Remediators shall provide to the Division quarterly progress reports documenting the remedial construction activities. The quarterly reports shall include, as a minimum and without limitation, a description of completed activities during the reporting period; a description of work remaining to complete the implementation of the remedy; a description of any actual or anticipated problems or delays, and recommendations or solutions developed or implemented to address or mitigate any actual or anticipated problems or delays.

    The first quarterly report shall be provided no later than one hundred and eighty (180) days after commencement of construction of remedial action systems and reports shall continue until the Remediators complete construction and start up of the approved remedy.

D. No later than the date upon which the Remediators have completed construction of the hydroxyl ion oxidation system pursuant to Section A.4. of this Statement of Work, the Remediators shall submit to the Division for approval a Remedial Groundwater and Surface Water Monitoring and Effectiveness Evaluation. This Plan shall supersede the Pre-Remedial Groundwater and Surface Water Monitoring Plan required by Section A.2. of this Statement of Work, be sufficient to monitor the effectiveness of the Approved Remedy and shall contain at least the following elements consistent with the Guidelines for Assessment and Cleanup: The content of the plan will contain at least the following:
    a. Monitoring objectives
    b. Ground water monitoring locations
    c. Surface water monitoring locations
    d. Analytical methods
    e. Quality control samples
    f. Monitoring and reporting schedule

g. Measurement of extraction rates of recovery wells
h. Evaluation of ground water drawdown and capture zones
i. Evaluation of rates of contaminant mass recovery
j. Overall performance evaluation of extraction well network
k. Optimization of system operating parameters
l. Issues and follow-up actions

E. Within ninety (90) days of commencement of operation of the hydroxyl ion oxidation system, the Remediators shall implement the Remedial Groundwater and Surface Water Monitoring and Effectiveness Evaluation Plan required by Section D of this Statement of Work. Thereafter the remedial monitoring and effectiveness evaluation activities shall be conducted and reported to the Division no later than January 30th on an annual basis. The annual reports shall include, at a minimum, a summary report including: data tables, laboratory reports, ground water elevation contour maps in plan view and cross section, isoconcentration contour maps for total volatile organic compounds and four of the primary compounds of concern (1,4-dioxane, 1,2-DCA, vinyl chloride and chlorobenzene) in plan view and cross section, an evaluation of the effectiveness of the remedial action, and graphs illustrating trends of indicator constituents from key/representative monitoring stations.

Once the Remediators have demonstrated that the hydraulic control system: 1) is preventing any additional offsite migration of contaminated ground water; 2) has reduced/eliminated any surface water violations in the onsite water bodies including the intermittent streams and the Deep River; and 3) reduced/eliminated any further discharges of contaminated ground water to the Deep River, then the Remediators may request and the Division may approve a reduction in the frequency of monitoring.

F. The Remediators shall perform a review of the implementation of the Approved Remedy no less often than every five years after commencement of operation of the remedial action systems. The purpose of the five-year review is to evaluate the effectiveness of the Approved Remedy and to assess whether the Approved Remedy remains effective and is protective of human health and the environment. The scope of work of the five-year review shall be in substantial compliance with the United States Environmental Protection Agency's (EPA's) Comprehensive Five-Year Review Guidance (OSWER Directive No. 9355.7-03B-P). The five-year review reports shall be provided to the Division within one hundred and eighty (180) days of the end of each five-year reporting period, with the first five-year reporting period commencing on the date the hydroxyl ion oxidation system is placed into operation. The reports will include a discussion of all plausible exposure pathways identified at the Site during the execution of the RI/FS and related studies and confirmation that each of these pathways is still being controlled. (E.g. all fences constructed pursuant to Section L.2 of this Statement of Work are intact.)

If the five-year review identifies conditions at the Site that significantly impact the effectiveness of the remediation system, a plan of appropriate follow-up actions will be developed. Potential types of follow-up actions may include the following:

1. Additional monitoring activities to confirm or supplement the routine monitoring data.
2. Modifications to operation and maintenance activities of the remediation system to address the issue.
3. Supplemental remedial assessment and/or risk assessment activities to further characterize the issue.
4. Additional remedial measures (i.e. additional recovery wells or institutional controls) to address the issue.

The plan of specific follow-up actions will be submitted to the Division for approval. The plan will include a schedule of implementation and reporting and the criteria that will be used to evaluate the effectiveness of the proposed action for achieving the remedial objectives.

G. Within forty-five (45) days of receiving notice from the Division of any deficiency in the reports or plans required by this Statement of Work or in the implementation of the plans required by this Statement of Work, the Remediators shall submit to the Division information or material sufficient to demonstrate correction of such deficiencies. No plans will be implemented without approval from agency.

H. In the absence of exigent circumstances, the Remediators shall notify the Division no less than ten (10) days prior to the initial commencement of any major field activity as identified in Section A above.

I. By October 1, 2008, the Remediators shall submit, for the Division's approval, land use restrictions and survey plats for the former Seaboard Chemical Corporation facility and the adjacent Crutchfield property located north and east of the Site and the Deep River. The survey plats shall comply with N.C.G.S. 130A-310.8(a). Upon the Division's approval the Remediators shall record the survey plats and land use restrictions within 30 days.

J. Within ninety (90) days after the Remediators conclude that all phases of the remedy have been constructed and are operational, the Remediators shall schedule and conduct a certification of completion inspection with the Division. If after the certification of completion inspection, the Division agrees that the work has been fully performed, the Remediators shall submit a Construction Completion Report stating that the work has been completed in satisfaction of the requirements of this Statement of Work. If the Division concludes, based on the inspection and the report, that the Work has been performed and completed in accordance with this Statement of Work, the Division shall so notify the Remediators in writing.

K. The Remediators shall continue to operate and maintain the remediation action systems until the remedial objectives set out in the Approved Remedy are met. When all remedial objectives are met, the Remediators shall submit a Remedial Action Completion Report that complies with section 5.6 of the Guidelines for Assessment and Cleanup.

L. In addition to its participation with the Remediators in the undertakings described in sections A through K of this Statement of Work, the City of High Point shall perform the following actions at the Landfill for purposes of implementation of the Approved Remedy:

1. Land Use Restrictions: Record the Declaration of Perpetual Land Use Restrictions and associated plat map, in accordance with N.C.G.S. 143B-279.9, as required by the approved Remedial Recommendation Document, and by N.C.G.S. 130A-301.

2. Site access control: install and maintain a six-foot chain link fence topped with barbed wire and a locked gate to surround and prevent unauthorized access to the following facilities: (1) leachate tanks and associated pipes; (2) sediment basin; (3) the piped segment of the northern intermittent stream (NIS); (4) the piped segment of the southern intermittent stream (SIS), and (5) all groundwater extraction/ recovery wells. Install and maintain "No Trespassing" signs spaced twenty feet apart around the unfenced perimeter of the landfill which borders the Randleman Reservoir. The signs, which shall be in both English and Spanish, shall also state: "DANGER: HAZARDOUS SUBSTANCES". (to be determined after further investigation)

3. Landfill gas: Manage and control landfill gas. Maintain the existing methane gas monitoring and passive mitigation systems, and continue to monitor for methane gas on a quarterly basis. Keep records of all monitoring; provide monitoring records to the Division upon request. Undertake methane gas remediation measures as may be necessary to ensure that the concentration of methane gas generated by the facility does not exceed 25 percent of the lower explosive limit for methane in facility structures and at the facility boundary. Comply with any applicable Clean Air Act requirements.

4. Surface water: Management and control surface water at the Landfill which meets the requirements of 15A N.C. Administrative Code 13B .0503(2) (c). Maintain the Landfill so that surface water runoff occurs in a controlled manner and that water is not impounded over waste.

5. Integrity and effectiveness of Landfill cover: Maintain and make any necessary repairs to the existing Landfill cover and erosion control devices, and maintain the enhanced Landfill cover which is installed over the burn pit soil residue mound as part of implementation of the remedy.

6. Leachate collection: Continue to collect, manage, store and treat the leachate from the existing leachate collection system at the Landfill. Maintain the security and integrity of the leachate collection tanks.

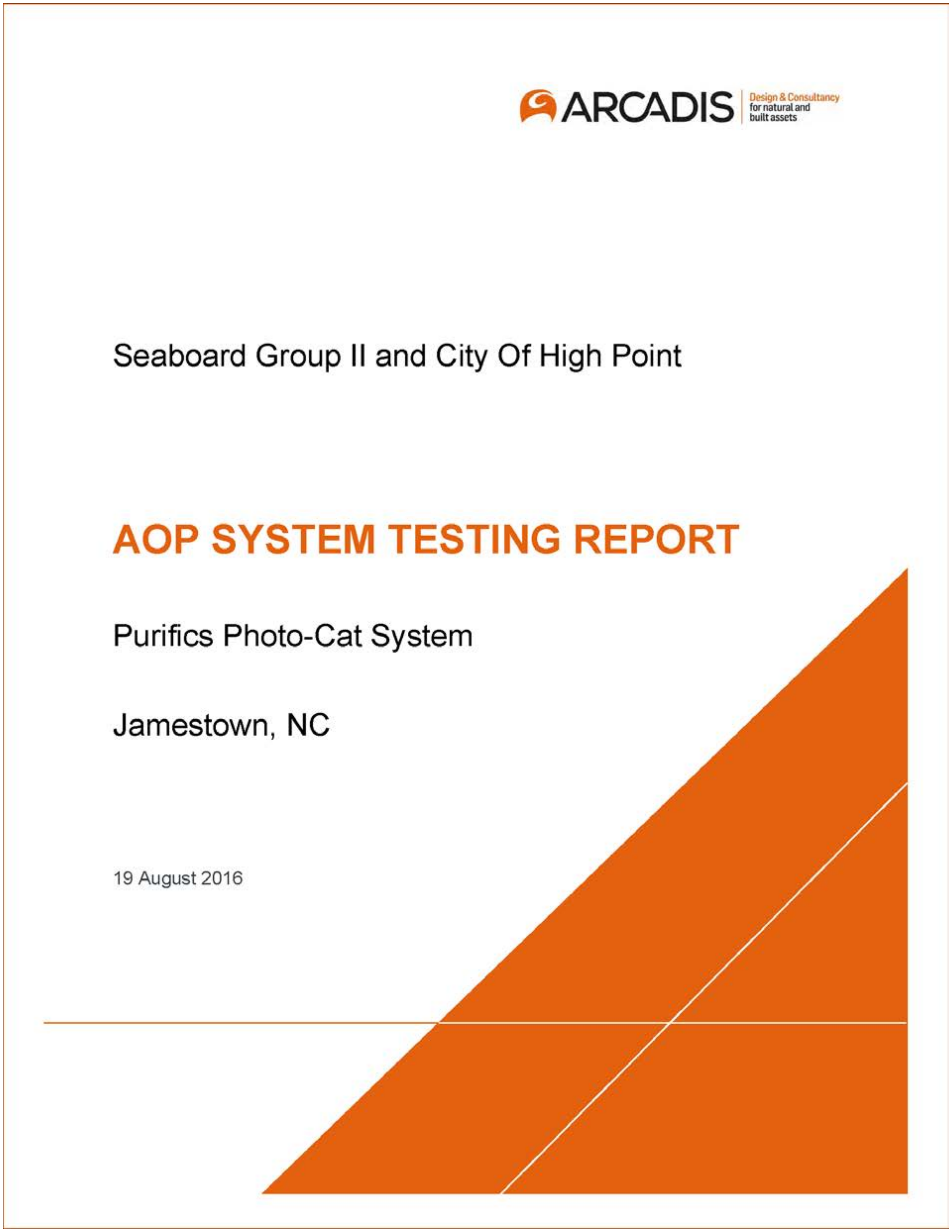
7. Abandonment of potable wells: Properly abandon two potable wells on the City property (one near the entrance road to the Landfill and one on the former Material Recovery Facility site) in accordance with 15A N.C. Administrative Code 2C. Abandonment shall be performed by a NC licensed well driller. Submit well abandonment forms to the Division's Solid Waste Section within 30 days of abandonment.

8. Monitoring wells: Maintain the security and integrity of all groundwater monitoring wells and monitoring well pads.

9. Contingency: In the event of default, for any reason and at any time, of the Remediators on their joint and several obligations under the Agreement, including this Statement of Work, the City shall, in addition to its responsibilities listed in paragraphs one through eight, above, continue with the scheduled monitoring of ground and surface water in the vicinity of the Site, as provided in the Statement of Work. All monitoring data shall be submitted to the Division within 90 days of receipt of analytical data from the laboratory. Depending upon conditions at the Site at the time of default, the Division and the City may agree to a more limited monitoring plan, provided that the plan provides the Division with sufficient information to determine whether additional remedial action may be necessary at the Site.

ATTACHMENT 7

ARCADUS REPORT



ARCADIS Design & Consultancy for natural and built assets

Seaboard Group II and City Of High Point

AOP SYSTEM TESTING REPORT

Purifics Photo-Cat System

Jamestown, NC

19 August 2016

AOP SYSTEM TESTING REPORT

John F. Perella, P.E.
Principal Engineer
(Licensed in Florida)

AOP SYSTEM TESTING REPORT

Purifics Photo-Cat System

Jamestown, NC

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Our Ref.:

TF001589.0001

Date:

August 19 2016

arcadis.com

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ACRONYMS AND ABBREVIATIONS

ADX	Adsorption Xcelerant
AOP	Advance Oxidation Process
Arcadis	Arcadis U.S., Inc.
COD	Chemical Oxygen Demand
CRU	Catalyst Recovery Unit
CVOCs	Chlorinated Volatile Organic Compounds
DPCV	Discharge Pressure Control Valve
FG	Food Grade
gpm	Gallons per Minute
H_2O_2	Hydrogen Peroxide
K	First Order Rate Constant
kW	Kilowatts
kW-hr/m^3	Kilowatt Hours per Cubic Meter
Lpm/kW	Liters per Minute per Kilowatts
LS-2	Lift Station 2
µg/L	Microgram per Liter
µm	Micron
mg/L	Milligram per Liter
ml/min	Milliliter per Minute
nano	Nanoparticle
ND	Non Detect
%	Percent
psi	Pounds per Square Inch
R^2	Coefficient of Determination
SFCV	Slurry Feed Control Valve
SLCV	Slurry Loop Control Valve
SU	Standard Unit
TDS	Total Dissolved Solids
TiO_2	Titanium Dioxide

UV	Ultraviolet
VOCs	Volatile Organic Compounds

1 INTRODUCTION

Arcadis U.S., Inc. (Arcadis) was retained by Williams Mullen to test and evaluate the performance of the existing Advance Oxidation Process (AOP) unit located at the Seaboard Group II facility in Jamestown, NC to determine system capabilities for reducing 1,4-dioxane concentrations in pretreated process water. Testing was performed between August 1 and 3, 2016. An Arcadis Remediation Engineer was present for Tests 0 through 6. Due to travel schedule constraints, the Arcadis Remediation Engineer assisted in initiating Test 7 and Test 8, but was not present for collection of effluent samples or during additional sampling performed on August 16, 2016.

This Expert Report is prepared for submission in the arbitration matter *Seaboard Group II and the City of High Point, North Carolina v. Purifics, ES, Inc. (ICC Case No. 20995/RD)*. Other than this engagement, Arcadis and the undersigned are independent of any of the parties to this dispute as well as the Arbitrator, Edna Sussman. The statements herein are based upon the knowledge and experience of the undersigned and, as stated below, upon review of the testing conducted in August 2016 and other documentary reports. This statement represents the genuine belief and opinion of the undersigned.

1.1 AOP Operational Experience

The Arcadis Remediation Engineer (John Perella) present during testing has 15 years of experience with the design and operation of AOP systems at environmental remediation sites, including the Calgon RayOx, Applied Process Technologies HiPOx and Purifics Photo-Cat. Direct experience with the Purifics Photo-Cat system includes one full scale and two pilot scale systems. John Perella's Curriculum Vitae is provided in **Appendix A**.

1.2 Document Review

Historical documents reviewed prior to testing and referenced for this report include:

- Seaboard Site Groundwater Remediation On-Site Verification Test Program, January 21, 2009 (Purifics, 2009a)
- Draft Photo-Cat Pilot Test & Sample Plan, March 16, 2009 (Purifics, 2009b)
- Preliminary On-Site Test Report Photo-Cat Treatment of Leachate and Groundwater at the Seaboard Site, May 4, 2009 (Purifics, 2009c)
- On-Site Test Report Photo-Cat Treatment of Leachate and Groundwater at the Seaboard Site, June 1, 2009 (Purifics 2009d)
- Response to Proposal Questions Seaboard Site, September 21, 2009 (Purifics, 2009e)
- Seaboard Site Mobile Groundwater Treatment System (Proposal), April 28, 2010 (Purifics, 2010)
- Operation & Maintenance Support Information Manual, December 5, 2011 (Purifics, 2011)
- Jamestown Landfill Leachate Treatment System Treatment Process Study, September 28, 2015 (Hazen, 2015)

- Draft Construction Completion Report, May 14, 2015 (Seaboard Group, 2015).

1.3 Summary of Initial Pilot Testing

On-Site testing or pilot testing was originally proposed by Purifics in January 2009 (Purifics, 2009a). A pilot scale system to include pretreatment systems (air stripping and iron and manganese removal) and primary AOP unit were proposed. Based on information in the proposal, the pilot scale system had a maximum starting load of 12 kilowatts (kW) and was capable of operating within a range of approximately 1 to 13 gallons per minute (gpm).

Pilot testing was performed on-Site between March 18 and May 10, 2009. During this period the pilot scale system was operated for nine days and 18 AOP treated effluent samples were collected. Pilot testing resulted in concentrations of 1,4-dioxane in AOP treated effluent between <2.0 and 1,650 micrograms per Liter (µg/L). It should be noted, of the 18 effluent samples collected, three showed no detection for 1,4-dioxane (<5.0 µg/L on April 28, 2009 [SEA-PUR-6-EFF] and <2.0 µg/L on May 9 and 10, 2009 [SEA-PUR-8-EFF and SEA-PUR-9-EFF]). These three results are referred to as "optimal test condition" in the On-Site Test Report (Purifics, 2009d). A summary of initial pilot test results is provided in **Table 1**.

Based on these results, Purifics recommended a Photo-Cat AOP unit with approximately 145 kW for treatment of Site process water with an operational flow rate of 50 gpm (Purifics, 2009d). Assuming a 1,4-dioxane design influent concentration of 3,000 µg/L and a design effluent concentration of <3.0 µg/L, the resulting AOP unit needs to reduce the concentration by 99.97 percent (%). A mathematical equation is used to provide a predictive tool to evaluate the performance of the AOP unit, the equation is referred to as the first order reaction equation. Within this equation is a term referred to as the first order reaction rate constant. This value provides a number that can be used to compare the performance of AOP treatment systems; the higher the number, the better the treatment. For example, a first order rate constant of 10 provides twice as much treatment as a value of 5. Additional discussion of the first order rate equation is provided in Section 3.

The first order rate constant was calculated by Arcadis to treat 1,4-dioxane from the expected influent concentrations of 3,000 µg/L to the design effluent concentration of <3.0 µg/L; the rate constant was calculated to be approximately 9 liters per minute per kilowatt (Lpm/kW). It should be noted, in the Purifics Proposal (Purifics, 2010), the AOP unit power was increased from 145 kW to 245 kW and the resulting 1,4-dioxane rate constant for the final proposed AOP unit was calculated by Arcadis to be approximately 5.3 Lpm/kW. There is no explanation for the increased power requirement within the Purifics Proposal 8P1205v5.

Verification of rate constants observed during the Purifics pilot tests was not possible since key data used in the rate constant calculation, such as flow rate, power and chemical dose were not provided in the On-Site Reports, Proposal or Operations and Maintenance Manual documents provided by Purifics.

1.4 Summary of 2014 Full Scale System Testing

In 2014 Seaboard Group II representatives tested the full-scale water treatment system, including the PhotoCat unit, to verify its performance. All tests completed were performed with the system operating under full power (240kW) and at a consistent flow rate of 35 gpm. Variables adjusted during testing were pH, hydrogen peroxide (H_2O_2) dose, and whether titanium dioxide (TiO_2) catalyst was used. Catalyst used during the 2014 event was a food grade (FG) TiO_2. All tests performed during the 2014 event were completed by Jamestown Engineering.

Full scale system testing occurred on September 29, October 2 and October 9, 2014. During these tests, 3 AOP system influent samples (one each day of testing) and 16 effluent samples were collected. These samples were sent to ENCO Laboratories for analysis. Full scale testing resulted in concentrations of 1,4-dioxane in AOP treated effluent between <2.0 and 1,420 µg/L. It should be noted, of the 16 effluent samples collected, one showed no detection for 1,4-dioxane (<2.0 µg/L on October 9, 2014 [AOP 16-4]) and a second resulted in relatively low concentration for 1,4-dioxane (15.8 µg/L on October 9, 2014 [AOP 16-3]). These two results are best case results for testing performed in 2014. A summary of 2014 full scale test results is provided in **Table 2** and a summary of resulting full scale system testing rate constants is provided in **Table 3**.

The two best case testing results above, both utilized a H_2O_2 concentration of approximately 54 milligrams per Liter (mg/L); however, influent pH was varied between tests (4 standard units (SU) for AOP 16-4 and 3 SU for AOP 16-3). Of note for these best case tests, is that no TiO_2 catalyst was utilized for either test, i.e. the only production of hydroxyl radicals was by the disassociation of H_2O_2, the same as traditional ultraviolet (UV)/H_2O_2 AOP systems. The resulting 1,4-dioxane rate constants were calculated by Arcadis to be approximately 4.0 Lpm/kW and 2.9 Lpm/kW for AOP 16-4 and AOP 16-3, respectively. Both of these rate constants are less than the final design rate constant of 5.3 Lpm/kW, as discussed in Section 1.3.

Other tests performed with TiO_2 catalyst in use (denoted with "TiO2" in the sample name, e.g. AOP 16-4 TiO_2), resulted in calculated 1,4-dioxane rate constants of approximately 1.1 Lpm/kW, similar to results of Test 7 and Test 8 performed during the August 2016 event, which are discussed in Section 3.2 below. Influent source water and concentrations for chlorinated volatile organic compounds (CVOCs) and 1,4-dioxane were similar based on analytical results for both 2014 and 2016 testing, hence based on the similarity of these results, incoming water quality for testing completed in 2014 and 2016 appear to be similar and consistent.

2 EXISTING PRETREATMENT SYSTEM

The purpose of the pretreatment systems installed at the Seaboard Site are to stabilize hardness (calcium and magnesium), remove iron and manganese, remove suspended solids, and remove volatile organic compounds. A clarifier and sludge handling equipment were recently added to the pretreatment process in 2016. Their design is based on field testing completed by Hazen and Sawyer in September 2015. The purpose of the clarifier is to remove solids and stabilize calcium (Hazen, 2015). Prior to its installation, calcium and solids precipitation resulted in short filter runs and operational issues due to scaling in piping and pumps. Based on discussions with Site operations staff, following the installation of the clarifier, solids precipitation and scaling has been minimized or eliminated.

The current pretreatment processes include the following: Extracted groundwater and leachate from the Site are combined in a pipe manifold located in Lift Station 2 (LS-2). Pre-slaked lime and ferric chloride are then injected into the combined process water stream prior to the clarifier, to increase pH, promote the development of an iron and manganese floc and stabilize calcium. Following the clarifier, process water gravity drains into an aeration tank followed by an equalization tank and is then pumped through media filters. These processes further oxidize, precipitate and mechanically filter remaining iron and manganese. Following the media filters, process water is pumped to a low profile air stripper, in which the majority of volatile organic compounds (VOCs) are removed. Following the air stripper, process water is pumped to a baffled settling tank and then pumped through 25 micron (µm) and 5 µm nominal bag filters that are in series for additional solids removal.

When the AOP is not in operation, process water is discharged to the phytoremediation irrigation system following the bag filters. However, if the PhotoCat AOP is utilized, a final filtration step through a 1 µm absolute cartridge filter is performed prior to the PhotoCat AOP unit. Additionally, with the PhotoCat AOP in operation, pH adjustment and chemical oxidant injection is performed prior to the 1 µm absolute cartridge filter. A general process flow diagram of all treatment systems is provided in **Figure 1**.

2.1 Influent Water Quality

Influent water quality samples were collected from the combined process water, prior to any treatment processes (Test 0 INF 080116) and from the AOP system influent following pH adjustment but prior to final 1 µm filtration (Test 0 PC INF 080116). Chemical oxidant injection, prior to the AOP, was turned off during the collection of this sample. The groundwater recovery and pretreatment systems were operated for approximately 24 hours prior to samples being collected. A summary of influent water quality is provided in **Table 4**. Analytical laboratory reports are provided in **Appendix C**.

The source of influent water was primarily from groundwater extraction well PW-DR1 and a lesser amount was leachate. To best match groundwater and leachate design flowrates as described by Purifics (Purifics 2009a and Purifics 2010) during testing, approximately 80 % of the water was groundwater and 20% leachate.

The compounds of concern, notably chlorinated VOCs and 1,4-dioxane, were observed in the influent water at the combined process water influent and are in general relatively high in concentration compared to most groundwater remediation systems for chlorinated VOCs and 1,4-dioxane. Approximate concentrations included total VOCs of 20,000 µg/L and 1,4-dioxane of 3,000 µg/L. From a remediation treatment perspective, although the dissolved organic concentrations are relatively high, they are certainly within range for treatment using multiple technologies.

There were some inorganic water quality conditions that are noteworthy that can affect both treatment performance and long-term operations and maintenance of treatment equipment. Of special note, the water is considered to have very high hardness (660 mg/L). Hardness is generally based on the concentrations of calcium and magnesium in the water and water is generally considered to be very hard above 180 mg/L. Hard groundwater can cause fouling of treatment equipment by causing excessive scale build-up on the equipment.

Iron and manganese were present with iron concentrations of 7.25 mg/L and manganese of 5.69 mg/L. Iron is a very common compound in shallow impacted aquifers and iron can cause fouling of treatment equipment. Usually iron concentrations exceeding 2 mg/L require pre-treatment and removal to prevent equipment fouling. Manganese can also foul equipment, but it does not precipitate as easily as iron and may or may not act to foul treatment equipment.

Other constituents of interest that can affect treatment using AOP technologies include alkalinity, bromide, chloride, and chemical oxygen demand. All of these parameters can act as hydroxyl radical scavengers which make AOP treatment of the 1,4-dioxane and chlorinated VOCs more challenging. Elevated concentrations of alkalinity, bromide, chloride and chemical oxygen demand (COD), may present challenges for treatment through an AOP. From review of sample results, each of these conditions is present in the groundwater and leachate at the Site.

The pre-treatment process improved the ability of the AOP system to treat the 1,4-dioxane; however, there are hydroxyl radical scavengers present (bromide, chloride) that may affect the treatment performance of AOP technologies to remove 1,4-dioxane. An additional discussion of bromide is presented in Section 3.2.

3 AOP SYSTEM TESTING

Contaminant destruction in AOP systems can be modeled using first order reaction principles and can be confirmed with field tests operated under various flow rate and power conditions while other operational parameters are kept constant, such as pH and chemical oxidant dose. As described in Section 1.3, the first order reaction equation is a method to provide a simple way of comparing the performance of the AOP treatment system. The first order rate constant (k) is the number that is used to make performance comparisons; the higher the k value, the better the performance. For example, a k value of 10 provides twice the treatment as a k value of 5. Evaluating and understanding the k value provides a way to compare different tests and is the primary way to compare the treatment performance of tests described in this testing program. The following first order equations apply for AOP systems:

$$C = Co \cdot e^{-k \cdot x} \qquad \text{(Eqn. 1)}$$

or:

$$k = \ln(Co/C) \cdot 1/x \qquad \text{(Eqn. 2)}$$

where:
Co = Initial Contaminant Concentration
C = Final Contaminant Concentration k
= first order rate constant
x = Dose per Volume Treated

$$x = P/Q \qquad \text{(Eqn. 3)}$$

$$P = \ln(Co/C) \cdot Q/k \qquad \text{(Eqn. 4)}$$

where:
P = Power (kW)
Q = Flow Rate

The goal of testing is to determine the first order rate constant, typically calculated in units of Lpm/kW. The first order rate constant can be calculated or converted to alternative units (e.g. kilowatt hours per cubic meter [kW-hr/m^3]), however for the purposes of this report the units Lpm/kW will be utilized..

The first order rate constant is specific for each contaminant, provides a general gauge of AOP performance and can be used for the design of full scale systems. The first order rate constant provides the ability for the designer to determine the power requirement (kW) for the full scale AOP system (see equation 4 above).

In the units Lpm/kW utilized here, higher rate constant values indicate better potential performance (ability to reduce contaminant concentrations) and lower power requirement for the AOP system. Based on experience, typically a first order rate constant for 1,4-dioxane greater than 10 Lpm/kW is desired when selecting an UV based AOP system, due to the first order kinetics of AOP systems. Specifically, because of first order kinetics, an AOP system power requirement will double if the rate constant is halved, e.g. an AOP designed with a rate constant of 10 Lpm/kW and requiring 100 kW, would require 200 kW if the rate constant was reduced to 5 Lpm/kW and 1,000 kW if the rate constant was reduced to 1 Lpm/kW.

In cases where water quality is consider challenging, lower rate constants (i.e. higher power requirements) may be acceptable, however the designer must consider the operational parameters (flow rate, initial contaminant concentrations and desired final contaminant concentrations) of the full scale system. For example, if the flow rate and/or initial concentration of contaminant are relatively low and/or the desired final contaminant concentration is relatively high, a low rate constant may be acceptable, since the relative power requirement may be considered reasonable. However, if flow rate and/or initial contaminant concentration are relatively high and/or the desired final contaminant concentration is low, the designer should evaluate methods to increase the rate constant (i.e. pretreatment prior to the AOP) or alternative methods for treatment of contaminant(s).

For the purpose of verifying first order reaction kinetics, a consistent testing strategy was employed for all tests completed during August 2016. During each Test performed, chemical oxidant concentration, catalyst utilized and pH were held constant, while flow and power combinations were varied. The variation of flow and power during testing are identified as "Runs." Each Test utilized three (3) Runs, which were maintained at approximately 40 gpm at 240 kW, 40 gpm at 120 kW and 30 gpm at 120 kW, i.e. power to flow ratios of 1.5, 0.75 and 1.0 Lpm/kW, respectively. Analysis of AOP system effluent concentrations collected from the three (3) Runs, allows for the verification and modeling of first order kinetics for the respective Test.

To best match groundwater and leachate design flowrates as described by Purifics (Purifics, 2009a and Purifics, 2010), testing of the AOP system was performed utilizing an approximate blend of 80% groundwater and 20% leachate throughout all testing. Water was pre-treated as described in Section 2 of this report.

Variation of AOP system power was achieved by operating the system with all lamps in operation for 240 kW Runs and by shutting down all lamps on one half of the reactor for 120 kW Runs.

3.1 AOP System Tests Performed

AOP system testing was performed on-Site between August 1 and 3, 2016. A total of nine distinct Tests (Test 0 through Test 8), were completed, with each Test including three (3) Runs (as described in the previous section). At the start of each Test, a pre-treated process water sample was collected from the AOP system influent. For each Run, the Photo-Cat unit was operated for a minimum of 30 minutes at consistent operating parameters, after which an effluent sample was collected. A summary of all testing completed and key operating parameters is provided in **Table 5**. Field data collected from each Test during the August event is provided in **Appendix B**.

A brief description of all tests completed is provided below:

Test 0 – UV only, no catalyst, no chemical oxidant. System performance by photolysis only.

Test 1 – UV and Food Grade (FG) Titanium Dioxide (TiO_2) catalyst. System performance with non-spec catalyst.

Test 2 – UV, FG TiO_2, 100 mg/L Adsorption Xcelerant (ADX). System performance with non-spec catalyst and ADX chemical oxidant.

Test 3 – UV, FG TiO_2, 60 mg/L ADX. Same as Test 2, with reduced concentration of ADX.

Test 4 – UV, no catalyst, 100 mg/L ADX. System performance with no catalyst and ADX chemical oxidant.

Test 5 – UV, no catalyst, 150 mg/L hydrogen peroxide (H_2O_2). System performance with no catalyst and H_2O_2 chemical oxidant.

Test 6 – UV, no catalyst, 200 mg/L H_2O_2. Same as Test 5, with increased concentration of H_2O_2.

Test 7 – UV, nanoparticle (nano) TiO_2, 150 mg/L H_2O_2. System performance with spec catalyst and H_2O_2 chemical oxidant.

Test 8 – UV, nano TiO_2, 100 mg/L ADX. System performance with spec catalyst and ADX chemical oxidant.

3.1.1 AOP System Testing Operational Parameters

A discussion of key operational parameters utilized for AOP system testing is provided below:

pH

To reduce the number of variables tested, all tests were performed with the AOP system influent pH maintained at approximately 4.2 SU (on a scale of 1 (highly acidic) to 14 (highly alkaline)). The reduced pH was selected for the purpose of eliminating bicarbonate alkalinity and maintaining consistent AOP unit operation.

Reduction of pH was achieved using phosphoric acid injected into the process water stream prior to the AOP system influent.

Chemical Oxidant

AOP units such as the PhotoCat at the Site use a chemical oxidant to improve performance in the elimination of 1,4 dioxane. The tests performed in August 2016 on the Site were conducted with either H_2O_2 or ADX, a proprietary material provided by Purifics.

Chemical oxidant concentrations were determined based on field COD (Chemical Oxygen Demand) samples collected on August 1, 2016. COD samples were collected from the AOP system influent sample port and results were 78 and 82 mg/L. For the purpose of the testing a general rule for traditional UV/H_2O_2 AOP systems was applied where the COD concentration is doubled to determine the approximate H_2O_2 dose required. Therefore, based on the COD results, H_2O_2 dose requirements were estimated to be between 150 and 200 mg/L.

ADX concentrations were selected based on the recommended mixed ADX solution concentration of 12% (Purifics, 2011) and the pumping capacity of the metering pump (maximum flow rate = 7.5 Lpm). Based on these criteria, concentrations of 60 and 100 mg/L were selected.

Concentrations of chemical oxidant (ADX or H_2O_2) are provided as pure product concentration in process water. Approximately 27.5 lbs of ADX powder (obtained from Purifics) was mixed with 24 gallons water to produce a 12% by weight concentration. A 12% ADX solution concentration was selected to match the same concentration identified in the Operations and Maintenance Manual (Purifics, 2011). Based on that concentration and the calculated specific gravity of the solution, the chemical metering flow rate required was calculated for various flow rates and concentrations. For example, to achieve a 100 mg/L concentration of ADX in a process water flow of 40 gpm, the chemical must be metered at approximately 122 ml/min or 98% capacity of the metering pump utilized.

H_2O_2 at the Site is 32% concentration, therefore achieving a 200 mg/L concentration at 40 gpm process water flow rate requires a chemical metering flow rate of approximately 84 milliliter/minute (ml/min) or 68% of the metering pump capacity.

AOP Unit Operation

During testing in which catalyst was used, the AOP unit was operated with the slurry loop control valve (SLCV) partially open to maintain a pressure between approximately 25 and 35 pounds per square inch (psi) on the slurry loop pressure transmitter. The discharge pressure control valve (DPCV) was partially opened to maintain a pressure between approximately 20 and 30 psi on the discharge pressure transmitter. Additionally the accumulator level was maintained at approximately 60% full, the slurry feed control valve (SFCV) was maintained at approximately 25% open and the catalyst recovery unit (CRU) back pulse was initiated once per minute. The operational set points described above are consistent with typical operational set points for other Photo-Cat AOP systems. Both a food grade and nanoparticle TiO_2 catalyst were tested. The nanoparticle TiO_2 catalyst was the material obtained from Purifics during initial receipt and testing of the Photo-Cat at the Site.

During testing in which catalyst was not used, the AOP unit was operated under the same approximate conditions with the exception that the SFCV was closed, and the CRU back pulse was disabled. Under these conditions the AOP unit was operated as a traditional UV/Oxidant AOP, i.e. single pass and no catalyst.

3.2 AOP System Testing Results

AOP system testing was performed on-Site between August 1 and 3, 2016. Analytical testing results are summarized in **Table 6** and first order rate constants and AOP performance data are summarized in **Table 7**. Plotted data and modeled decay curves for each test are provided in **Figures 2** through **6**. Analytical lab reports are provided in **Appendix C**.

A description of test results are provided below:

Test 0 – UV only, no catalyst, no chemical oxidant

Test 0 was performed to provide a baseline for AOP performance and a comparison to treatment of process water by photolysis alone. Photolysis is the disassociation of molecules by light alone and can be an indication of UV lamp performance.

Concentrations of 1,4-dioxane were reduced by 36% to 57% during this test and the resulting first order rate constant (rate constant) for 1,4-dioxane was modeled to be approximately 0.54 Lpm/kW. This test had excellent correlation between Runs, with a coefficient of determination (R^2) factor of 0.99. The results of this test indicate the AOP unit lamps are in good working condition.

Test 1 – UV and FG TiO_2 catalyst

Test 1 was performed to determine the performance of the AOP unit utilizing a FG TiO_2 catalyst. Typically, the Photo-Cat AOP uses a nano TiO_2 catalyst, which has a much smaller diameter than the FG TiO_2 and should theoretically be more effective. Results of this test allow for a comparison between catalyst types.

Concentrations of 1,4-dioxane were reduced by 47% to 60% during this test and the resulting rate constant was modeled to be approximately 0.63 Lpm/kW. This test had very good correlation between Runs, with a R^2 factor of 0.91. The results of this test show minor improvement over Test 0, indicating moderate production of hydroxyl radicals with the FG TiO_2.

Test 2 – UV, FG TiO_2, 100 mg/L ADX

Test 2 was performed to determine the performance of the AOP unit utilizing the FG TiO_2 catalyst and ADX chemical oxidant. ADX is a proprietary chemical provided by Purifics and is supposed to enhance operation of the AOP. During this test, ADX was injected into the AOP system influent at an approximate concentration of 100 mg/L.

Concentrations of 1,4-dioxane were reduced by 52% to 62% during this test and the resulting rate constant was modeled to be approximately 0.64 Lpm/kW. This test had very good correlation between Runs, with a R^2 factor of 0.93. The results of this test show effectively no improvement over Test 1, indicating limited effectiveness of the ADX during this test.

Test 3 – UV, FG TiO_2, 60 mg/L ADX

Test 3 was performed the same as Test 2, except the concentration of ADX was reduced to 60 mg/L to allow comparison between different concentration of ADX.

Concentrations of 1,4-dioxane were reduced by 48% to 73% during this test and the resulting rate constant was modeled to be approximately 0.83 Lpm/kW. This test had excellent correlation between Runs, with a R^2 factor of 0.99. The results of this test show moderate improvement over Test 2, which may indicate the ideal concentration of ADX is closer to 60 mg/L than 100 mg/L for this process water.

Test 4 – UV, no catalyst, 100 mg/L ADX

Test 4 was performed to determine performance of the AOP unit utilizing no catalyst and ADX. During this test the AOP unit was operated as a traditional UV/Oxidant AOP, i.e. single pass and no catalyst. ADX was injected into the AOP system influent at an approximate concentration of 100 mg/L.

Concentrations of 1,4-dioxane were reduced by 57% to 67% during this test and the resulting rate constant was modeled to be approximately 0.67 Lpm/kW. This test had good correlation between Runs, with a R^2 factor of 0.79. The results of this test show moderate reduction in performance compare to Test 3, but similar results to Test 2.

Test 5 – UV, no catalyst, 150 mg/L H_2O_2

Test 5 was performed to determine performance of the AOP unit utilizing H_2O_2, but no catalyst. During this test the AOP unit was operated as a traditional UV/Oxidant AOP, i.e. single pass and no catalyst. H_2O_2 was injected into the AOP system influent at an approximate concentration of 150 mg/L.

Concentrations of 1,4-dioxane were reduced by 38% to 100% during this test. Run A, operating at 30 gpm and 120 kW produced a result of non-detect (ND) for 1,4-dioxane in effluent. This result is considered anomalous when compared to Runs B and C. If Run A is included in the model analysis of data the resulting R^2 factor is 0.07 and effectively shows no correlation. While in comparison, if Run A is removed from the model analysis of data the resulting R^2 factor is 1.0 and shows perfect correlation. Further Run A represents the mid-point operational power to flow ratio (1.06 kW/Lpm) of Test 5, hence since Run A did not utilize the maximum power to flow ratio for the Test and both the low and maximum power to flow ratio results have perfect correlation, the likelihood of Run A being an anomaly is very high. Therefore for the purpose of this report, Run A data is not used for the model analysis of the rate constant, e.g. the rate constant accepted as the result for this test is approximately 0.59 Lpm/kW. The effective results for this show only slight improvement compared to the baseline test (Test 0).

Test 6 – UV, no catalyst, 200 mg/L H_2O_2

Test 6 was performed the same as Test 5, except the concentration of H_2O_2 was increased to 200 mg/L to allow comparison between different concentration of H_2O_2.

Concentrations of 1,4-dioxane were reduced by 40% to 64% during this test and the resulting rate constant was modeled to be approximately 0.63 Lpm/kW. This test had excellent correlation between Runs, with a R^2 factor of 0.99. The results of this test show moderate improvement over Test 5, which may indicate the ideal concentration of H_2O_2 is greater than 200 mg/L for this process water.

Test 7 – UV, nano TiO_2, 150 mg/L H_2O_2

Test 7 was performed to determine the performance of the AOP unit utilizing the standard Photo-Cat specified nano TiO_2 catalyst and H_2O_2. During this test, H_2O_2 was injected into the AOP system influent at an approximate concentration of 150 mg/L.

Concentrations of 1,4-dioxane were reduced by 54% to 78% during this test and the resulting rate constant was modeled to be approximately 0.89 Lpm/kW. This test had good correlation between Runs, with a R^2 factor of 0.82. The results of this test show moderate improvement over previous testing with FG TiO_2 and H_2O_2 alone. Based on these results the nano TiO_2 catalyst provides better performance than the FG TiO_2.

Test 8 – UV, nano TiO_2, 100 mg/L ADX

Test 8 was performed to determine the performance of the AOP unit utilizing the standard Photo-Cat specified nano TiO_2 catalyst and ADX. During this test, ADX was injected into the AOP system influent at an approximate concentration of 100 mg/L.

Concentrations of 1,4-dioxane were reduced by 65% to 78% during this test and the resulting rate constant was modeled to be approximately 1.02 Lpm/kW. This test had very good correlation between

Runs, with a R^2 factor of 0.93. Results from this test were the best of all test performed during the August testing event. Based on these results, the combination of ADX and nano TiO_2, are the most effective for the reduction of 1,4-dioxane in this process water, but H_2O_2 and nano TiO_2 appear to be equally effective.

Additional Bromide Sampling

Bromide is an aggressive radical scavenger and can adversely affect the performance of AOP systems, by consuming hydroxyl radicals and limiting their availability for the destruction of target contaminants. Bromide was detected in all samples analyzed for bromide during the August 2016 AOP testing event. To determine the source of bromide in process water, additional samples for bromide were collected on August 16, 2016. Water samples were collected and analyzed for bromide from extraction well PWDR-1 and combined Leactate and from chemical solutions utilized by the clarifier (Ferric Chloride and Lime). Analytical results for these samples are provided in **Table 6**.

Results from these samples indicate that the source of bromide in process water is Site groundwater and leachate, as bromide concentrations were 6 mg/L and 10 mg/L for PWDR-1 and Leachate, respectively. Ferric Chloride and Lime samples were both ND for bromide, and therefore were shown not to contribute to bromide concentrations in process water.

3.3 Conclusions

Of the nine tests performed, the best AOP unit performance was observed when both the nano TiO_2 catalyst and chemical oxidant (H_2O_2 or ADX) were used (Tests 7 and 8). 1,4-dioxane concentrations were reduced by 78% for both tests and rate constants were modeled to be approximately 0.89 and 1.02 Lpm/kW for Test 7 and Test 8, respectively. However, these rate constants for 1,4-dioxane are considered extremely low. As stated previously, a rate constant of 10 Lpm/kW or greater is generally desirable when designing an AOP system. In cases where water is considered very difficult to treat, a lower rate constant may be acceptable, however in those instances in which a low rate constant would be acceptable the influent concentration of the contaminate and/or the system flow rate should be relatively low, otherwise the cost of operating the system due to power requirements becomes much less attractive.

In the case of the Seaboard Site, based on the testing results, the best case rate constant observed was approximately 1 Lpm/kW. With no safety factor, the AOP unit power required to treat the Site process water at the design flow rate of 50 gpm, an influent concentration of 3,000 µg/L and a design effluent concentration of <3 µg/L would be approximately 1,250 kW, more than five times larger than the existing AOP unit. An AOP unit this large would not be attractive for this Site, due to costs for power and extreme temperature increases to the process water through the AOP unit, which would require additional systems to reduce the water temperature to levels acceptable by other infrastructure.

As discussed in Section 2.1, it is recognized that the water at the Site presents challenges for treatment of 1,4-dioxane. Radical scavengers, such as alkalinity, bromide, chloride and COD are known to consume hydroxyl radicals within an AOP reactor, limiting radical availability for the destruction of contaminates, such as 1,4-dioxane. As seen in the test results, photolysis alone (Test 0) was shown to remove 1,4-dioxane concentrations by 36 to 57%. Therefore, even for the best case scenario tested (Test 8) at least half of the 1,4-dioxane reduction can be contributed to photolysis. This result may implicate radical scavengers are contributing to the limited performance of the AOP.

Based on the poor performance of the AOP unit during testing and the challenging influent water quality, Arcadis does not believe the existing AOP system, Photo-Cat, could be successfully implemented at the Site to consistently reduce 1,4-dioxane concentrations in the existing pre-treated process water to below design effluent concentrations (3 µg/L).

Purifics states in the final On-Site Test Report (Purifics, 2009d), "Purifics has concluded that the groundwater at the Seaboard site contains very high levels of radical scavengers." Section 4.4 "Radical Scavengers," following that statement discusses the potential for the presence of surfactants. While acknowledging the presence of very high levels of radical scavengers within the same On-site Test Report, Purifics proposes the full-scale Photo-Cat system power requirement will be "approximately 145 kw" for "full-scale operation at a flow rate of 50gpm." As discussed previously, a 1,4-dioxane rate constant of at least 9 Lpm/kW would be required to meet the design objective for 1,4-dioxane effluent concentrations for a 145 kW Photo-Cat.

Within the Purifics Final Proposal (Purifics, 2010) the final proposed AOP system is a "245 kW DQL Photo-Cat." As discussed previously, a 1,4-dioxane rate constant of at least 5.3 Lpm/kW would be required to meet the design objectives for 1,4-dioxane effluent concentrations for a 245 kW Photo-Cat. There is no explanation for the increased power requirement within the proposal and there is no discussion concerning the need to reduce surfactant or other radical scavenger concentrations.

As stated previously, based on the testing performed during the August 2016 event and comparison to the similar results of the 2014 testing event, the existing Photo-Cat is undersized and cannot achieve the rate constants required to meet the required performance. Based on the analysis of the data collected from the August 2016 event, the Photo-Cat would require approximately 5 times more power than the existing system to achieve design criteria. In order for the existing PhotoCat unit to meet the design criteria and performance requirements of reduction of 1,4-dioxane concentrations to < 3 µg/L, additional pretreatment to remove radical scavengers and thereby increase the AOP first order rate constant for 1,4-dioxane would also be required. These additional pretreatment measures were not included in the delivered system and would likely add significantly to the cost of the overall system.

Long Term Operational Issues with Photo-Cat

Some additional significant potential issues were noted with the Photo-Cat unit during the August 2016 event at the Seaboard Site that may cause operational issues if this system is operated long term. Specifically, based on our inspection of the lamps currently utilized by this Photo-Cat, the lamps are believed to use a defective insulation on the lamp power cables. The defective insulation may degrade over time and cause lamp failure or limited UV transmittance through the quartz sleeves. Lamps currently utilized by Purifics use an upgraded insulation, and we understand Purifics had replaced these lamps in units similar to the one at the Site.

Additionally, the lamp drivers utilized to power the lamps are proprietary to Purifics and are not available through an alternative vendor. Currently at the Seaboard Site, within the existing Photo-Cat, there are two spare lamp drivers. As these drivers fail, replacement drivers would have to be purchased directly through Purifics.

Finally, the seal plug removal tool could not be located at the Site. This tool is required to remove quartz sleeves, so they may be inspected or replaced. This tool is only available through Purifics.

TABLES

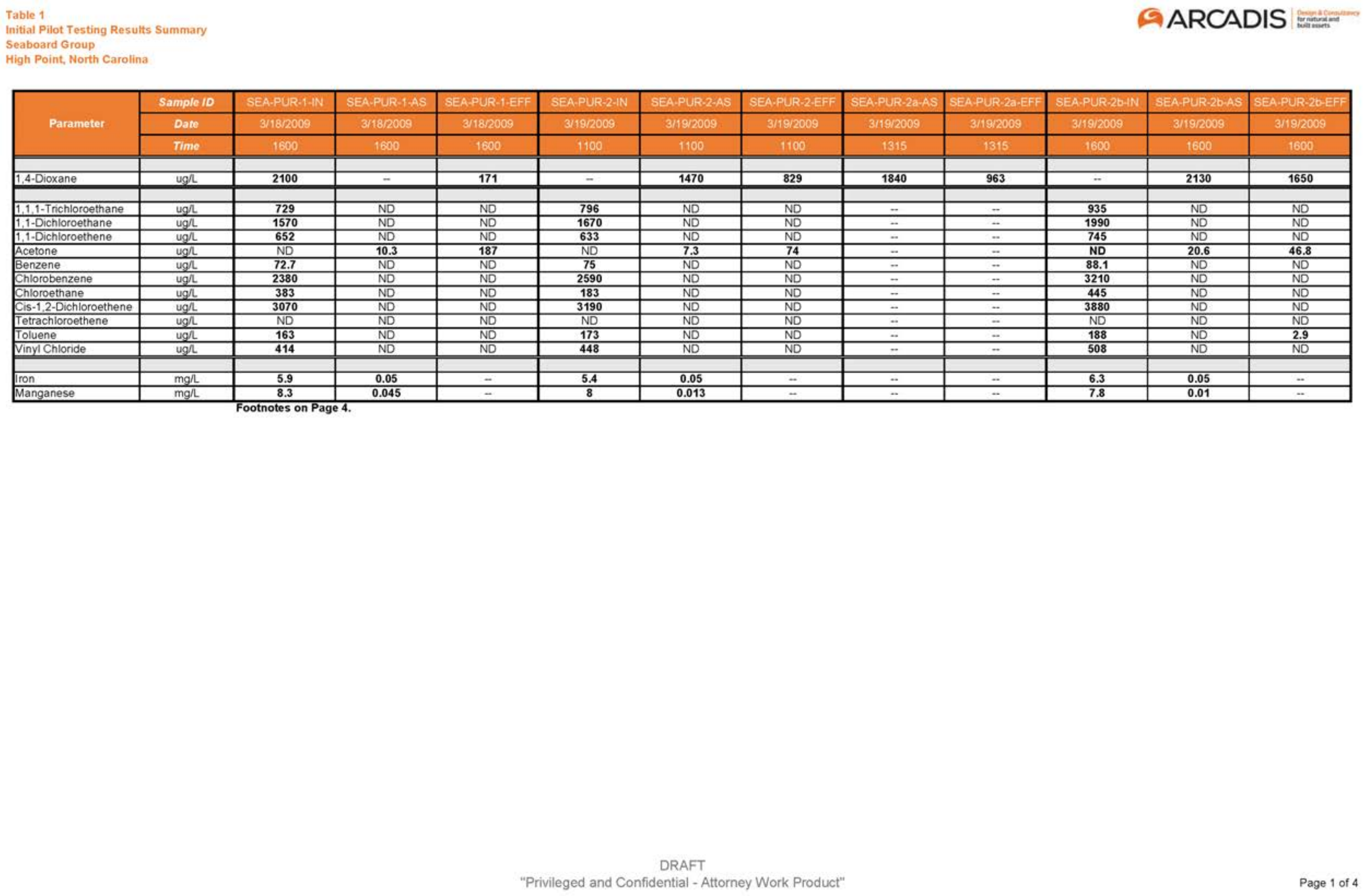

Table 1
Initial Pilot Testing Results Summary
Seaboard Group
High Point, North Carolina

Parameter	Sample ID	SEA-PUR-1-IN	SEA-PUR-1-AS	SEA-PUR-1-EFF	SEA-PUR-2-IN	SEA-PUR-2-AS	SEA-PUR-2-EFF	SEA-PUR-2a-AS	SEA-PUR-2a-EFF	SEA-PUR-2b-IN	SEA-PUR-2b-AS	SEA-PUR-2b-EFF
	Date	3/18/2009	3/18/2009	3/18/2009	3/19/2009	3/19/2009	3/19/2009	3/19/2009	3/19/2009	3/19/2009	3/19/2009	3/19/2009
	Time	1600	1600	1600	1100	1100	1100	1315	1315	1600	1600	1600
1,4-Dioxane	ug/L	**2100**	--	**171**	--	**1470**	**829**	**1840**	**963**	--	**2130**	**1650**
1,1,1-Trichloroethane	ug/L	**729**	ND	ND	**796**	ND	ND	--	--	**935**	ND	ND
1,1-Dichloroethane	ug/L	**1570**	ND	ND	**1670**	ND	ND	--	--	**1990**	ND	ND
1,1-Dichloroethene	ug/L	**652**	ND	ND	**633**	ND	ND	--	--	**745**	ND	ND
Acetone	ug/L	ND	**10.3**	**187**	ND	**7.3**	**74**	--	--	**ND**	**20.6**	**46.8**
Benzene	ug/L	**72.7**	ND	ND	**75**	ND	ND	--	--	**88.1**	ND	ND
Chlorobenzene	ug/L	**2380**	ND	ND	**2590**	ND	ND	--	--	**3210**	ND	ND
Chloroethane	ug/L	**383**	ND	ND	**183**	ND	ND	--	--	**445**	ND	ND
Cis-1,2-Dichloroethene	ug/L	**3070**	ND	ND	**3190**	ND	ND	--	--	**3880**	ND	ND
Tetrachloroethene	ug/L	ND	ND	ND	ND	ND	ND	--	--	ND	ND	ND
Toluene	ug/L	**163**	ND	ND	**173**	ND	ND	--	--	**188**	ND	**2.9**
Vinyl Chloride	ug/L	**414**	ND	ND	**448**	ND	ND	--	--	**508**	ND	ND
Iron	mg/L	**5.9**	**0.05**	--	**5.4**	**0.05**	--	--	--	**6.3**	**0.05**	--
Manganese	mg/L	**8.3**	**0.045**	--	**8**	**0.013**	--	--	--	**7.8**	**0.01**	--

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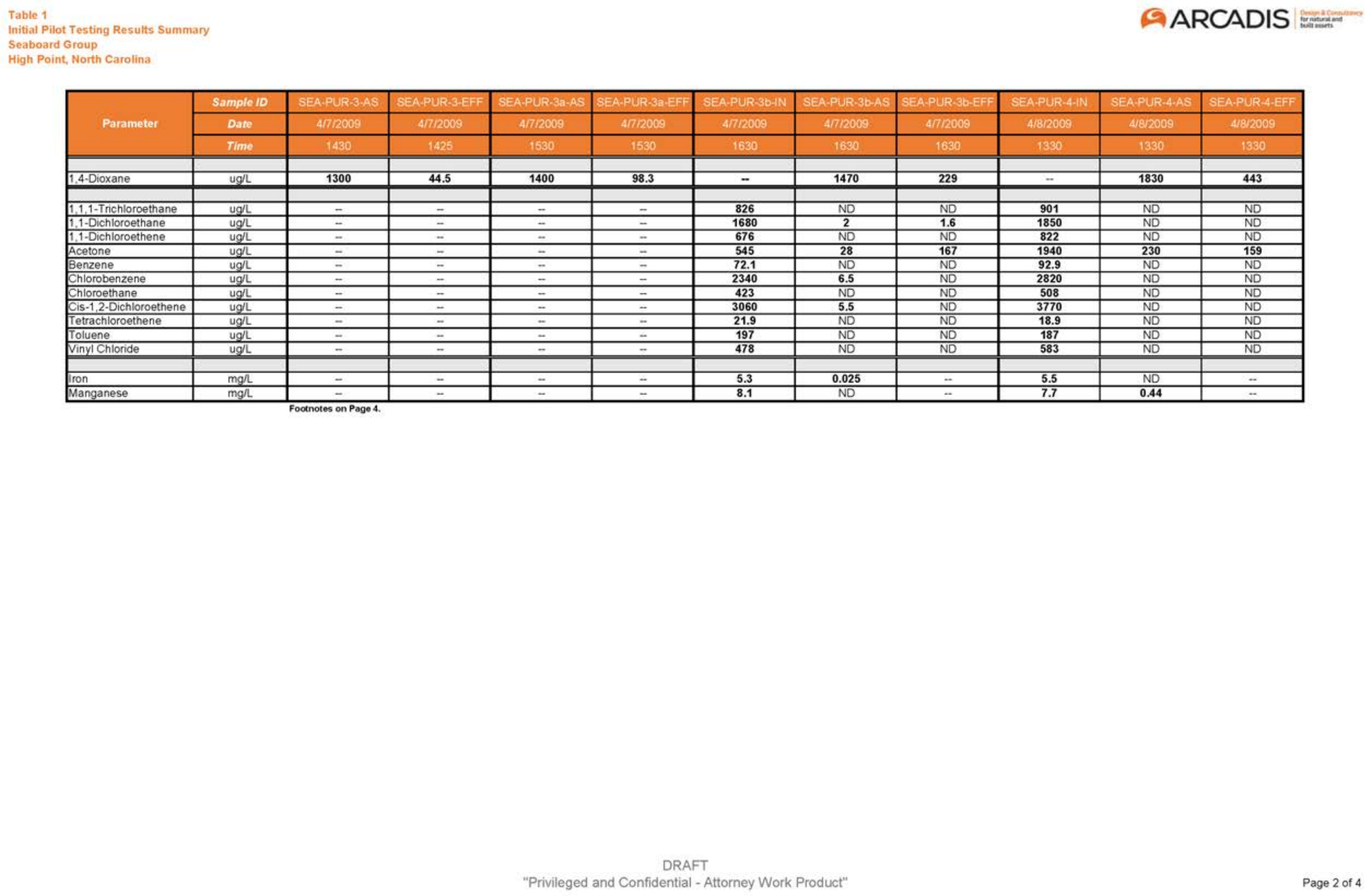

Table 1
Initial Pilot Testing Results Summary
Seaboard Group
High Point, North Carolina

Parameter	Sample ID	SEA-PUR-3-AS	SEA-PUR-3-EFF	SEA-PUR-3a-AS	SEA-PUR-3a-EFF	SEA-PUR-3b-IN	SEA-PUR-3b-AS	SEA-PUR-3b-EFF	SEA-PUR-4-IN	SEA-PUR-4-AS	SEA-PUR-4-EFF
	Date	4/7/2009	4/7/2009	4/7/2009	4/7/2009	4/7/2009	4/7/2009	4/7/2009	4/8/2009	4/8/2009	4/8/2009
	Time	1430	1425	1530	1530	1630	1630	1630	1330	1330	1330
1,4-Dioxane	ug/L	**1300**	**44.5**	**1400**	**98.3**	--	**1470**	**229**	--	**1830**	**443**
1,1,1-Trichloroethane	ug/L	--	--	--	--	**826**	ND	ND	**901**	ND	ND
1,1-Dichloroethane	ug/L	--	--	--	--	**1680**	**2**	**1.6**	**1850**	ND	ND
1,1-Dichloroethene	ug/L	--	--	--	--	**676**	ND	ND	**822**	ND	ND
Acetone	ug/L	--	--	--	--	**545**	**28**	**167**	**1940**	**230**	**159**
Benzene	ug/L	--	--	--	--	**72.1**	ND	ND	**92.9**	ND	ND
Chlorobenzene	ug/L	--	--	--	--	**2340**	**6.5**	ND	**2820**	ND	ND
Chloroethane	ug/L	--	--	--	--	**423**	ND	ND	**508**	ND	ND
Cis-1,2-Dichloroethene	ug/L	--	--	--	--	**3060**	**5.5**	ND	**3770**	ND	ND
Tetrachloroethene	ug/L	--	--	--	--	**21.9**	ND	ND	**18.9**	ND	ND
Toluene	ug/L	--	--	--	--	**197**	ND	ND	**187**	ND	ND
Vinyl Chloride	ug/L	--	--	--	--	**478**	ND	ND	**583**	ND	ND
Iron	mg/L	--	--	--	--	**5.3**	**0.025**	--	**5.5**	ND	--
Manganese	mg/L	--	--	--	--	**8.1**	ND	--	**7.7**	**0.44**	--

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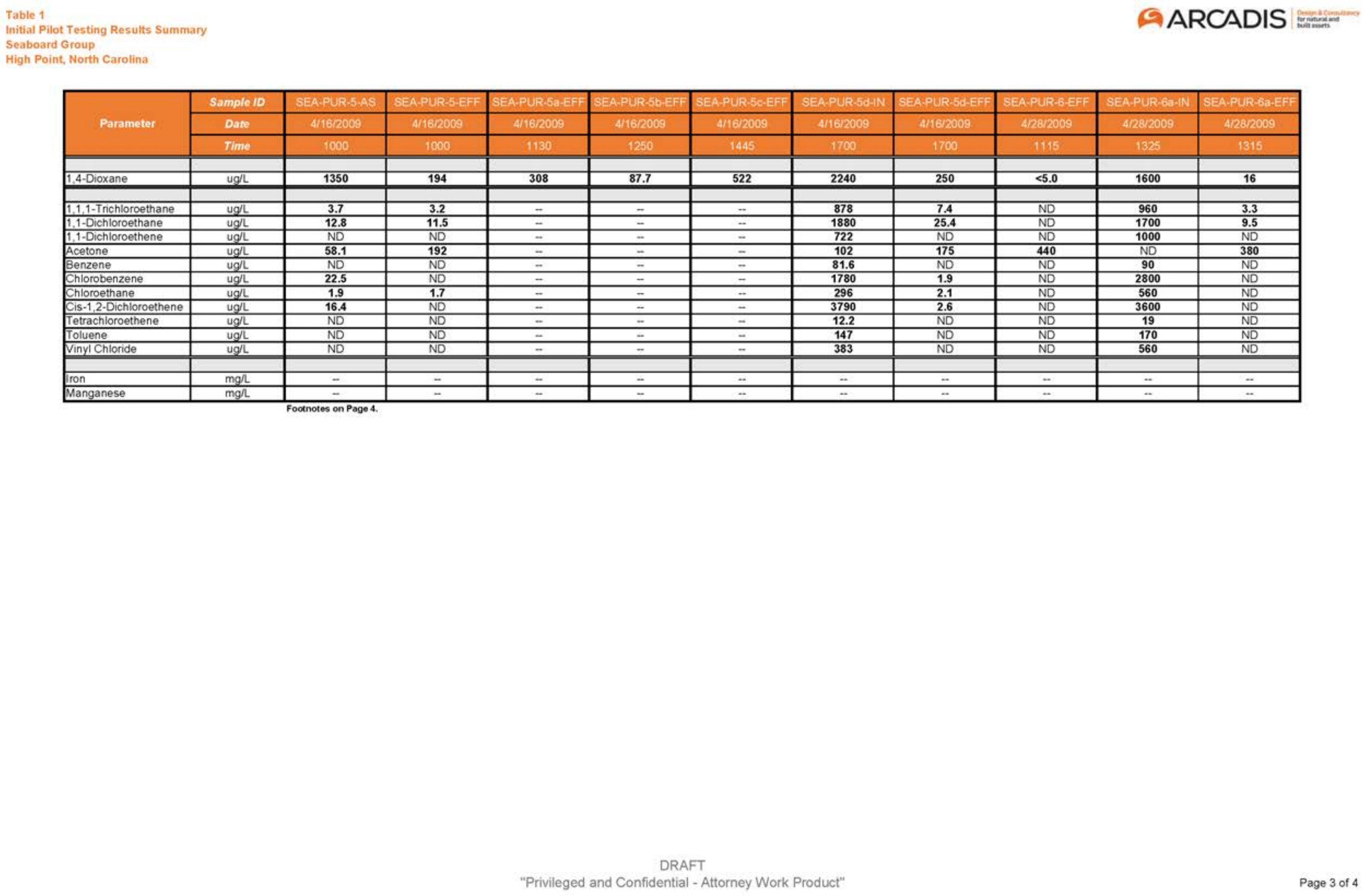

Table 1
Initial Pilot Testing Results Summary
Seaboard Group
High Point, North Carolina

Parameter	Sample ID	SEA-PUR-5-AS	SEA-PUR-5-EFF	SEA-PUR-5a-EFF	SEA-PUR-5b-EFF	SEA-PUR-5c-EFF	SEA-PUR-5d-IN	SEA-PUR-5d-EFF	SEA-PUR-6-EFF	SEA-PUR-6a-IN	SEA-PUR-6a-EFF
	Date	4/16/2009	4/16/2009	4/16/2009	4/16/2009	4/16/2009	4/16/2009	4/16/2009	4/28/2009	4/28/2009	4/28/2009
	Time	1000	1000	1130	1250	1445	1700	1700	1115	1325	1315
1,4-Dioxane	ug/L	**1350**	**194**	**308**	**87.7**	**522**	**2240**	**250**	**<5.0**	**1600**	**16**
1,1,1-Trichloroethane	ug/L	**3.7**	**3.2**	--	--	--	**878**	**7.4**	ND	**960**	**3.3**
1,1-Dichloroethane	ug/L	**12.8**	**11.5**	--	--	--	**1880**	**25.4**	ND	**1700**	**9.5**
1,1-Dichloroethene	ug/L	ND	ND	--	--	--	**722**	ND	ND	**1000**	ND
Acetone	ug/L	**58.1**	**192**	--	--	--	**102**	**175**	**440**	ND	**380**
Benzene	ug/L	ND	ND	--	--	--	**81.6**	ND	ND	**90**	ND
Chlorobenzene	ug/L	**22.5**	ND	--	--	--	**1780**	**1.9**	ND	**2800**	ND
Chloroethane	ug/L	**1.9**	**1.7**	--	--	--	**296**	**2.1**	ND	**560**	ND
Cis-1,2-Dichloroethene	ug/L	**16.4**	ND	--	--	--	**3790**	**2.6**	ND	**3600**	ND
Tetrachloroethene	ug/L	ND	ND	--	--	--	**12.2**	ND	ND	**19**	ND
Toluene	ug/L	ND	ND	--	--	--	**147**	ND	ND	**170**	ND
Vinyl Chloride	ug/L	ND	ND	--	--	--	**383**	ND	ND	**560**	ND
Iron	mg/L	--	--	--	--	--	--	--	--	--	--
Manganese	mg/L	--	--	--	--	--	--	--	--	--	--

Footnotes on Page 4.

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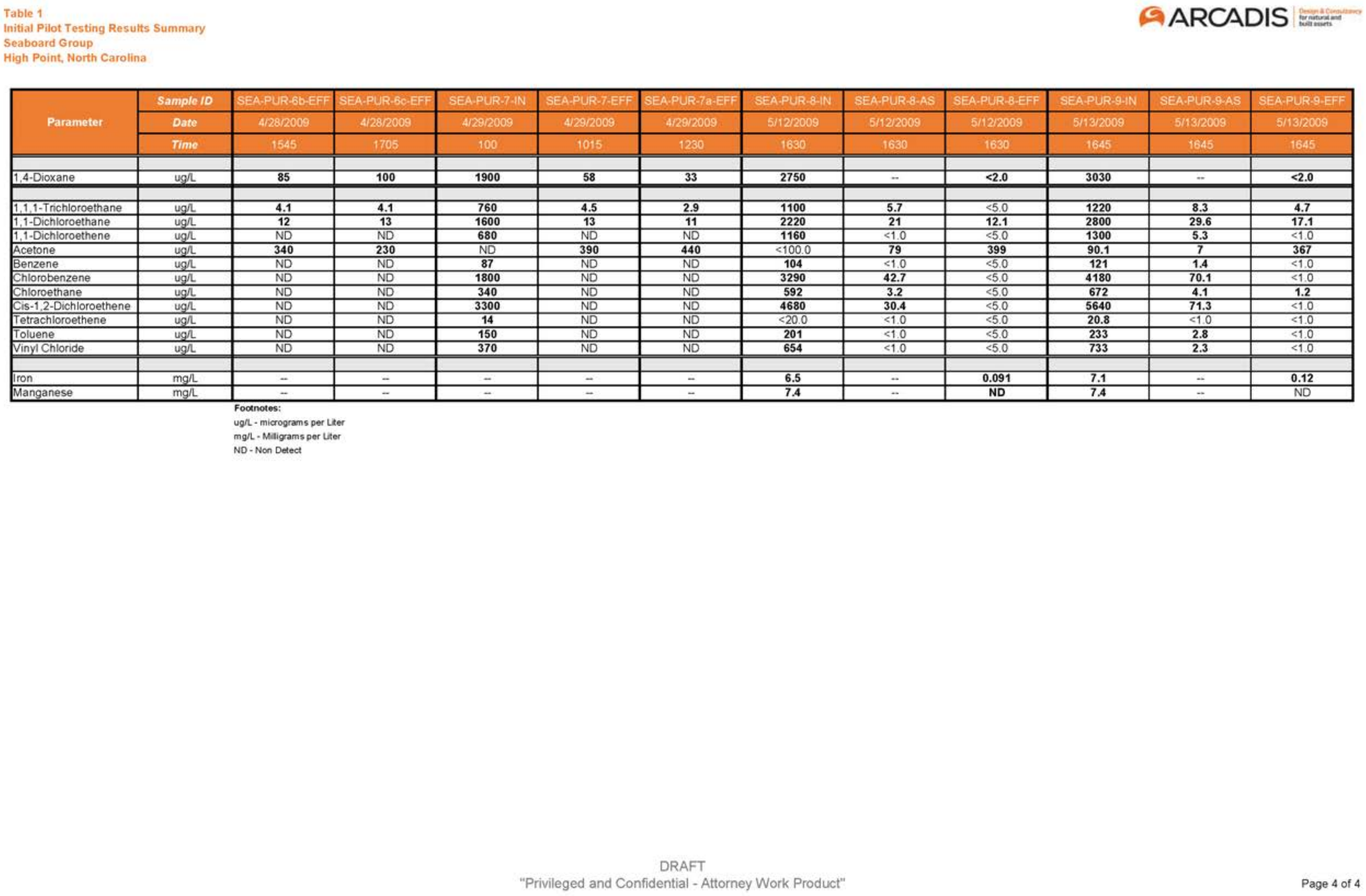

Table 1
Initial Pilot Testing Results Summary
Seaboard Group
High Point, North Carolina

ARCADIS Design & Consultancy for natural and built assets

Parameter	Sample ID	SEA-PUR-6b-EFF	SEA-PUR-6c-EFF	SEA-PUR-7-IN	SEA-PUR-7-EFF	SEA-PUR-7a-EFF	SEA-PUR-8-IN	SEA-PUR-8-AS	SEA-PUR-8-EFF	SEA-PUR-9-IN	SEA-PUR-9-AS	SEA-PUR-9-EFF
	Date	4/28/2009	4/28/2009	4/29/2009	4/29/2009	4/29/2009	5/12/2009	5/12/2009	5/12/2009	5/13/2009	5/13/2009	5/13/2009
	Time	1545	1705	100	1015	1230	1630	1630	1630	1645	1645	1645
1,4-Dioxane	ug/L	**85**	**100**	**1900**	**58**	**33**	**2750**	--	**<2.0**	**3030**	--	**<2.0**
1,1,1-Trichloroethane	ug/L	**4.1**	**4.1**	**760**	**4.5**	**2.9**	**1100**	**5.7**	<5.0	**1220**	**8.3**	**4.7**
1,1-Dichloroethane	ug/L	**12**	**13**	**1600**	**13**	**11**	**2220**	**21**	**12.1**	**2800**	**29.6**	**17.1**
1,1-Dichloroethene	ug/L	ND	ND	**680**	ND	ND	**1160**	<1.0	<5.0	**1300**	**5.3**	<1.0
Acetone	ug/L	**340**	**230**	ND	**390**	**440**	<100.0	**79**	**399**	**90.1**	**7**	**367**
Benzene	ug/L	ND	ND	**87**	ND	ND	**104**	<1.0	<5.0	**121**	**1.4**	<1.0
Chlorobenzene	ug/L	ND	ND	**1800**	ND	ND	**3290**	**42.7**	<5.0	**4180**	**70.1**	<1.0
Chloroethane	ug/L	ND	ND	**340**	ND	ND	**592**	**3.2**	<5.0	**672**	**4.1**	**1.2**
Cis-1,2-Dichloroethene	ug/L	ND	ND	**3300**	ND	ND	**4680**	**30.4**	<5.0	**5640**	**71.3**	<1.0
Tetrachloroethene	ug/L	ND	ND	**14**	ND	ND	<20.0	<1.0	<5.0	**20.8**	<1.0	<1.0
Toluene	ug/L	ND	ND	**150**	ND	ND	**201**	<1.0	<5.0	**233**	**2.8**	<1.0
Vinyl Chloride	ug/L	ND	ND	**370**	ND	ND	**654**	<1.0	<5.0	**733**	**2.3**	<1.0
Iron	mg/L	--	--	--	--	--	**6.5**	--	**0.091**	**7.1**	--	**0.12**
Manganese	mg/L	--	--	--	--	--	**7.4**	--	**ND**	**7.4**	--	ND

Footnotes:
ug/L - micrograms per Liter
mg/L - Milligrams per Liter
ND - Non Detect

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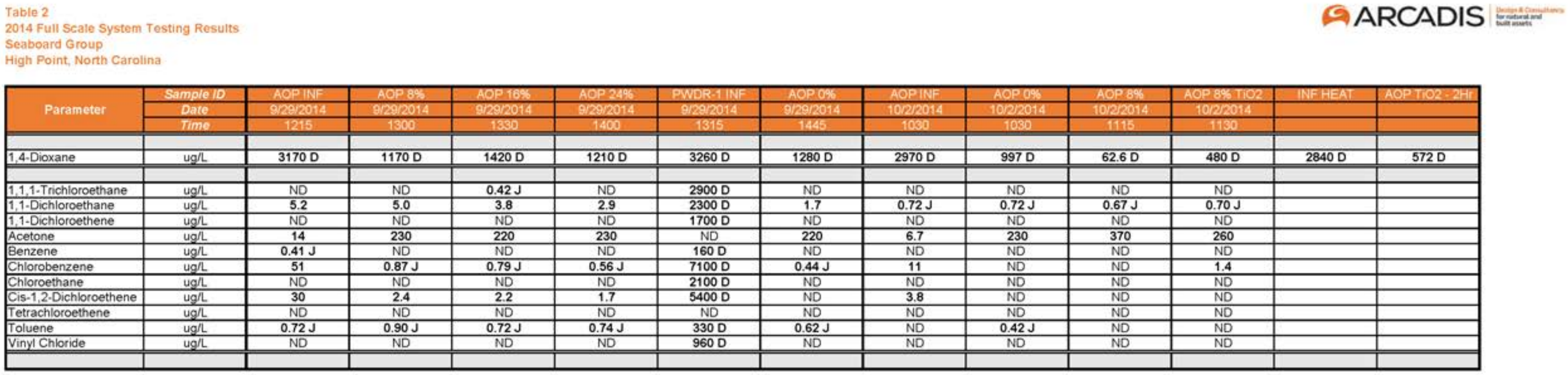

Table 2
2014 Full Scale System Testing Results
Seaboard Group
High Point, North Carolina

Parameter	Sample ID	AOP INF	AOP 8%	AOP 16%	AOP 24%	PWDR-1 INF	AOP 0%	AOP INF	AOP 0%	AOP 8%	AOP 8% TiO2	INF HEAT	AOP TiO2 - 2Hr
	Date	9/29/2014	9/29/2014	9/29/2014	9/29/2014	9/29/2014	9/29/2014	10/2/2014	10/2/2014	10/2/2014	10/2/2014		
	Time	1215	1300	1330	1400	1315	1445	1030	1030	1115	1130		
1,4-Dioxane	ug/L	3170 D	1170 D	1420 D	1210 D	3260 D	1280 D	2970 D	997 D	62.6 D	480 D	2840 D	572 D
1,1,1-Trichloroethane	ug/L	ND	ND	0.42 J	ND	2900 D	ND	ND	ND	ND	ND		
1,1-Dichloroethane	ug/L	5.2	5.0	3.8	2.9	2300 D	1.7	0.72 J	0.72 J	0.67 J	0.70 J		
1,1-Dichloroethene	ug/L	ND	ND	ND	ND	1700 D	ND	ND	ND	ND	ND		
Acetone	ug/L	14	230	220	230	ND	220	6.7	230	370	260		
Benzene	ug/L	0.41 J	ND	ND	ND	160 D	ND	ND	ND	ND	ND		
Chlorobenzene	ug/L	51	0.87 J	0.79 J	0.56 J	7100 D	0.44 J	11	ND	ND	1.4		
Chloroethane	ug/L	ND	ND	ND	ND	2100 D	ND	ND	ND	ND	ND		
Cis-1,2-Dichloroethene	ug/L	30	2.4	2.2	1.7	5400 D	ND	3.8	ND	ND	ND		
Tetrachloroethene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Toluene	ug/L	0.72 J	0.90 J	0.72 J	0.74 J	330 D	0.62 J	ND	0.42 J	ND	ND		
Vinyl Chloride	ug/L	ND	ND	ND	ND	960 D	ND	ND	ND	ND	ND		

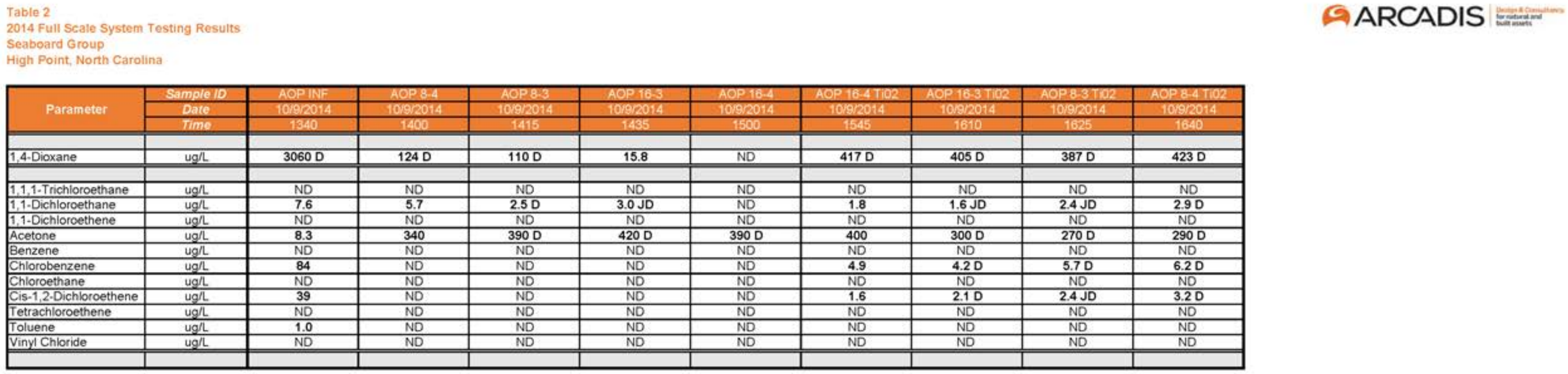

Table 2
2014 Full Scale System Testing Results
Seaboard Group
High Point, North Carolina

Parameter	Sample ID	AOP INF	AOP 8-4	AOP 8-3	AOP 16-3	AOP 16-4	AOP 16-4 Ti02	AOP 16-3 Ti02	AOP 8-3 Ti02	AOP 8-4 Ti02
	Date	10/9/2014	10/9/2014	10/9/2014	10/9/2014	10/9/2014	10/9/2014	10/9/2014	10/9/2014	10/9/2014
	Time	1340	1400	1415	1435	1500	1545	1610	1625	1640
1,4-Dioxane	ug/L	3060 D	124 D	110 D	15.8	ND	417 D	405 D	387 D	423 D
1,1,1-Trichloroethane	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,1-Dichloroethane	ug/L	7.6	5.7	2.5 D	3.0 JD	ND	1.8	1.6 JD	2.4 JD	2.9 D
1,1-Dichloroethene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acetone	ug/L	8.3	340	390 D	420 D	390 D	400	300 D	270 D	290 D
Benzene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Chlorobenzene	ug/L	84	ND	ND	ND	ND	4.9	4.2 D	5.7 D	6.2 D
Chloroethane	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cis-1,2-Dichloroethene	ug/L	39	ND	ND	ND	ND	1.6	2.1 D	2.4 JD	3.2 D
Tetrachloroethene	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND
Toluene	ug/L	1.0	ND	ND	ND	ND	ND	ND	ND	ND
Vinyl Chloride	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND

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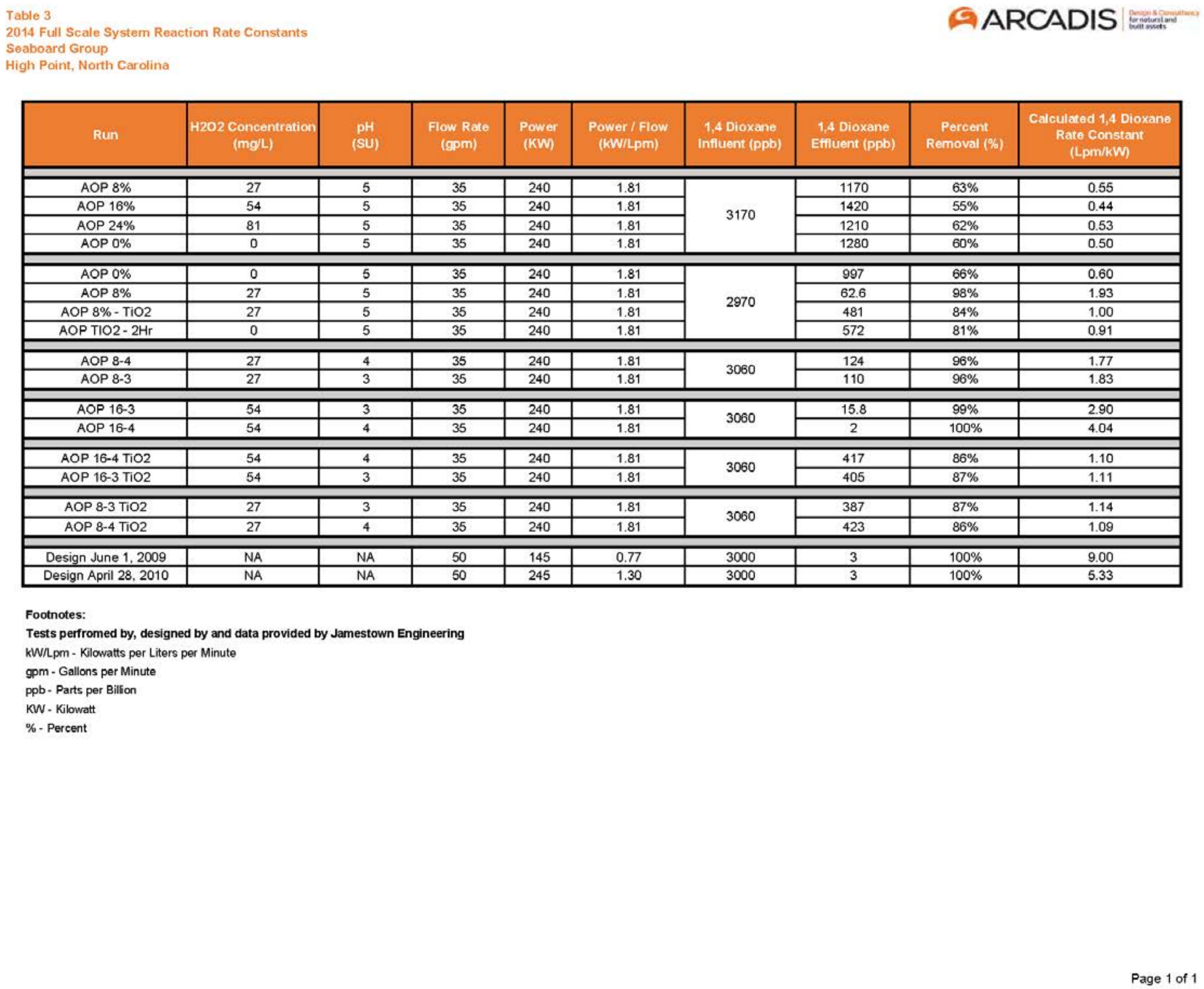


Table 3
2014 Full Scale System Reaction Rate Constants
Seaboard Group
High Point, North Carolina

ARCADIS Design & Consultancy for natural and built assets

Run	H2O2 Concentration (mg/L)	pH (SU)	Flow Rate (gpm)	Power (KW)	Power / Flow (kW/Lpm)	1,4 Dioxane Influent (ppb)	1,4 Dioxane Effluent (ppb)	Percent Removal (%)	Calculated 1,4 Dioxane Rate Constant (Lpm/kW)
AOP 8%	27	5	35	240	1.81	3170	1170	63%	0.55
AOP 16%	54	5	35	240	1.81		1420	55%	0.44
AOP 24%	81	5	35	240	1.81		1210	62%	0.53
AOP 0%	0	5	35	240	1.81		1280	60%	0.50
AOP 0%	0	5	35	240	1.81	2970	997	66%	0.60
AOP 8%	27	5	35	240	1.81		62.6	98%	1.93
AOP 8% - TiO2	27	5	35	240	1.81		481	84%	1.00
AOP TIO2 - 2Hr	0	5	35	240	1.81		572	81%	0.91
AOP 8-4	27	4	35	240	1.81	3060	124	96%	1.77
AOP 8-3	27	3	35	240	1.81		110	96%	1.83
AOP 16-3	54	3	35	240	1.81	3060	15.8	99%	2.90
AOP 16-4	54	4	35	240	1.81		2	100%	4.04
AOP 16-4 TiO2	54	4	35	240	1.81	3060	417	86%	1.10
AOP 16-3 TiO2	54	3	35	240	1.81		405	87%	1.11
AOP 8-3 TiO2	27	3	35	240	1.81	3060	387	87%	1.14
AOP 8-4 TiO2	27	4	35	240	1.81		423	86%	1.09
Design June 1, 2009	NA	NA	50	145	0.77	3000	3	100%	9.00
Design April 28, 2010	NA	NA	50	245	1.30	3000	3	100%	5.33

Footnotes:

Tests perfromed by, designed by and data provided by Jamestown Engineering

kW/Lpm - Kilowatts per Liters per Minute

gpm - Gallons per Minute

ppb - Parts per Billion

KW - Kilowatt

% - Percent

Page 1 of 1

Table 4
Influent Water Quality Data
Seaboard Group II
High Point, North Carolina

Parameter	Method	Units	Raw Influent [1]	Photo-Cat Influent [2]
Chemicals of Concern - 1,4-Dioxane				
1,4-Dioxane	8260C	ug/L	3,300	2,800
Chemicals of Concern - Volatile Organic Compounds				
1,1,1-Trichloroethane	8260B	ug/L	2,000	2.5
1,1-Dichloroethane	8260B	ug/L	1,900	11
1,1-Dichloroethene	8260B	ug/L	1,400	0.62
Acetone	8260B	ug/L	1,000	38
Benzene	8260B	ug/L	110	0.72
Chlorobenzene	8260B	ug/L	5,600	73
Chloroethane	8260B	ug/L	1,600	2.4
cis-1,2-Dichloroethene	8260B	ug/L	5,000	52
Tetrachloroethene	8260B	ug/L	17	0.17
Toluene	8260B	ug/L	220	1.2
Vinyl chloride	8260B	ug/L	1,700	0.67
General Water Quality Parameters				
Calcium	6010D	mg/L	154	203
Magnesium	6010D	mg/L	67.5	69.3
Iron	6010D	mg/L	7.25	0.58
Manganese	6010D	mg/L	5.69	4.22
Potassium	6010D	mg/L	9.33	14
Sodium	6010D	mg/L	59.5	73.8
Bicarbonate (as CaCO3)	4500	mg/L	640	14
pH (SU)	4500	mg/L	6.4	2.9
Total Alkalinity as CaCO3	310.2	mg/L	640	14
Hardness	2340B	mg/L	660	790
Calcium Hardness	2340B	mg/L	390	510
Magnesium Hardness	2340B	mg/L	280	280
Bromide	300.0	mg/L	2.1 - 10 [3]	7.5 - 14
Chloride	300.0	mg/L	190	400
Sulfate as SO4	300	mg/L	9.3	57
Nitrate as N	353.2	mg/L	0.025	0.025
Nitrite as N	354.2	mg/L	0.017	0.017
Nitrate/Nitrite as N	355.2	mg/L	0.041	0.041
Total Dissolved Solids	2540C	mg/L	960	1,800
Total Suspended Solids	2540D	mg/L	16	2.5
Chemical Oxygen Demand	5220D	mg/L	120	99
Total Organic Carbon	5310B	mg/L	22	21

Footnotes:

[1] Sample ID "TEST 0 INF 80116" - collected on 8-01-2016, influent water made up of groundwater and leachate, estimated to be 80-90% groundwater and 10-20% leachate

[2] Sample ID "Test 0 PC INF 80116" - collected after pre-treatment system and directly prior to the Purifics Phot-Cat Unit

[3] There was an initial influent sample with a bromide detection of 2.1 mg/L, additional bromide data was collecting indicating that the well PWDR-1 was 6.0 mg/L and the leachate was 10.0 mg/L. This range in bromide concentrations is reflected here.

[4] This is the range of bromide concentrations observed from seven Photo-Cat influent bromide samples collected during the test.

mg/L - milligrams per Liter

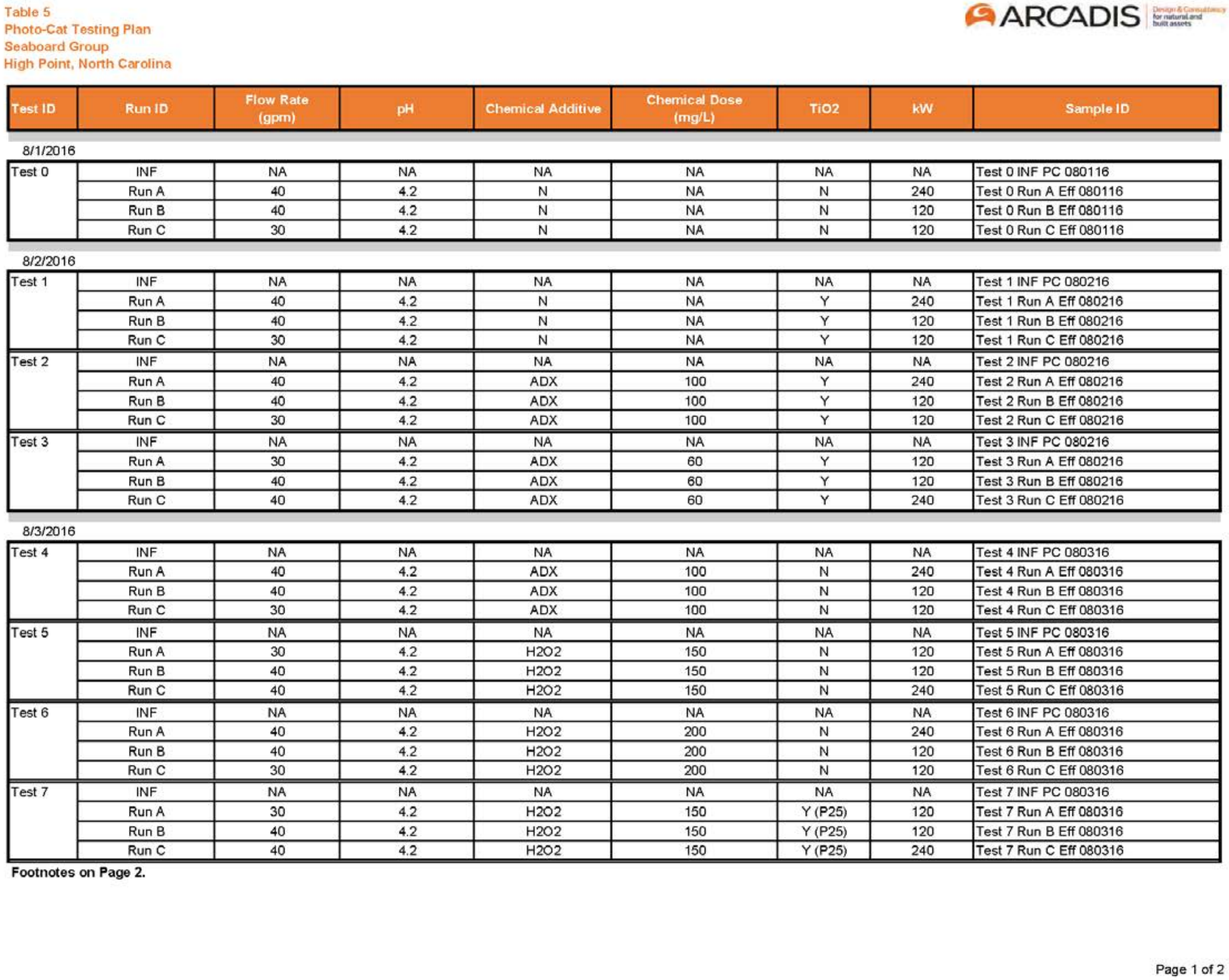
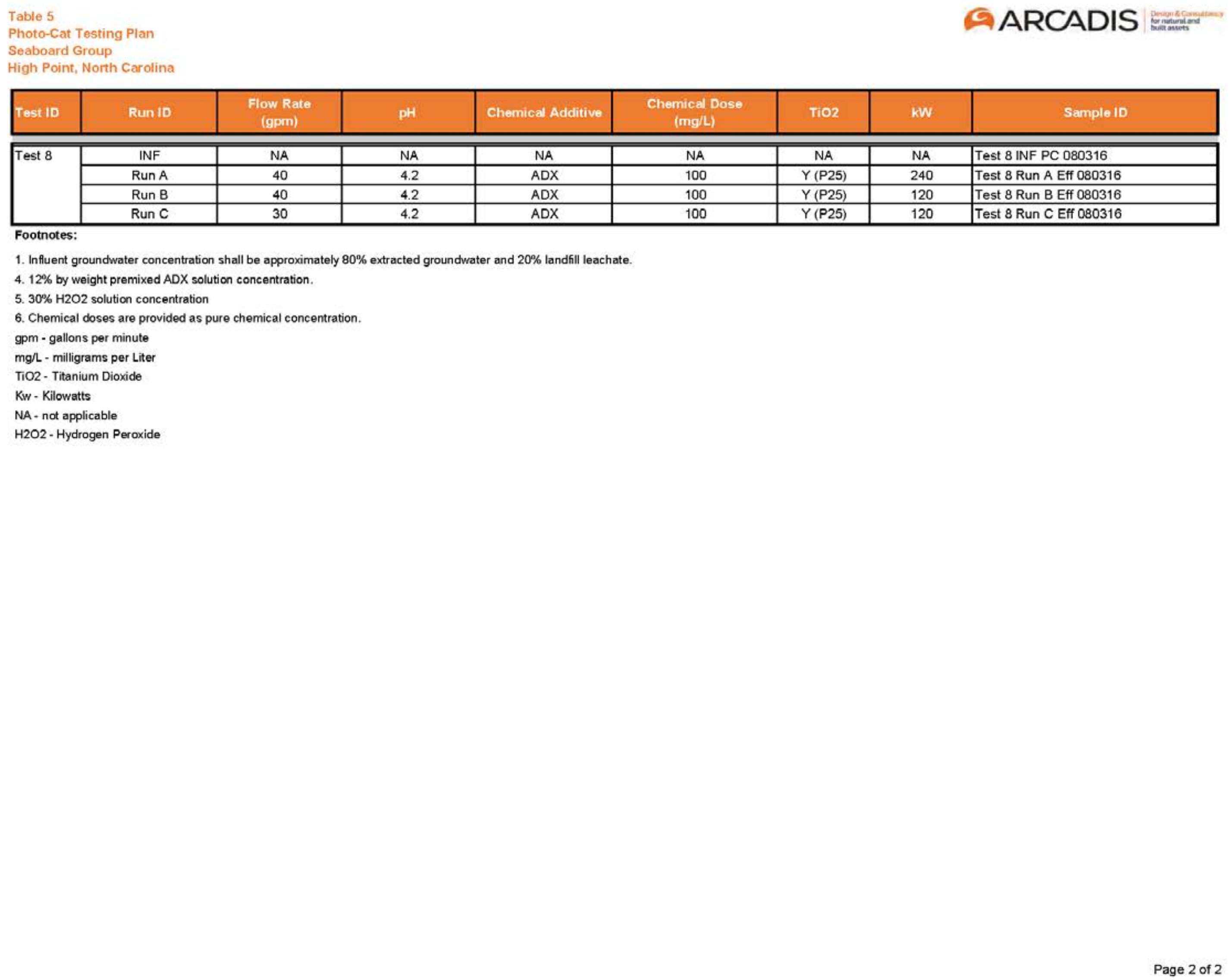


Table 5
Photo-Cat Testing Plan
Seaboard Group
High Point, North Carolina

ARCADIS Design & Consultancy for natural and built assets

Test ID	Run ID	Flow Rate (gpm)	pH	Chemical Additive	Chemical Dose (mg/L)	TiO2	kW	Sample ID
8/1/2016								
Test 0	INF	NA	NA	NA	NA	NA	NA	Test 0 INF PC 080116
	Run A	40	4.2	N	NA	N	240	Test 0 Run A Eff 080116
	Run B	40	4.2	N	NA	N	120	Test 0 Run B Eff 080116
	Run C	30	4.2	N	NA	N	120	Test 0 Run C Eff 080116
8/2/2016								
Test 1	INF	NA	NA	NA	NA	NA	NA	Test 1 INF PC 080216
	Run A	40	4.2	N	NA	Y	240	Test 1 Run A Eff 080216
	Run B	40	4.2	N	NA	Y	120	Test 1 Run B Eff 080216
	Run C	30	4.2	N	NA	Y	120	Test 1 Run C Eff 080216
Test 2	INF	NA	NA	NA	NA	NA	NA	Test 2 INF PC 080216
	Run A	40	4.2	ADX	100	Y	240	Test 2 Run A Eff 080216
	Run B	40	4.2	ADX	100	Y	120	Test 2 Run B Eff 080216
	Run C	30	4.2	ADX	100	Y	120	Test 2 Run C Eff 080216
Test 3	INF	NA	NA	NA	NA	NA	NA	Test 3 INF PC 080216
	Run A	30	4.2	ADX	60	Y	120	Test 3 Run A Eff 080216
	Run B	40	4.2	ADX	60	Y	120	Test 3 Run B Eff 080216
	Run C	40	4.2	ADX	60	Y	240	Test 3 Run C Eff 080216
8/3/2016								
Test 4	INF	NA	NA	NA	NA	NA	NA	Test 4 INF PC 080316
	Run A	40	4.2	ADX	100	N	240	Test 4 Run A Eff 080316
	Run B	40	4.2	ADX	100	N	120	Test 4 Run B Eff 080316
	Run C	30	4.2	ADX	100	N	120	Test 4 Run C Eff 080316
Test 5	INF	NA	NA	NA	NA	NA	NA	Test 5 INF PC 080316
	Run A	30	4.2	H2O2	150	N	120	Test 5 Run A Eff 080316
	Run B	40	4.2	H2O2	150	N	120	Test 5 Run B Eff 080316
	Run C	40	4.2	H2O2	150	N	240	Test 5 Run C Eff 080316
Test 6	INF	NA	NA	NA	NA	NA	NA	Test 6 INF PC 080316
	Run A	40	4.2	H2O2	200	N	240	Test 6 Run A Eff 080316
	Run B	40	4.2	H2O2	200	N	120	Test 6 Run B Eff 080316
	Run C	30	4.2	H2O2	200	N	120	Test 6 Run C Eff 080316
Test 7	INF	NA	NA	NA	NA	NA	NA	Test 7 INF PC 080316
	Run A	30	4.2	H2O2	150	Y (P25)	120	Test 7 Run A Eff 080316
	Run B	40	4.2	H2O2	150	Y (P25)	120	Test 7 Run B Eff 080316
	Run C	40	4.2	H2O2	150	Y (P25)	240	Test 7 Run C Eff 080316

Footnotes on Page 2.



ARCADIS Design & Consultancy for natural and built assets

Table 5
Photo-Cat Testing Plan
Seaboard Group
High Point, North Carolina

Test ID	Run ID	Flow Rate (gpm)	pH	Chemical Additive	Chemical Dose (mg/L)	TiO2	kW	Sample ID
Test 8	INF	NA	NA	NA	NA	NA	NA	Test 8 INF PC 080316
	Run A	40	4.2	ADX	100	Y (P25)	240	Test 8 Run A Eff 080316
	Run B	40	4.2	ADX	100	Y (P25)	120	Test 8 Run B Eff 080316
	Run C	30	4.2	ADX	100	Y (P25)	120	Test 8 Run C Eff 080316

Footnotes:

1. Influent groundwater concentration shall be approximately 80% extracted groundwater and 20% landfill leachate.

4. 12% by weight premixed ADX solution concentration.

5. 30% H_2O_2 solution concentration

6. Chemical doses are provided as pure chemical concentration.

gpm - gallons per minute
mg/L - milligrams per Liter
TiO_2 - Titanium Dioxide
Kw - Kilowatts
NA - not applicable
H_2O_2 - Hydrogen Peroxide

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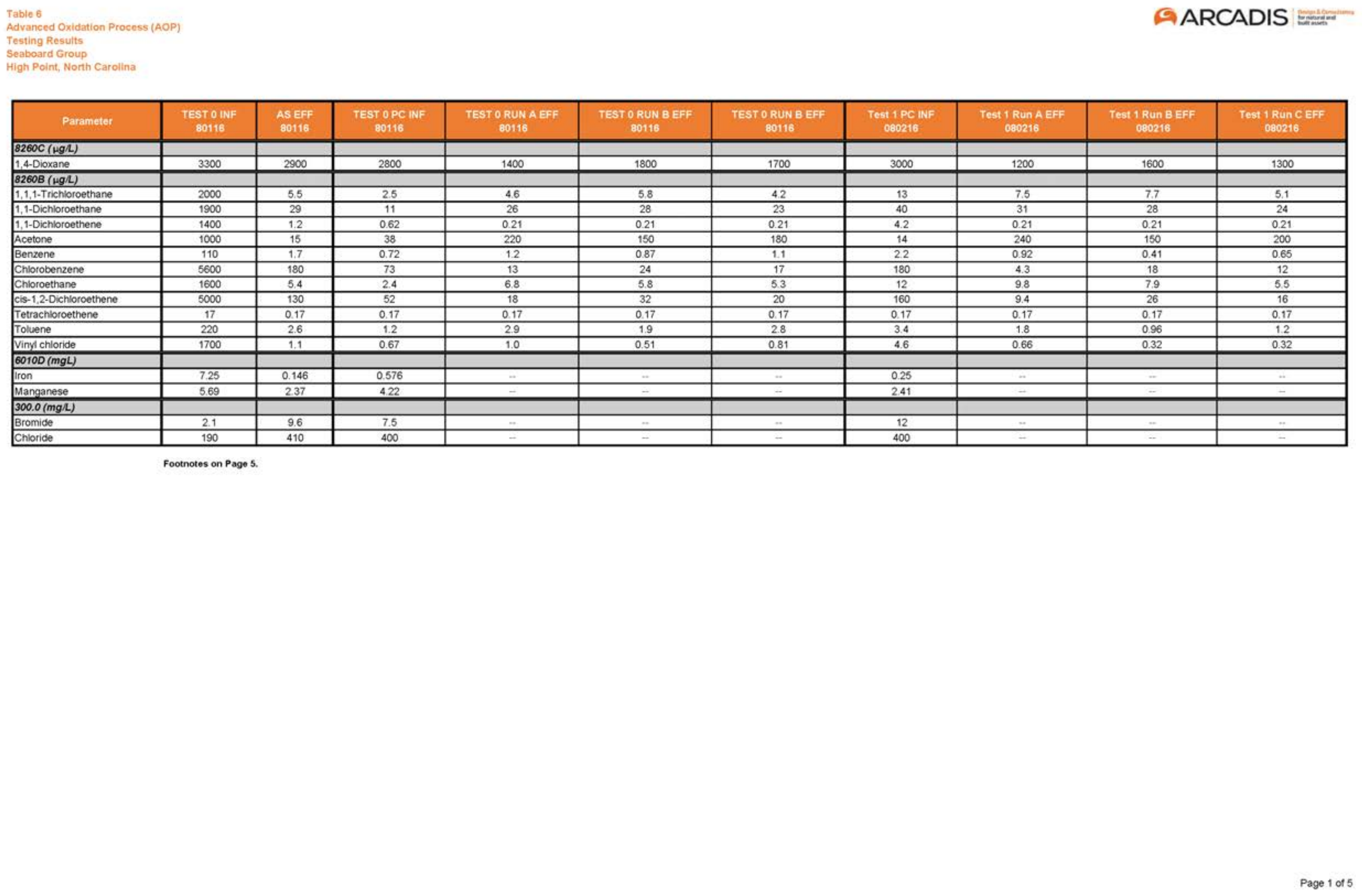

Table 6
Advanced Oxidation Process (AOP)
Testing Results
Seaboard Group
High Point, North Carolina

Parameter	TEST 0 INF 80116	AS EFF 80116	TEST 0 PC INF 80116	TEST 0 RUN A EFF 80116	TEST 0 RUN B EFF 80116	TEST 0 RUN B EFF 80116	Test 1 PC INF 080216	Test 1 Run A EFF 080216	Test 1 Run B EFF 080216	Test 1 Run C EFF 080216
8260C (µg/L)										
1,4-Dioxane	3300	2900	2800	1400	1800	1700	3000	1200	1600	1300
8260B (µg/L)										
1,1,1-Trichloroethane	2000	5.5	2.5	4.6	5.8	4.2	13	7.5	7.7	5.1
1,1-Dichloroethane	1900	29	11	26	28	23	40	31	28	24
1,1-Dichloroethene	1400	1.2	0.62	0.21	0.21	0.21	4.2	0.21	0.21	0.21
Acetone	1000	15	38	220	150	180	14	240	150	200
Benzene	110	1.7	0.72	1.2	0.87	1.1	2.2	0.92	0.41	0.65
Chlorobenzene	5600	180	73	13	24	17	180	4.3	18	12
Chloroethane	1600	5.4	2.4	6.8	5.8	5.3	12	9.8	7.9	5.5
cis-1,2-Dichloroethene	5000	130	52	18	32	20	160	9.4	26	16
Tetrachloroethene	17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Toluene	220	2.6	1.2	2.9	1.9	2.8	3.4	1.8	0.96	1.2
Vinyl chloride	1700	1.1	0.67	1.0	0.51	0.81	4.6	0.66	0.32	0.32
6010D (mgL)										
Iron	7.25	0.146	0.576	--	--	--	0.25	--	--	--
Manganese	5.69	2.37	4.22	--	--	--	2.41	--	--	--
300.0 (mg/L)										
Bromide	2.1	9.6	7.5	--	--	--	12	--	--	--
Chloride	190	410	400	--	--	--	400	--	--	--

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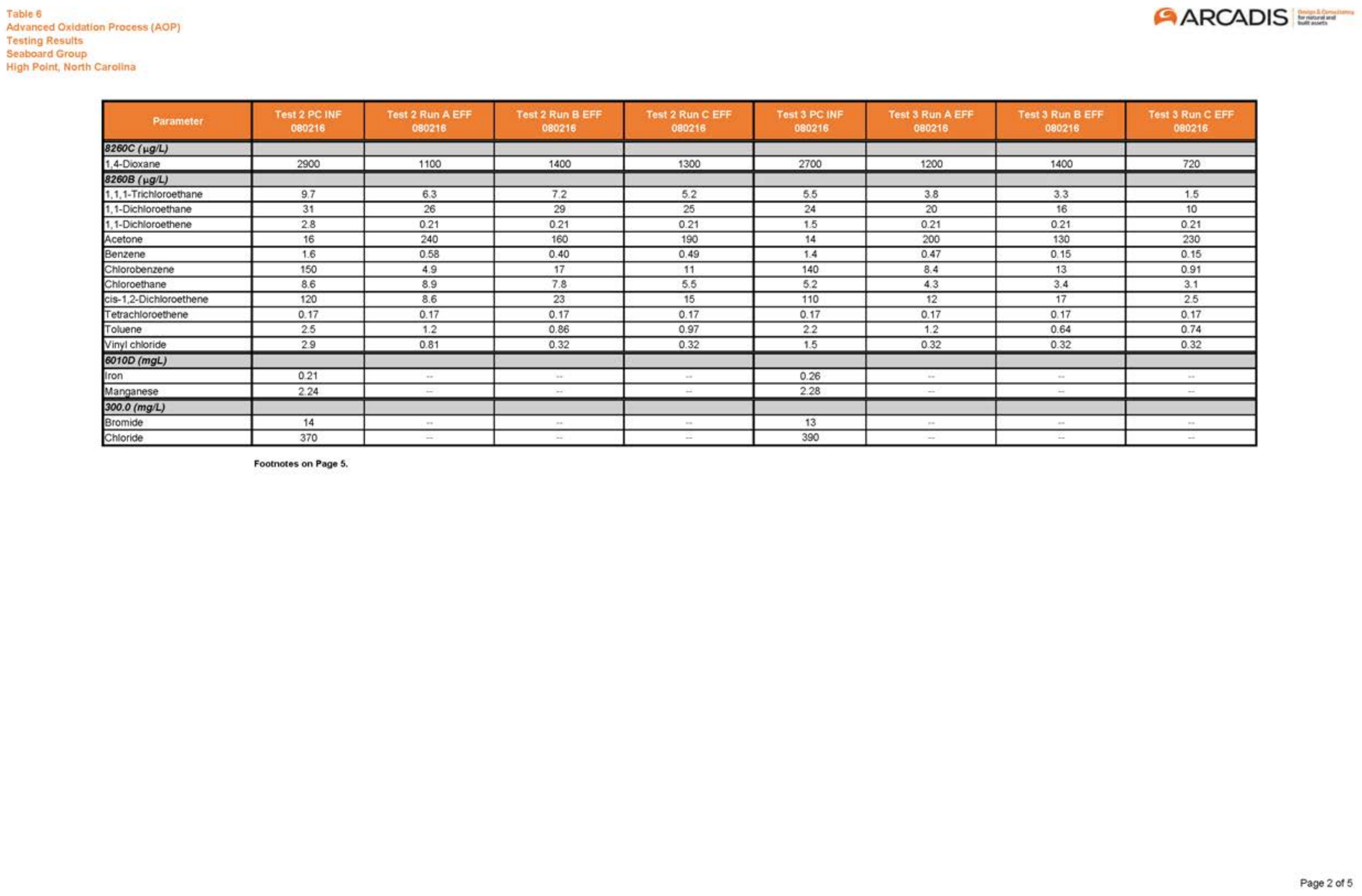

Table 6
Advanced Oxidation Process (AOP)
Testing Results
Seaboard Group
High Point, North Carolina

Parameter	Test 2 PC INF 080216	Test 2 Run A EFF 080216	Test 2 Run B EFF 080216	Test 2 Run C EFF 080216	Test 3 PC INF 080216	Test 3 Run A EFF 080216	Test 3 Run B EFF 080216	Test 3 Run C EFF 080216
8260C (µg/L)								
1,4-Dioxane	2900	1100	1400	1300	2700	1200	1400	720
8260B (µg/L)								
1,1,1-Trichloroethane	9.7	6.3	7.2	5.2	5.5	3.8	3.3	1.5
1,1-Dichloroethane	31	26	29	25	24	20	16	10
1,1-Dichloroethene	2.8	0.21	0.21	0.21	1.5	0.21	0.21	0.21
Acetone	16	240	160	190	14	200	130	230
Benzene	1.6	0.58	0.40	0.49	1.4	0.47	0.15	0.15
Chlorobenzene	150	4.9	17	11	140	8.4	13	0.91
Chloroethane	8.6	8.9	7.8	5.5	5.2	4.3	3.4	3.1
cis-1,2-Dichloroethene	120	8.6	23	15	110	12	17	2.5
Tetrachloroethene	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Toluene	2.5	1.2	0.86	0.97	2.2	1.2	0.64	0.74
Vinyl chloride	2.9	0.81	0.32	0.32	1.5	0.32	0.32	0.32
6010D (mgL)								
Iron	0.21	--	--	--	0.26	--	--	--
Manganese	2.24	--	--	--	2.28	--	--	--
300.0 (mg/L)								
Bromide	14	--	--	--	13	--	--	--
Chloride	370	--	--	--	390	--	--	--

Footnotes on Page 5.

Page 2 of 5

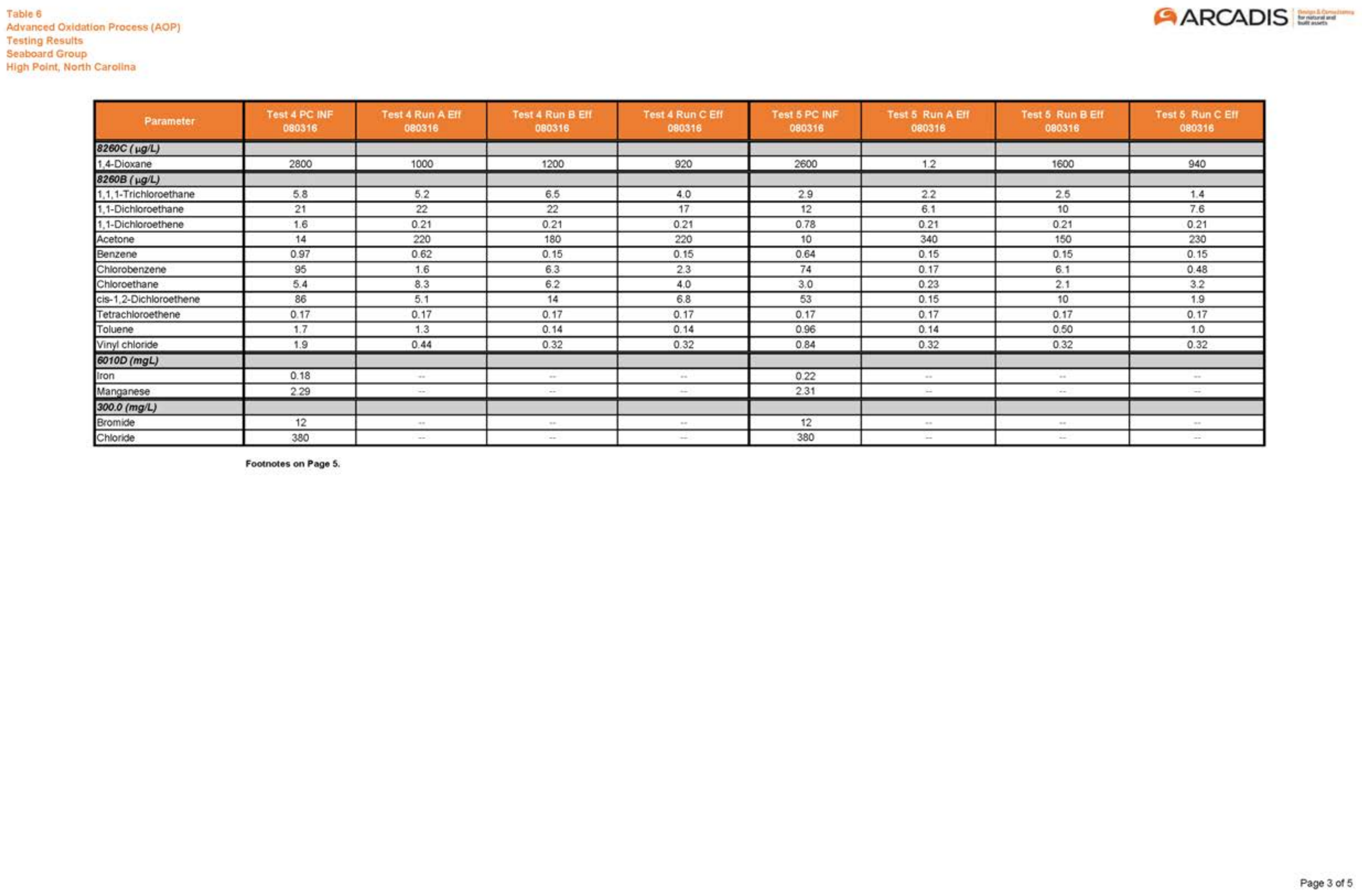

Table 6
Advanced Oxidation Process (AOP)
Testing Results
Seaboard Group
High Point, North Carolina

ARCADIS

Parameter	Test 4 PC INF 080316	Test 4 Run A Eff 080316	Test 4 Run B Eff 080316	Test 4 Run C Eff 080316	Test 5 PC INF 080316	Test 5 Run A Eff 080316	Test 5 Run B Eff 080316	Test 5 Run C Eff 080316
8260C (µg/L)								
1,4-Dioxane	2800	1000	1200	920	2600	1.2	1600	940
8260B (µg/L)								
1,1,1-Trichloroethane	5.8	5.2	6.5	4.0	2.9	2.2	2.5	1.4
1,1-Dichloroethane	21	22	22	17	12	6.1	10	7.6
1,1-Dichloroethene	1.6	0.21	0.21	0.21	0.78	0.21	0.21	0.21
Acetone	14	220	180	220	10	340	150	230
Benzene	0.97	0.62	0.15	0.15	0.64	0.15	0.15	0.15
Chlorobenzene	95	1.6	6.3	2.3	74	0.17	6.1	0.48
Chloroethane	5.4	8.3	6.2	4.0	3.0	0.23	2.1	3.2
cis-1,2-Dichloroethene	86	5.1	14	6.8	53	0.15	10	1.9
Tetrachloroethene	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Toluene	1.7	1.3	0.14	0.14	0.96	0.14	0.50	1.0
Vinyl chloride	1.9	0.44	0.32	0.32	0.84	0.32	0.32	0.32
6010D (mgL)								
Iron	0.18	--	--	--	0.22	--	--	--
Manganese	2.29	--	--	--	2.31	--	--	--
300.0 (mg/L)								
Bromide	12	--	--	--	12	--	--	--
Chloride	380	--	--	--	380	--	--	--

Footnotes on Page 5.

Page 3 of 5

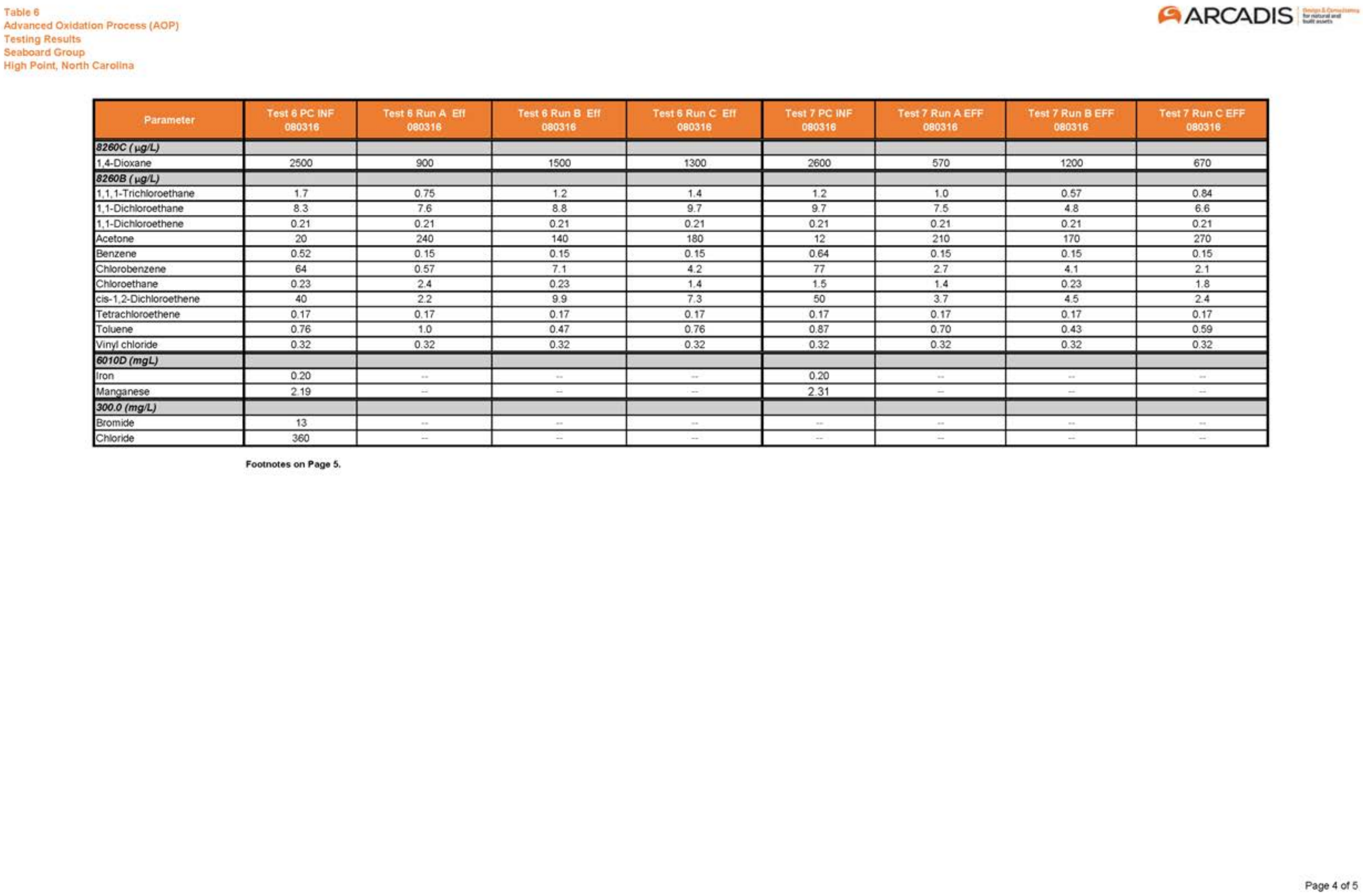

Table 6
Advanced Oxidation Process (AOP)
Testing Results
Seaboard Group
High Point, North Carolina

ARCADIS

Parameter	Test 6 PC INF 080316	Test 6 Run A Eff 080316	Test 6 Run B Eff 080316	Test 6 Run C Eff 080316	Test 7 PC INF 080316	Test 7 Run A EFF 080316	Test 7 Run B EFF 080316	Test 7 Run C EFF 080316
8260C (µg/L)								
1,4-Dioxane	2500	900	1500	1300	2600	570	1200	670
8260B (µg/L)								
1,1,1-Trichloroethane	1.7	0.75	1.2	1.4	1.2	1.0	0.57	0.84
1,1-Dichloroethane	8.3	7.6	8.8	9.7	9.7	7.5	4.8	6.6
1,1-Dichloroethene	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
Acetone	20	240	140	180	12	210	170	270
Benzene	0.52	0.15	0.15	0.15	0.64	0.15	0.15	0.15
Chlorobenzene	64	0.57	7.1	4.2	77	2.7	4.1	2.1
Chloroethane	0.23	2.4	0.23	1.4	1.5	1.4	0.23	1.8
cis-1,2-Dichloroethene	40	2.2	9.9	7.3	50	3.7	4.5	2.4
Tetrachloroethene	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17
Toluene	0.76	1.0	0.47	0.76	0.87	0.70	0.43	0.59
Vinyl chloride	0.32	0.32	0.32	0.32	0.32	0.32	0.32	0.32
6010D (mgL)								
Iron	0.20	--	--	--	0.20	--	--	--
Manganese	2.19	--	--	--	2.31	--	--	--
300.0 (mg/L)								
Bromide	13	--	--	--	--	--	--	--
Chloride	360	--	--	--	--	--	--	--

Footnotes on Page 5.

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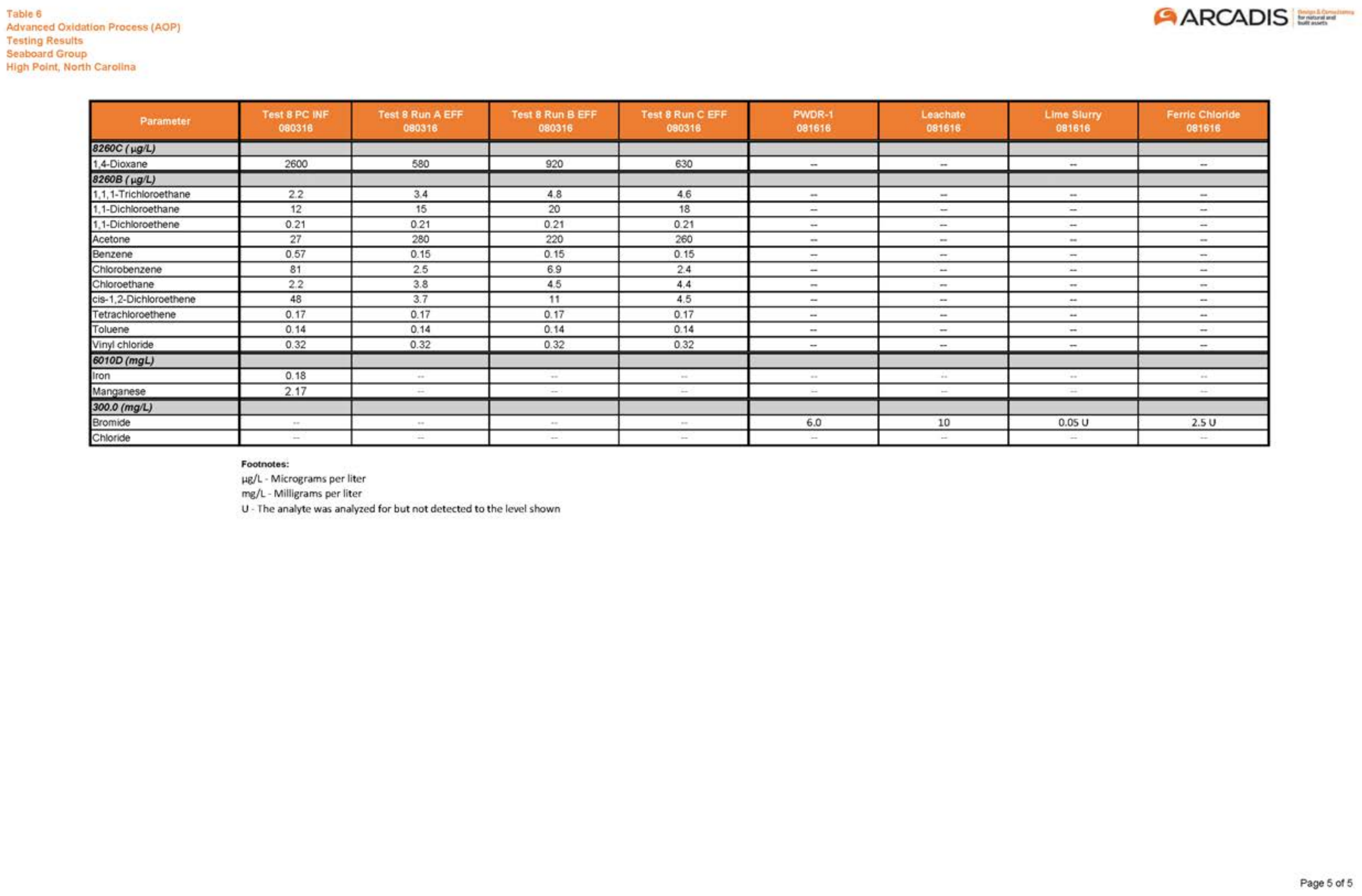

Table 6
Advanced Oxidation Process (AOP)
Testing Results
Seaboard Group
High Point, North Carolina

ARCADIS

Parameter	Test 8 PC INF 080316	Test 8 Run A EFF 080316	Test 8 Run B EFF 080316	Test 8 Run C EFF 080316	PWDR-1 081616	Leachate 081616	Lime Slurry 081616	Ferric Chloride 081616
8260C (µg/L)								
1,4-Dioxane	2600	580	920	630	--	--	--	--
8260B (µg/L)								
1,1,1-Trichloroethane	2.2	3.4	4.8	4.6	--	--	--	--
1,1-Dichloroethane	12	15	20	18	--	--	--	--
1,1-Dichloroethene	0.21	0.21	0.21	0.21	--	--	--	--
Acetone	27	280	220	260	--	--	--	--
Benzene	0.57	0.15	0.15	0.15	--	--	--	--
Chlorobenzene	81	2.5	6.9	2.4	--	--	--	--
Chloroethane	2.2	3.8	4.5	4.4	--	--	--	--
cis-1,2-Dichloroethene	48	3.7	11	4.5	--	--	--	--
Tetrachloroethene	0.17	0.17	0.17	0.17	--	--	--	--
Toluene	0.14	0.14	0.14	0.14	--	--	--	--
Vinyl chloride	0.32	0.32	0.32	0.32	--	--	--	--
6010D (mgL)								
Iron	0.18	--	--	--	--	--	--	--
Manganese	2.17	--	--	--	--	--	--	--
300.0 (mg/L)								
Bromide	--	--	--	--	6.0	10	0.05 U	2.5 U
Chloride	--	--	--	--	--	--	--	--

Footnotes:
µg/L - Micrograms per liter
mg/L - Milligrams per liter
U - The analyte was analyzed for but not detected to the level shown

Page 5 of 5

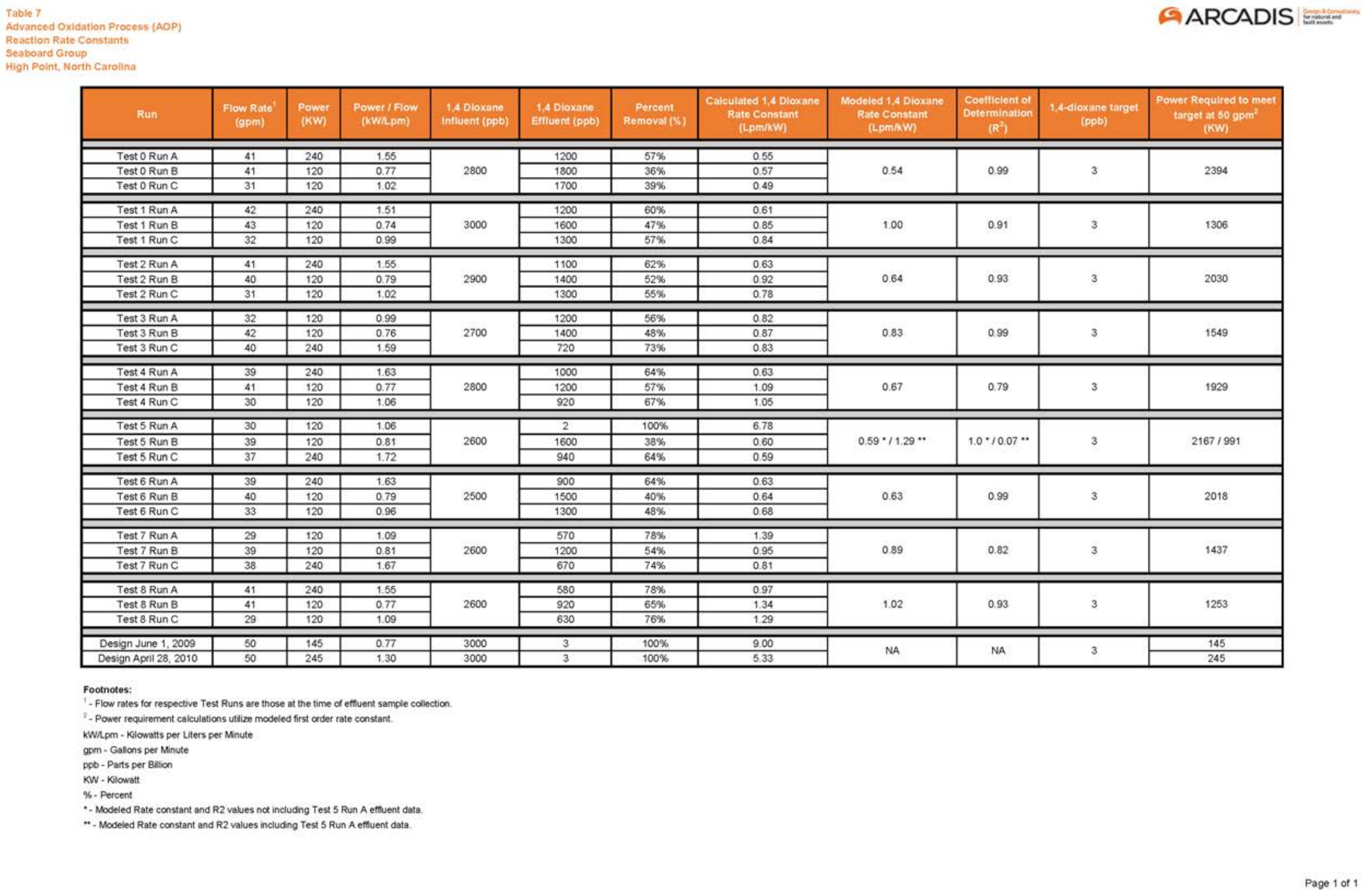

Table 7
Advanced Oxidation Process (AOP)
Reaction Rate Constants
Seaboard Group
High Point, North Carolina

ARCADIS

Run	Flow Rate[1] (gpm)	Power (KW)	Power / Flow (kW/Lpm)	1,4 Dioxane Influent (ppb)	1,4 Dioxane Effluent (ppb)	Percent Removal (%)	Calculated 1,4 Dioxane Rate Constant (Lpm/kW)	Modeled 1,4 Dioxane Rate Constant (Lpm/kW)	Coefficient of Determination (R^2)	1,4-dioxane target (ppb)	Power Required to meet target at 50 gpm[2] (KW)
Test 0 Run A	41	240	1.55	2800	1200	57%	0.55	0.54	0.99	3	2394
Test 0 Run B	41	120	0.77		1800	36%	0.57				
Test 0 Run C	31	120	1.02		1700	39%	0.49				
Test 1 Run A	42	240	1.51	3000	1200	60%	0.61	1.00	0.91	3	1306
Test 1 Run B	43	120	0.74		1600	47%	0.85				
Test 1 Run C	32	120	0.99		1300	57%	0.84				
Test 2 Run A	41	240	1.55	2900	1100	62%	0.63	0.64	0.93	3	2030
Test 2 Run B	40	120	0.79		1400	52%	0.92				
Test 2 Run C	31	120	1.02		1300	55%	0.78				
Test 3 Run A	32	120	0.99	2700	1200	56%	0.82	0.83	0.99	3	1549
Test 3 Run B	42	120	0.76		1400	48%	0.87				
Test 3 Run C	40	240	1.59		720	73%	0.83				
Test 4 Run A	39	240	1.63	2800	1000	64%	0.63	0.67	0.79	3	1929
Test 4 Run B	41	120	0.77		1200	57%	1.09				
Test 4 Run C	30	120	1.06		920	67%	1.05				
Test 5 Run A	30	120	1.06	2600	2	100%	6.78	0.59 * / 1.29 **	1.0 * / 0.07 **	3	2167 / 991
Test 5 Run B	39	120	0.81		1600	38%	0.60				
Test 5 Run C	37	240	1.72		940	64%	0.59				
Test 6 Run A	39	240	1.63	2500	900	64%	0.63	0.63	0.99	3	2018
Test 6 Run B	40	120	0.79		1500	40%	0.64				
Test 6 Run C	33	120	0.96		1300	48%	0.68				
Test 7 Run A	29	120	1.09	2600	570	78%	1.39	0.89	0.82	3	1437
Test 7 Run B	39	120	0.81		1200	54%	0.95				
Test 7 Run C	38	240	1.67		670	74%	0.81				
Test 8 Run A	41	240	1.55	2600	580	78%	0.97	1.02	0.93	3	1253
Test 8 Run B	41	120	0.77		920	65%	1.34				
Test 8 Run C	29	120	1.09		630	76%	1.29				
Design June 1, 2009	50	145	0.77	3000	3	100%	9.00	NA	NA	3	145
Design April 28, 2010	50	245	1.30	3000	3	100%	5.33				245

Footnotes:

[1] - Flow rates for respective Test Runs are those at the time of effluent sample collection.

[2] - Power requirement calculations utilize modeled first order rate constant.

kW/Lpm - Kilowatts per Liters per Minute
gpm - Gallons per Minute
ppb - Parts per Billion
KW - Kilowatt
% - Percent
* - Modeled Rate constant and R2 values not including Test 5 Run A effluent data.
** - Modeled Rate constant and R2 values including Test 5 Run A effluent data.

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FIGURES

Figure 1. Process Flow Diagram

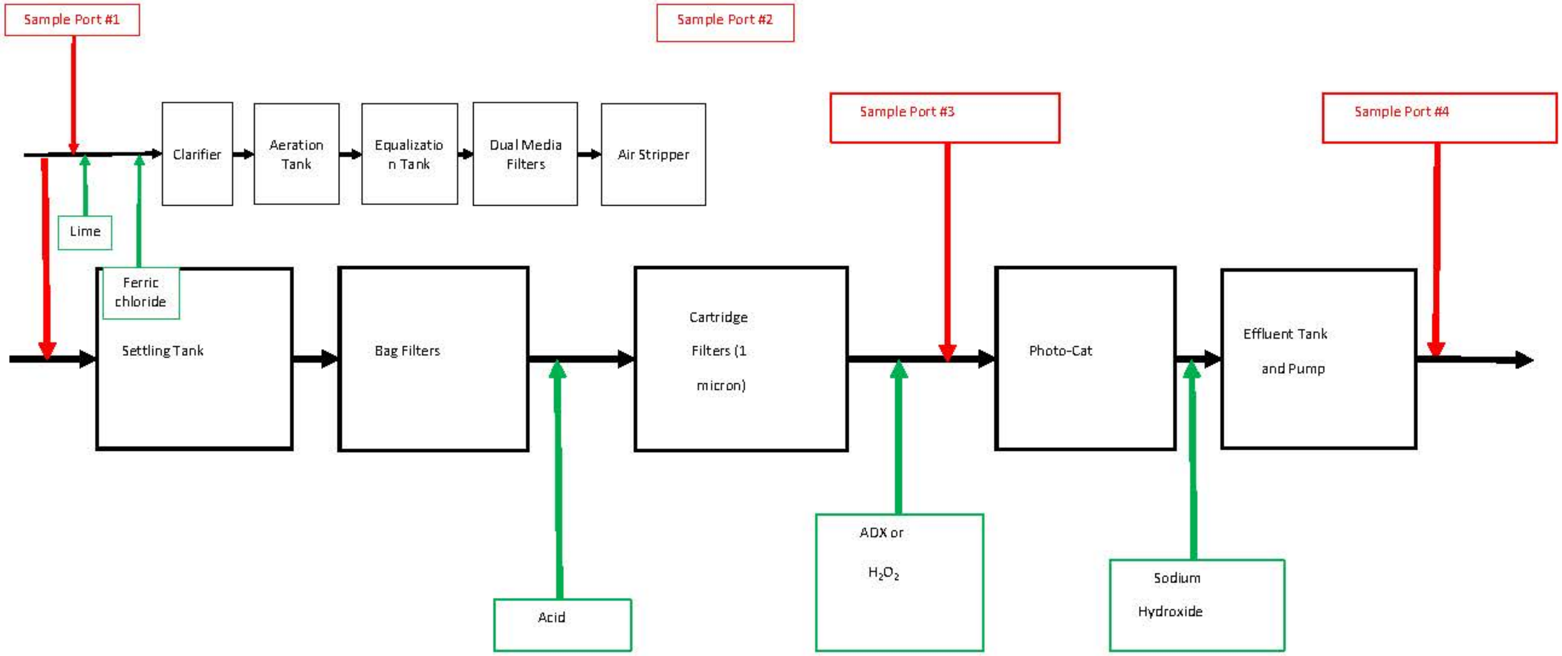


Figure 2. Test 0 and Test 1 AOP Performance Decay Curves

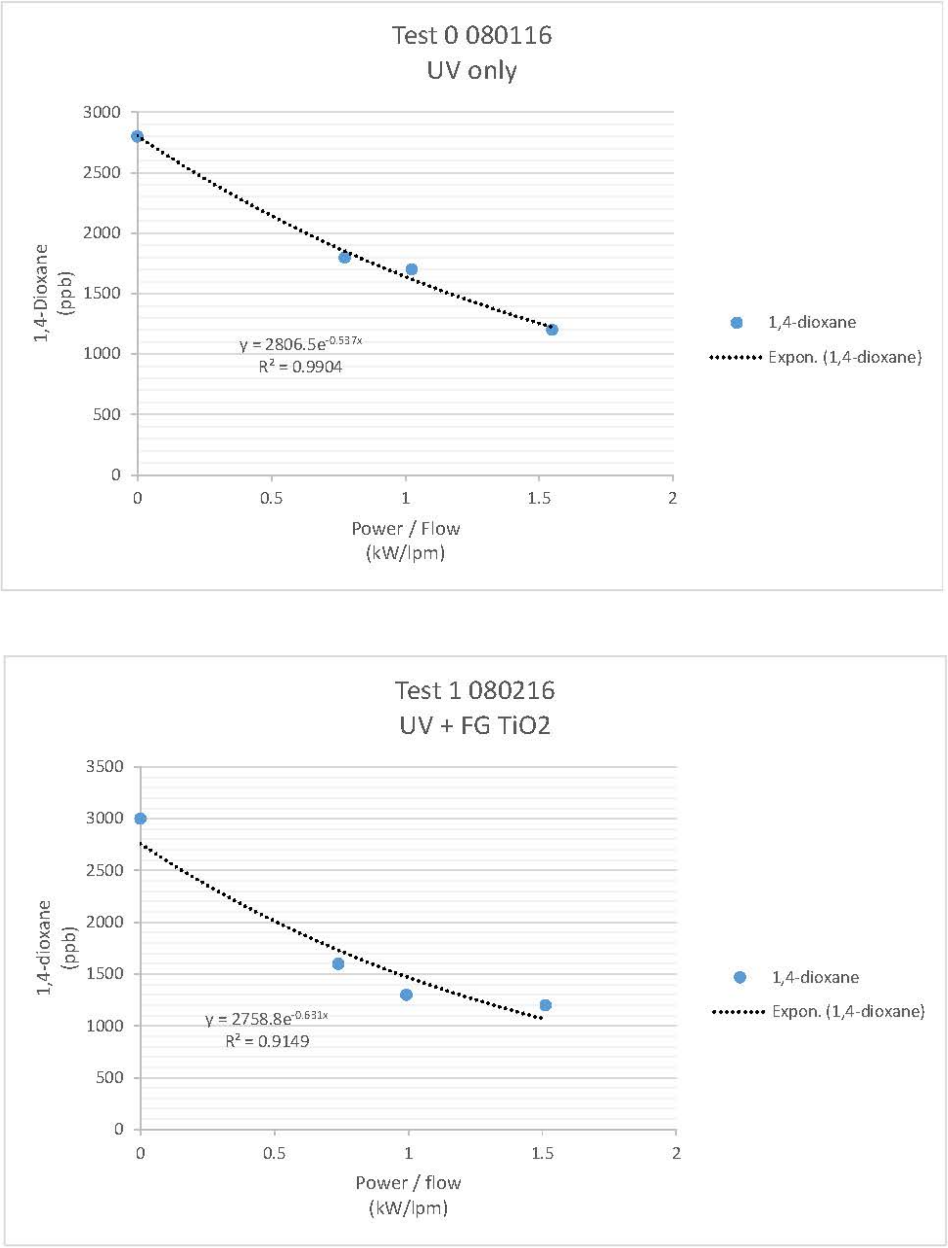
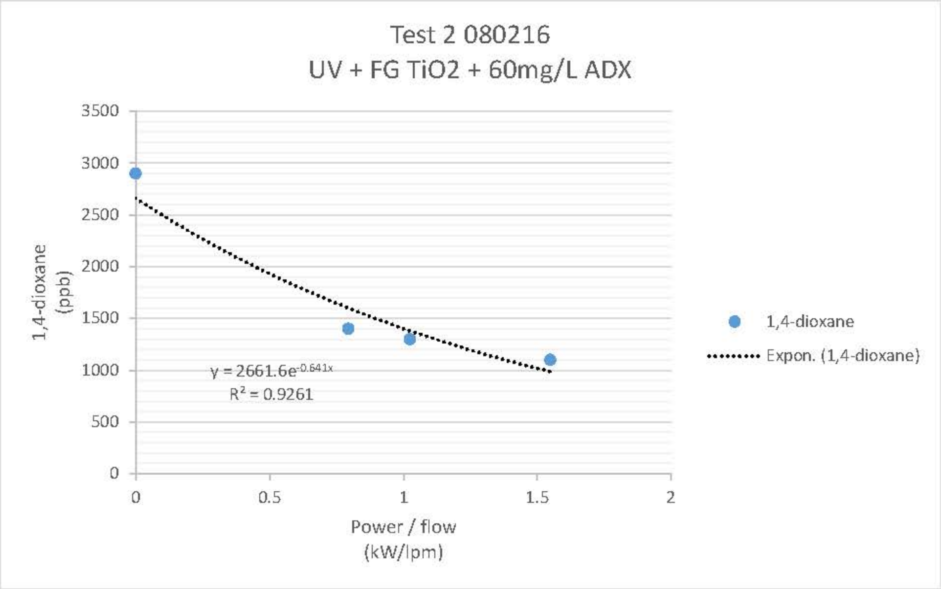


Figure 3. Test 2 and Test 3 AOP Performance Decay Curves



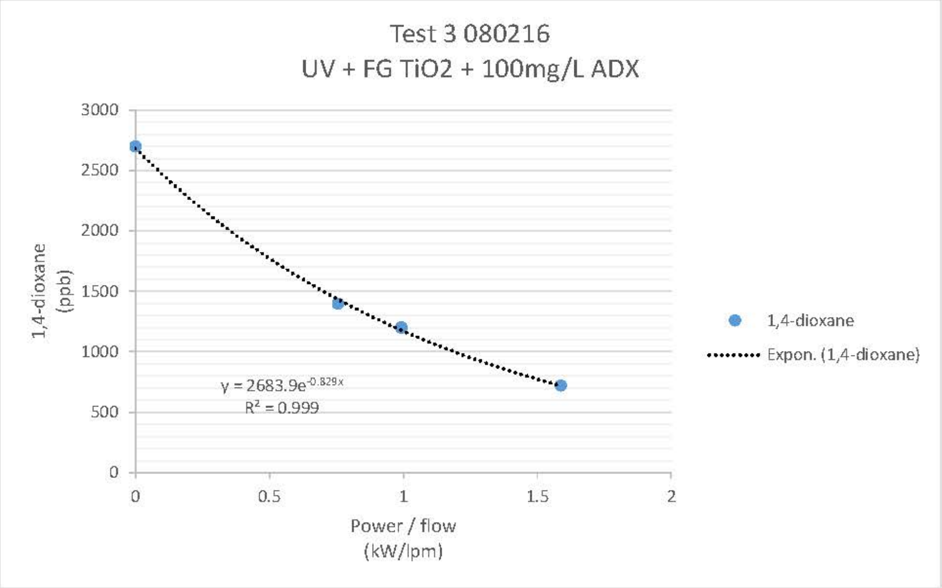


Figure 4. Test 4 and Test 6 AOP Performance Decay Curves

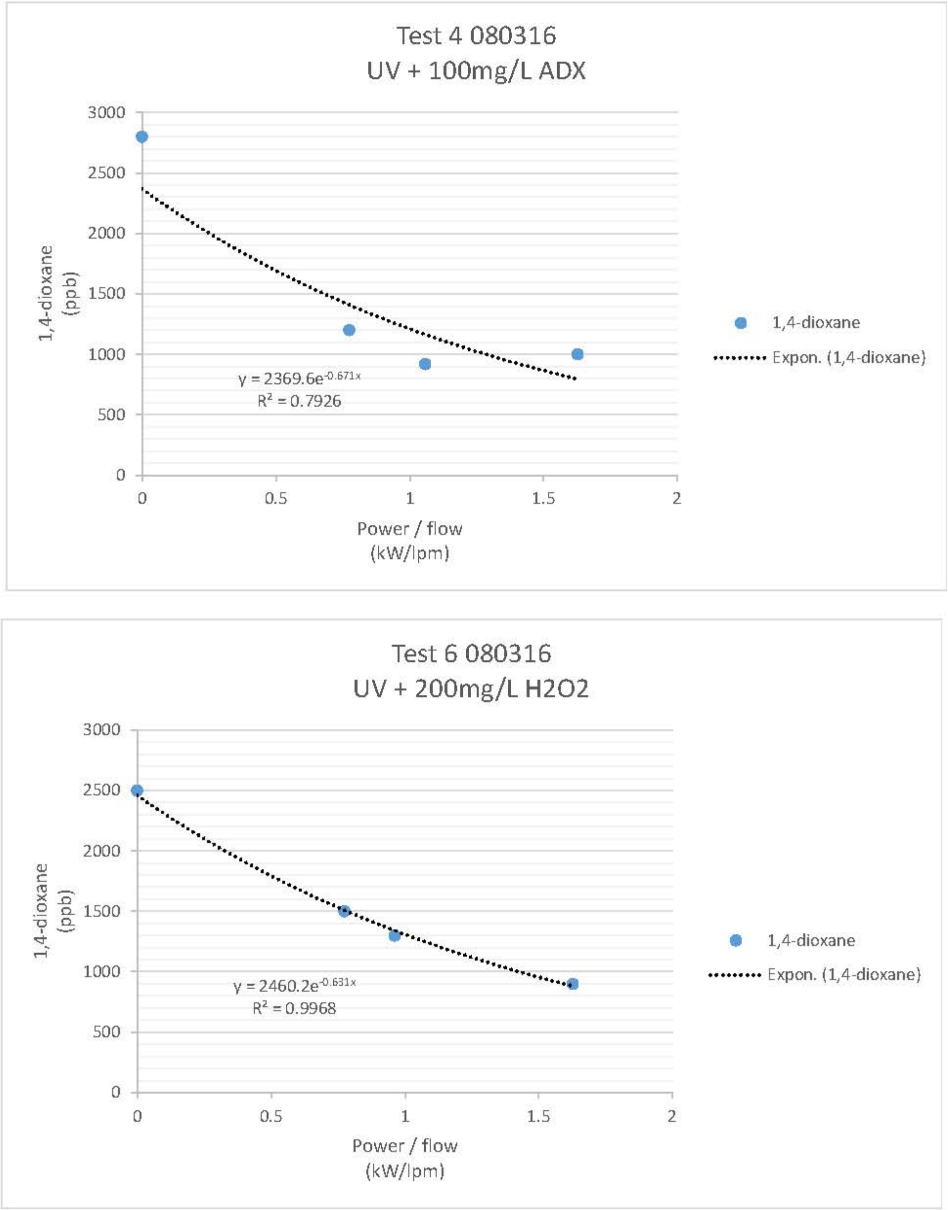
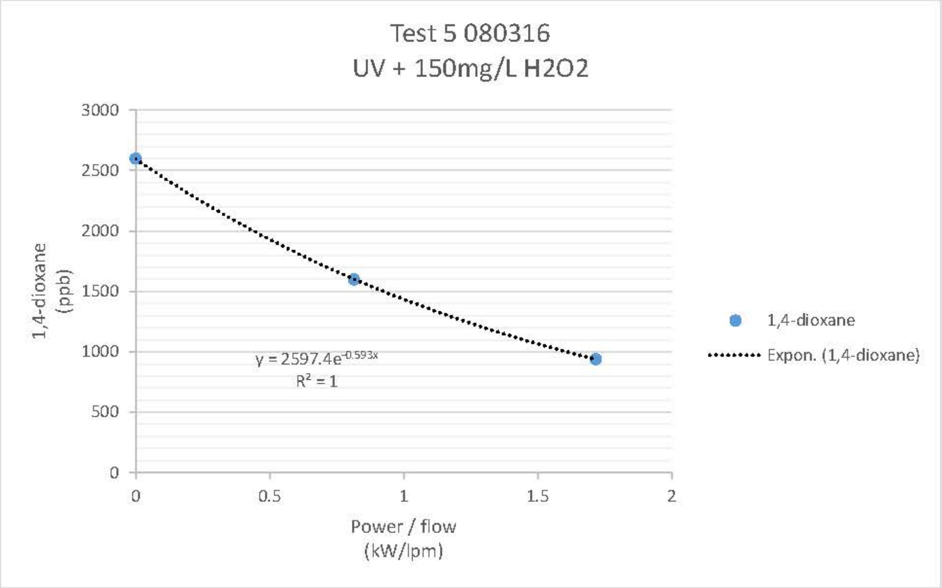
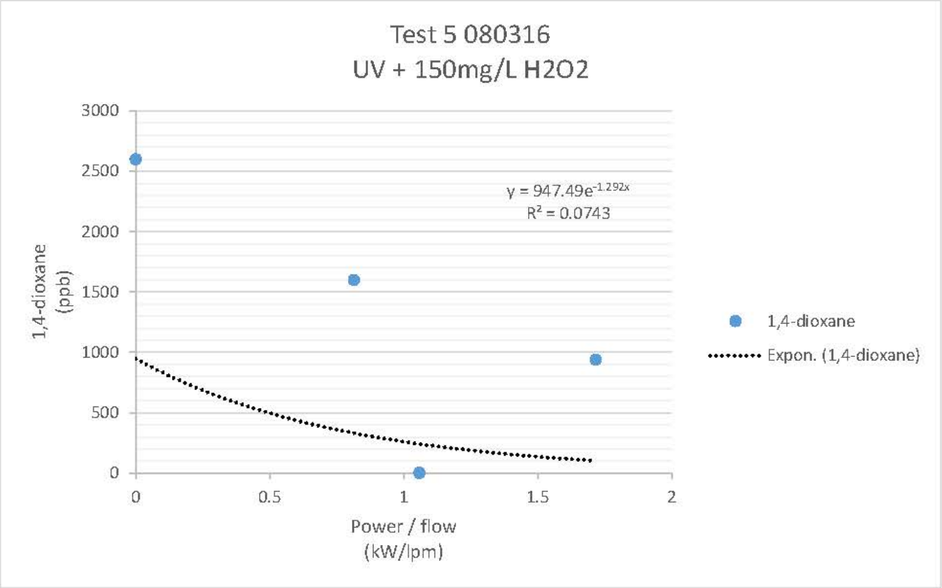


Figure 5. Test 5 AOP Performance Decay Curves

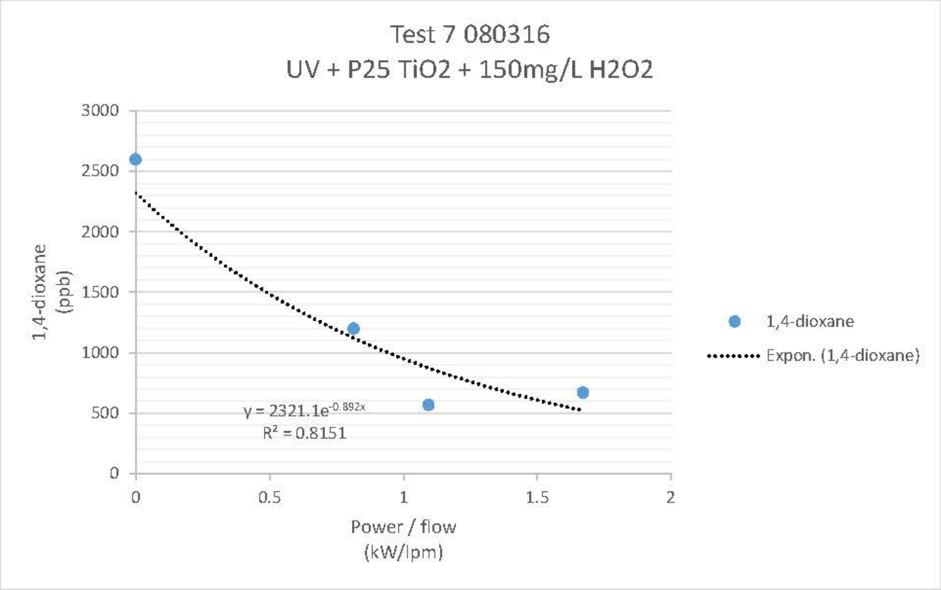


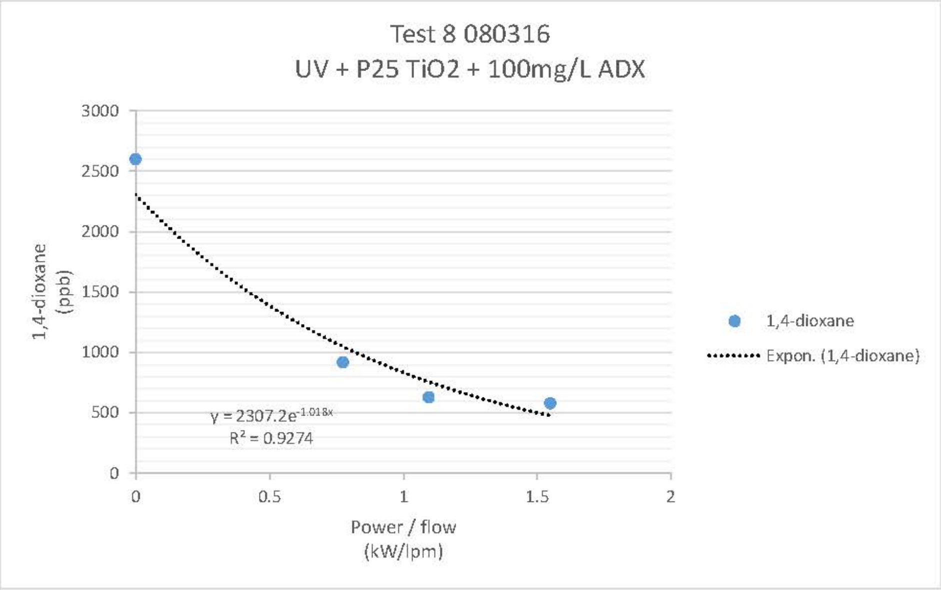
Note: Test 5 Run A data point not included for the calculation of the decay curve shown.



Note: Test 5 Run A data point included for the calculation of the decay curve shown.

Figure 6. Test 7 and Test 8 AOP Performance Decay Curves





APPENDIX A

Curriculum Vitae – John Perella

PERSONNEL RESUME

ARCADIS Design & Consultancy for natural and built assets

JOHN F PERELLA

PRINCIPAL ENVIRONMENTAL ENGINEER

EDUCATION

BS, Environmental Engineer, North Carolina State University at Raleigh, 1997

YEARS OF EXPERIENCE

Total – 17 years
With ARCADIS – 10 years

PROFESSIONAL REGISTRATIONS

Professional Engineer - FL

CORE SKILLS

1. Engineered Treatment Systems
2. Remediation Engineering
3. Operations and Maintenance
4. Site Assessment

PROFESSIONAL ASSOCIATIONS

National Society of Professional Engineers (NSPE)

CERTIFICATIONS

OSHA 40 hour HAZWOPER
OSHA 8 hour Site Supervisor

Mr. Perella has 17 years of experience in the environmental profession. Currently, his primary roles include serving as senior technical engineer and to provide technical support/review for environmental remediation projects. Mr. Perella has been involved in all phases of groundwater and soil remediation projects including remedial action planning and strategic development, treatment process development, detailed engineering design, plant construction, plant operations, and site closures. Mr. Perella has developed expertise in designing, constructing, and operating aboveground treatment systems associated with 1,4-dioxane and in-situ thermal remediation projects. Remediation experience also includes the design and implementation of in-situ remediation techniques including air sparging, soil vapor extraction, in-situ thermal heating, and enhancement of subsurface conditions to promote biological degradation of contaminants (for example, enhanced reductive dechlorination for chlorinated organic compounds).

Mr. Perella has been a key presenter for the Arcadis Technical Knowledge and Innovation (TKI) Knowledge Transfer Series for Engineered Treatment Systems presenting specifically on Advance Oxidation Processes (AOPs) and the treatment of 1,4-dioxane.

Project Experience

In-Situ Thermal Heating and Groundwater Pump and Treat Systems – Chlorinated Solvent Site

Tampa, Florida

Engineer of Record for chlorinated solvent site, responsible for design, construction management, operations and maintenance (O&M) management, and training of O&M personnel for a 50 gpm surficial, 550 gpm Floridan aquifer pump-and-treat system and 900 scfm / 30 gpm dual phase extraction (DPE) system utilizing 3-phase electric resistive heating (ERH) for the treatment of source areas. ERH system installed in phases in two source areas both with elevated concentrations of chlorinated solvents and 1,4-dioxane. ERH systems utilized approximately 30 electrodes in each source area installed approximately 2 feet from the base of the clay confining layer. The aboveground treatment system utilized air stripping, advanced oxidation process (AOP) utilizing the Calgon Carbon RayOx system with hydrogen peroxide injection, and carbon adsorption to remove contaminates from the water and vapor.

Project Experience Continued

Groundwater Pump and Treat System – Chlorinated Solvent Site

Bradenton, Florida

Senior Process Engineer for chlorinated solvent site, responsible for design, construction oversight and operation, maintenance and management for the Interim Remedial Action (IRA) system. Groundwater contaminated with chlorinated solvents and 1,4-dioxane. Extraction system consists of 10 groundwater extraction wells producing 30 gpm. Treatment system consists of iron removal pretreatment, an advance oxidation process (AOP) utilizing the Purifics ES Photo-Cat and granular activated carbon (GAC) for effluent polishing. Treated effluent discharged to the local POTW. Responsible for Remedial Action Plan (RAP) and preliminary full scale system design, consisting of over 70 extraction wells producing approximately 200 gpm. Full scale treatment system consists of iron and aluminium removal pretreatment, media and ultra-filtration, AOP treatment, GAC polishing, reverse osmosis for a portion of the treated effluent to be discharged to offsite infiltration galleries, onsite injection of treated effluent and discharge of effluent to offsite POTW.

Water Treatment System for Thermal Project – Chlorinated Solvent Site

St. Petersburg, Florida

Senior Process Engineer for the design and implementation of an 80 gallon per minute groundwater treatment system to support an in-situ thermal desorption remediation project to reduce chlorinated solvents and 1,4-dioxane. Responsibilities included coordination of overall project activities including local permitting and general contractor support of the project and managing the water system design team that included process, electrical, mechanical, and structural aspects. The system incorporates a synthetic media system as the primary water treatment method with other processes designed to reduce iron. The system has been operating successfully since August 2012 and is operating as designed.

Interim Chlorinated Plume and 1,4-Dioxane System– Chlorinated Solvent Site

St. Petersburg, Florida

Senior Process Engineer for an interim water treatment system that included advanced oxidation process as the primary treatment technique to remove chlorinated compounds and 1,4-dioxane. The system utilized HiPOx APT AOP system for treatment of 1,4-dioxane. The system also included various process steps to remove iron. The 32 gallon per minute treatment system has been operating successfully for over four years.

Advanced Oxidation Pilot Test– Chlorinated Solvent Site

St. Petersburg, Florida

Senior Process Engineer for the design and implementation of a 32 gallon per minute pilot groundwater extraction and treatment system. The pilot system includes iron removal processes and a side-by-side evaluation of two advanced oxidation process units. The site is impacted with chlorinated volatile organic compounds and 1,4-dioxane. The system has been operating consistently with > 90 percent uptime and has achieved the treatment goals.

Groundwater Pump and Treat System – Chlorinated Solvent Site

Sarasota, Florida

Senior Process Engineer for chlorinated solvent site, responsible for the design, construction oversight and groundwater treatment system operation and maintenance management for the groundwater extraction and treatment system. Groundwater contaminated with chlorinated solvents, 1,4-dioxane and arsenic. System utilizes a 15-foot-deep and 140-foot-long groundwater extraction trench designed to limit the movement of contaminated groundwater

Project Experience Continued

offsite. The construction of the extraction trench utilized a single pass horizontal trencher. The horizontal trencher eliminated the need for any dewatering during the construction of the extraction trench. The treatment system consists of an advanced oxidation process utilizing the Calgon Ray/Ox system with hydrogen peroxide injection, air stripping, and activated alumina adsorption. System flow rate is approximately 40 gpm and treated groundwater is discharged onsite utilizing approximately 600 feet of infiltration gallery, during high water events excess water is discharge to NPDES permitted surface water outfall.

Groundwater Pump and Treat and Air Sparge and Soil Vapor Extraction Systems – Chlorinated Solvent Site

Orlando, Florida

Engineer of Record for chlorinated solvent site, responsible for the design, construction oversight and groundwater treatment system operation and maintenance management for the groundwater extraction and treatment system and air sparge and soil vapor extraction (AS/SVE) system. Groundwater contaminated with chlorinated solvents. Groundwater extraction system consists of 7 extraction wells producing approximately 30 gpm. Treatment of groundwater consists of air stripping and pH adjustment with discharge of treated water to the POTW. AS/SVE system consists of 40 AS wells and 5 SVE trenches. AS/SVE system is designed as a barrier wall system to protect surface water from groundwater daylighting.

Groundwater Pump and Treat Systems – Chlorinated Solvent Site

Jacksonville, Florida

Engineer of Record for chlorinated solvent site, responsible for the design, construction oversight and groundwater treatment system operation and maintenance management for the groundwater extraction and treatment system. Groundwater contaminated with chlorinated solvents. Groundwater extraction system consists of 6 extraction wells producing approximately 30 gpm. Treatment of groundwater consists of air stripping utilizing a turbo stripper fluidized bed air stripper with discharge of treated water to the POTW.

Groundwater Pump and Treat Systems – Explosives Site

Milan, Tennessee

Senior Process Engineer for the Milan Army Ammunitions Plant, responsible for the operations and maintenance management of two groundwater pump and treat systems and design and implementation of extraction and conveyance systems expansion. Both treatment systems operate at approximately 1200 gpm each. Responsible for the design and implementation of 6 new extraction wells and approximately 5-miles of HDPE pipeline. Average flow rate for extraction wells is approximately 200 gpm each. Treatment process consists of iron and manganese removal pretreatment by pH adjustment and sand filtration and granular activated carbon (GAC) for the removal of explosives. Treated effluent is discharged to surface water via NPDES permit.

In-Situ Thermal Heating – Chlorinated Solvent Site

Orlando, Florida

Engineer of Record for chlorinated solvent site, responsible for design, construction management, operations and maintenance (O&M) management, and training of O&M personnel for a 1200 scfm / 30 gpm multi-phase extraction (MPE) system utilizing 3-phase electric resistive heating (ERH) for the treatment of source area. ERH system utilized 93 electrodes and 44 extraction wells in the source area. The aboveground treatment system utilized air stripping and Liquid Phase granular activated carbon (GAC) for treatment of liquids, while vapors were treated through a regenerative Vapor Phase GAC system.

Project Experience Continued

Groundwater Pump and Treat System – Chloride Site

Odessa, Texas

Senior Process Engineer for chloride site, responsible for design for the modification to an existing groundwater treatment system. Modifications include the installation of additional extraction and injection wells to cover an area greater than 4 miles. Treatment system includes electro-dialysis reversal (EDR) and reverse osmosis for the removal of chlorides. Treated water will be returned to the aquifer as to limit impacts of remediation on the aquifer. Brine concentrate is discharged to a deep aquifer injection well. Total system flow rate approximately 300 gpm.

Free Product Recovery – Petroleum Terminal

Nassau, Bahamas

Project Engineer for petroleum terminal, responsible for design, construction oversight and groundwater treatment system operation and maintenance management for a free product recovery system. Recovery system consists of 5 recovery wells located in a petroleum storage tank farm. Recovered free product is pumped to an onsite holding tank and removed from the site by an asphalt manufacturer at no cost to the client. Approximately 20,000 gallons of free product has been removed since the installation of the recovery system.

Petroleum Impacted Soils Excavation – Petroleum Site

Ocklawaha, Florida

Project Engineer for petroleum site, conducted site assessment and remediation activities under the Florida Department of Environmental Protection (FDEP) petroleum preapproval program. Responsibilities included design and construction oversight of a 5,300-ton petroleum-contaminated soil excavation.

Groundwater Pump and Treat, AS/SVE, Ex-Situ Soil Remediation and Excavation – Solvent Site

Lakeland, Florida

Project Engineer for solvent site, responsible for groundwater and soil remediation system operations and maintenance management for a 20 gpm surficial aquifer pump and treat system as well as an AS/SVE system with 300 scfm and 500 scfm flow rates, respectively. Responsible for design and construction oversight of a 4,000 cubic yard ex-situ biopile construction project and design and construction oversight of a 5,000 cubic yard contaminated soil excavation. The excavation required the installation of approximately 200 feet of sheet piling. Dewatering requirement for the excavation was approximately 30 gpm of contaminated groundwater, which was treated with the onsite treatment system and discharged to the existing infiltration galleries.

Low Temperature Thermal Desorption – Pesticide Site

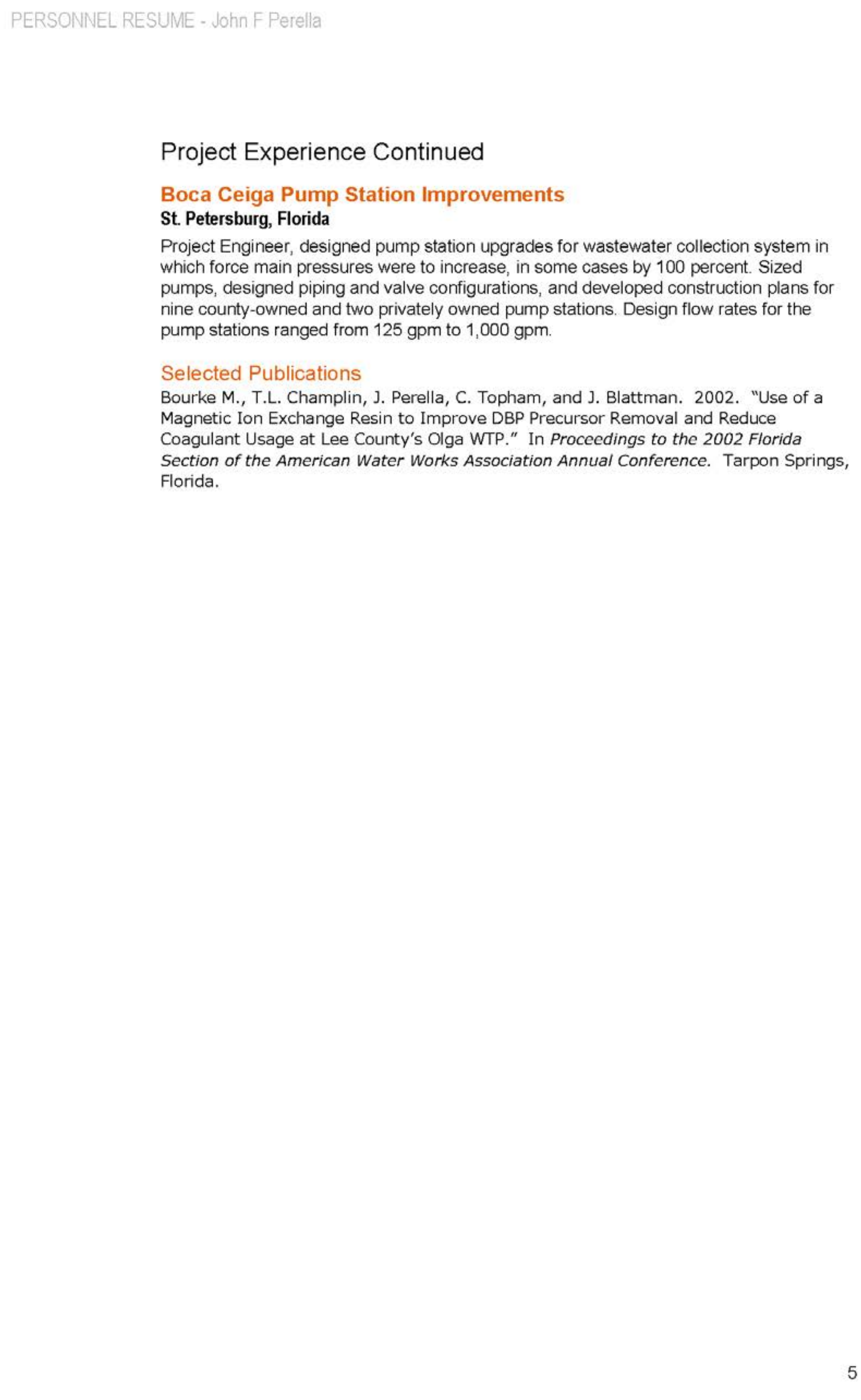
Tampa, Florida

Project Engineer for pesticide site, responsible for design and implementation of a cooling water pumping system during operations of a low-temperature thermal desorption unit for soil remediation.

Olga Water Treatment Plant (WTP) Improvements

Fort Myers, Florida

Project Engineer, evaluated Miex® DOC resin, ferric sulfate, and aluminium sulfate for removal of dissolved organic carbon (DOC) and color in surface water utilized by the WTP. Determined theoretical softening requirements utilizing both lime and soda ash as well as evaluating the possible effects of organics coagulation prior to softening. Authored applicable portions of the basis of design report.



Project Experience Continued

Boca Ceiga Pump Station Improvements

St. Petersburg, Florida

Project Engineer, designed pump station upgrades for wastewater collection system in which force main pressures were to increase, in some cases by 100 percent. Sized pumps, designed piping and valve configurations, and developed construction plans for nine county-owned and two privately owned pump stations. Design flow rates for the pump stations ranged from 125 gpm to 1,000 gpm.

Selected Publications

Bourke M., T.L. Champlin, J. Perella, C. Topham, and J. Blattman. 2002. "Use of a Magnetic Ion Exchange Resin to Improve DBP Precursor Removal and Reduce Coagulant Usage at Lee County's Olga WTP." In *Proceedings to the 2002 Florida Section of the American Water Works Association Annual Conference.* Tarpon Springs, Florida.

NOTE:

This version of the Arcadis Report is not a complete copy of the original version. Appendix B “Data” and Appendix C “Laboratory Analytical Data” have been intentionally omitted from this report. This information has been submitted separately to NCDEQ.

ARCADIS Design & Consultancy for natural and built assets

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Tampa, Florida 33637
Tel 813 903 3100
Fax 813 903 9115

www.arcadis.com

ATTACHMENT 8

CITY OF HIGH POINT PRETREATMENT PERMIT

City of High Point

Public Services Department
LAB SERVICES DIVISION

HIGH POINT
NORTH CAROLINA'S INTERNATIONAL CITY™

VIA INTER-DEPARTMENT MAIL

September 8, 2015

Mr. Terry Houk
Director of Public Services
City of High Point
P.O. Box 230
High Point, NC 27261

RE: Industrial User Permit #0150 – Permit Renewal

Dear Mr. Houk:

Enclosed is the new Industrial User Permit for the Seaboard facility effective October 1, 2015 to October 1, 2020. This permit is issued pursuant to the requirements of North Carolina General Statues 143-215.1 and the City of High Point Sewer Use Ordinance Section 8-2-52(A).

Since the facility has not been operating, there are no limits assigned to the organic parameters. Once the site is operational, the data collected will be evaluated to assign appropriate limits for the toxic organic pollutants and review assigned limits for the allocated parameters.

The permit includes the following narrative changes: A definition for monthly average, Part III (5) certified operator language has been updated and Part II, Item #1 now includes an automatic sampler requirement. Please review the permit. If any parts, measurement frequencies, or sampling requirements contained in this permit are unacceptable to you, you have the right to an adjudicatory hearing upon written request within thirty (30) days following receipt of this letter. Unless such demand is made, the decision shall be final and binding. If you have any questions, please call me at (336) 883-3090.

Sincerely,

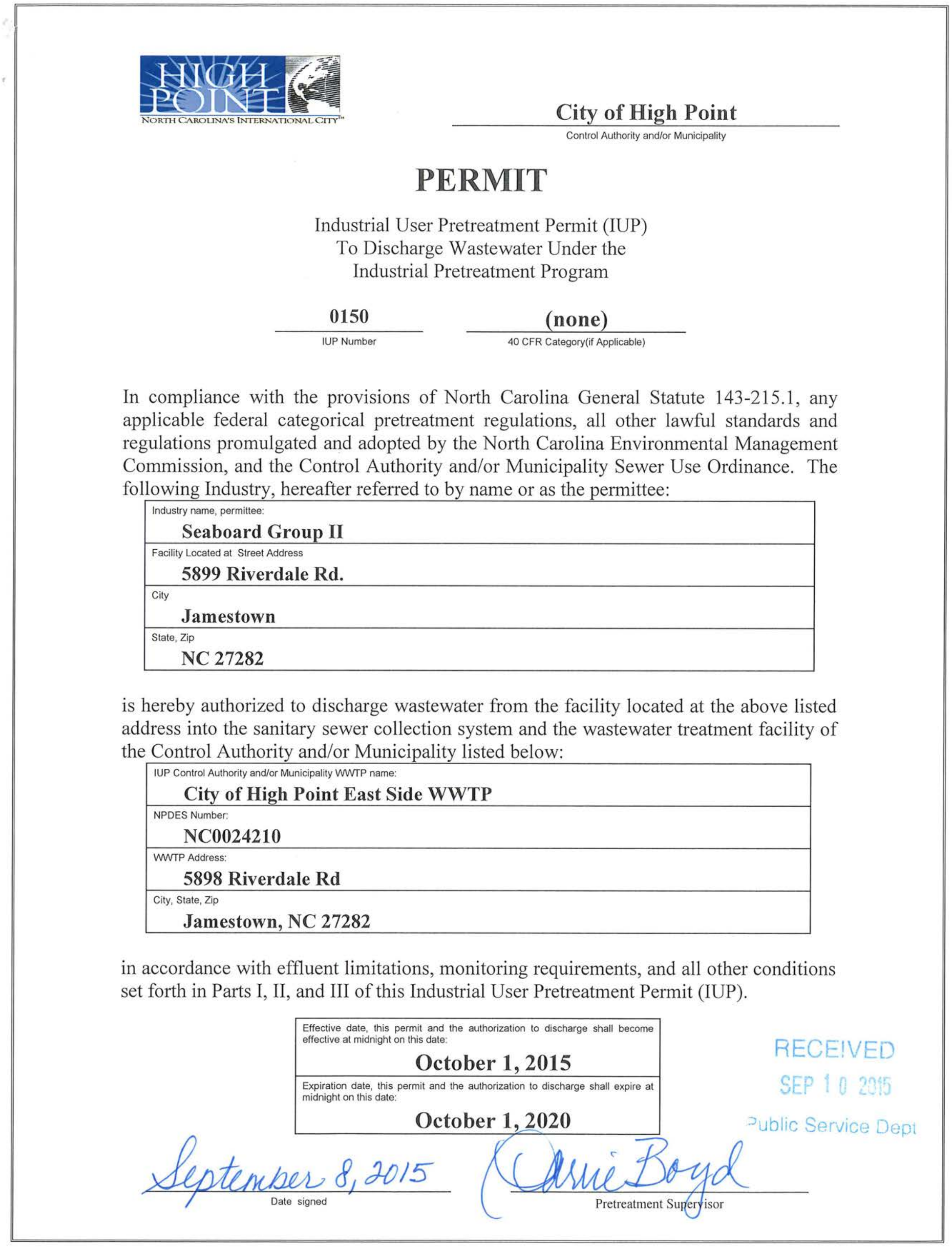
Carrie Boyd

Carrie Boyd
Pretreatment Supervisor

Enclosure

cc with attachments: Monti Hassan, NCDWR PERCS

RECEIVED
SEP 10 2015
Public Service Dept.



HIGH POINT
NORTH CAROLINA'S INTERNATIONAL CITY™

City of High Point
Control Authority and/or Municipality

PERMIT

Industrial User Pretreatment Permit (IUP)
To Discharge Wastewater Under the
Industrial Pretreatment Program

0150	(none)
IUP Number	40 CFR Category(if Applicable)

In compliance with the provisions of North Carolina General Statute 143-215.1, any applicable federal categorical pretreatment regulations, all other lawful standards and regulations promulgated and adopted by the North Carolina Environmental Management Commission, and the Control Authority and/or Municipality Sewer Use Ordinance. The following Industry, hereafter referred to by name or as the permittee:

Industry name, permittee: **Seaboard Group II**
Facility Located at Street Address **5899 Riverdale Rd.**
City **Jamestown**
State, Zip **NC 27282**

is hereby authorized to discharge wastewater from the facility located at the above listed address into the sanitary sewer collection system and the wastewater treatment facility of the Control Authority and/or Municipality listed below:

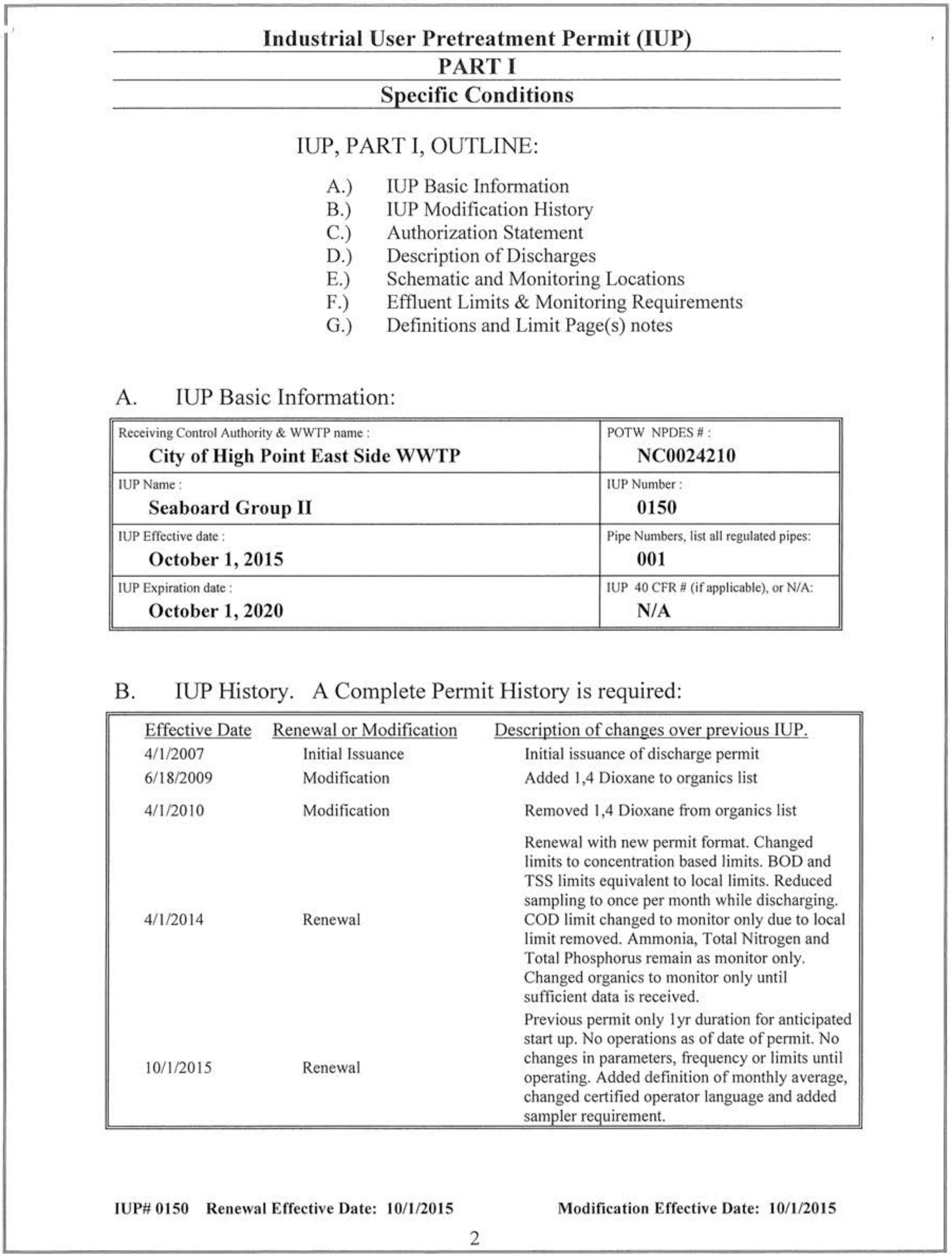
IUP Control Authority and/or Municipality WWTP name: **City of High Point East Side WWTP**
NPDES Number: **NC0024210**
WWTP Address: **5898 Riverdale Rd**
City, State, Zip **Jamestown, NC 27282**

in accordance with effluent limitations, monitoring requirements, and all other conditions set forth in Parts I, II, and III of this Industrial User Pretreatment Permit (IUP).

Effective date, this permit and the authorization to discharge shall become effective at midnight on this date: **October 1, 2015**
Expiration date, this permit and the authorization to discharge shall expire at midnight on this date: **October 1, 2020**

September 8, 2015
Date signed

Carrie Boyd
Pretreatment Supervisor



Industrial User Pretreatment Permit (IUP)
PART I
Specific Conditions

IUP, PART I, OUTLINE:

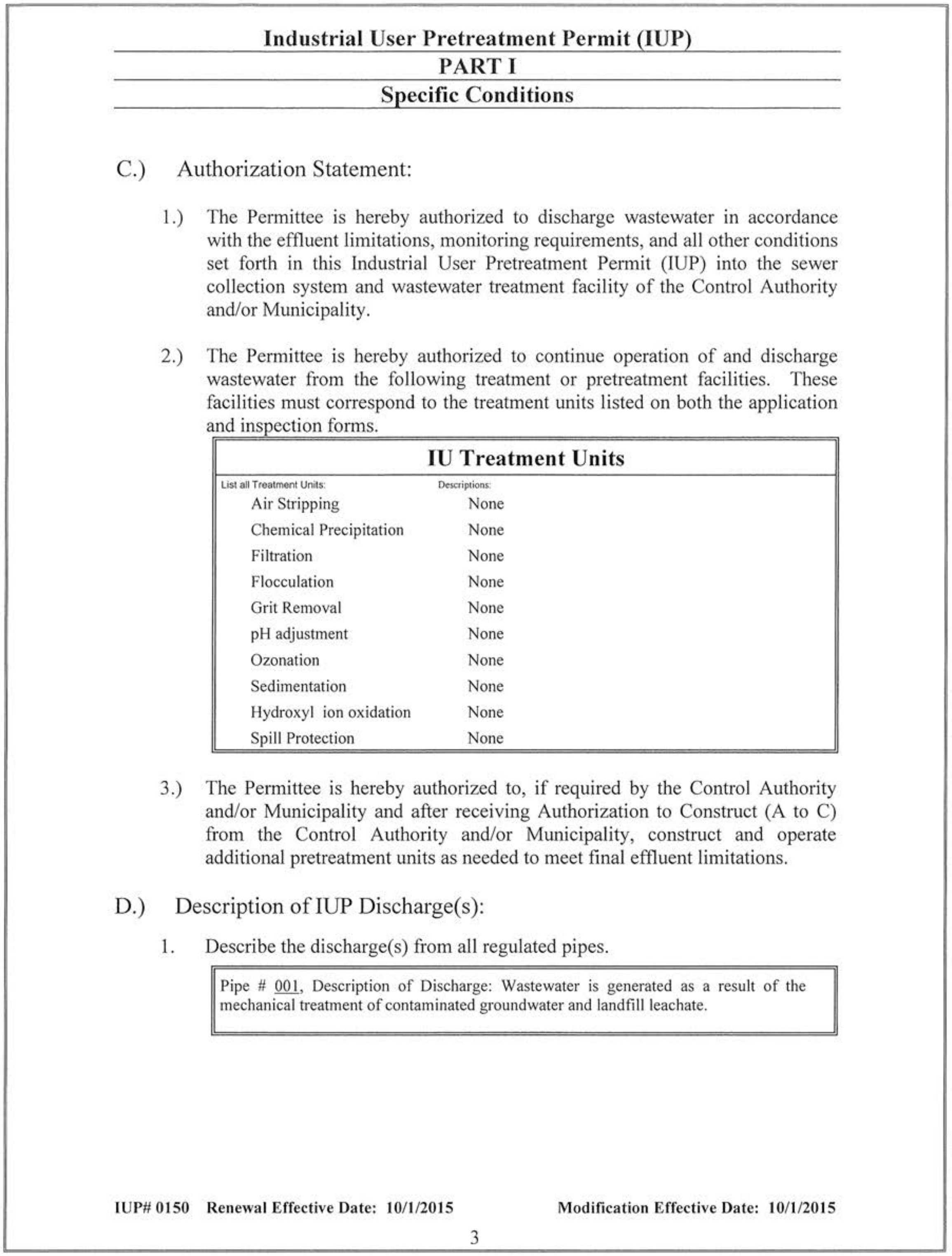
A.) IUP Basic Information
B.) IUP Modification History
C.) Authorization Statement
D.) Description of Discharges
E.) Schematic and Monitoring Locations
F.) Effluent Limits & Monitoring Requirements
G.) Definitions and Limit Page(s) notes

A. IUP Basic Information:

Receiving Control Authority & WWTP name : **City of High Point East Side WWTP**	POTW NPDES # : **NC0024210**
IUP Name : **Seaboard Group II**	IUP Number : **0150**
IUP Effective date : **October 1, 2015**	Pipe Numbers, list all regulated pipes: **001**
IUP Expiration date : **October 1, 2020**	IUP 40 CFR # (if applicable), or N/A: **N/A**

B. IUP History. A Complete Permit History is required:

Effective Date	Renewal or Modification	Description of changes over previous IUP.
4/1/2007	Initial Issuance	Initial issuance of discharge permit
6/18/2009	Modification	Added 1,4 Dioxane to organics list
4/1/2010	Modification	Removed 1,4 Dioxane from organics list
4/1/2014	Renewal	Renewal with new permit format. Changed limits to concentration based limits. BOD and TSS limits equivalent to local limits. Reduced sampling to once per month while discharging. COD limit changed to monitor only due to local limit removed. Ammonia, Total Nitrogen and Total Phosphorus remain as monitor only. Changed organics to monitor only until sufficient data is received.
10/1/2015	Renewal	Previous permit only 1yr duration for anticipated start up. No operations as of date of permit. No changes in parameters, frequency or limits until operating. Added definition of monthly average, changed certified operator language and added sampler requirement.



Industrial User Pretreatment Permit (IUP)

PART I

Specific Conditions

C.) Authorization Statement:

1.) The Permittee is hereby authorized to discharge wastewater in accordance with the effluent limitations, monitoring requirements, and all other conditions set forth in this Industrial User Pretreatment Permit (IUP) into the sewer collection system and wastewater treatment facility of the Control Authority and/or Municipality.

2.) The Permittee is hereby authorized to continue operation of and discharge wastewater from the following treatment or pretreatment facilities. These facilities must correspond to the treatment units listed on both the application and inspection forms.

IU Treatment Units

List all Treatment Units:	Descriptions:
Air Stripping	None
Chemical Precipitation	None
Filtration	None
Flocculation	None
Grit Removal	None
pH adjustment	None
Ozonation	None
Sedimentation	None
Hydroxyl ion oxidation	None
Spill Protection	None

3.) The Permittee is hereby authorized to, if required by the Control Authority and/or Municipality and after receiving Authorization to Construct (A to C) from the Control Authority and/or Municipality, construct and operate additional pretreatment units as needed to meet final effluent limitations.

D.) Description of IUP Discharge(s):

1. Describe the discharge(s) from all regulated pipes.

Pipe # 001, Description of Discharge: Wastewater is generated as a result of the mechanical treatment of contaminated groundwater and landfill leachate.

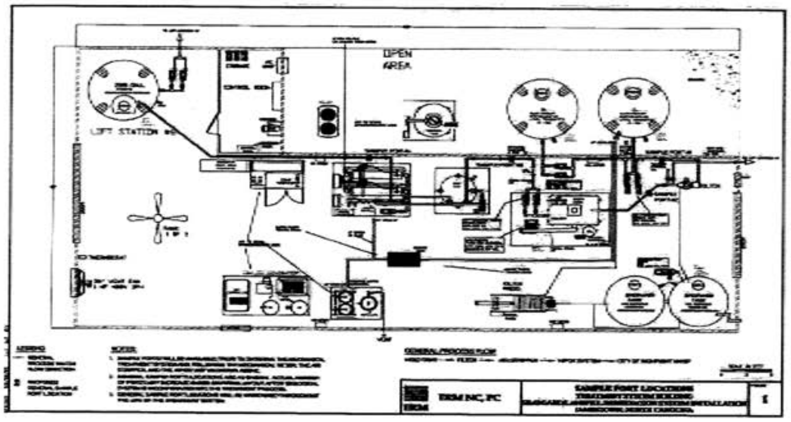
Industrial User Pretreatment Permit (IUP)

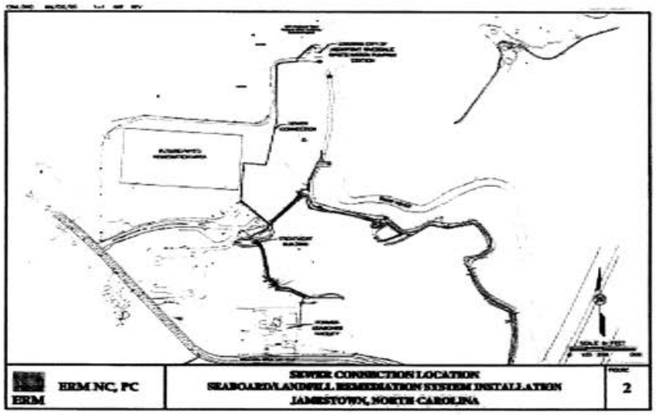
PART I

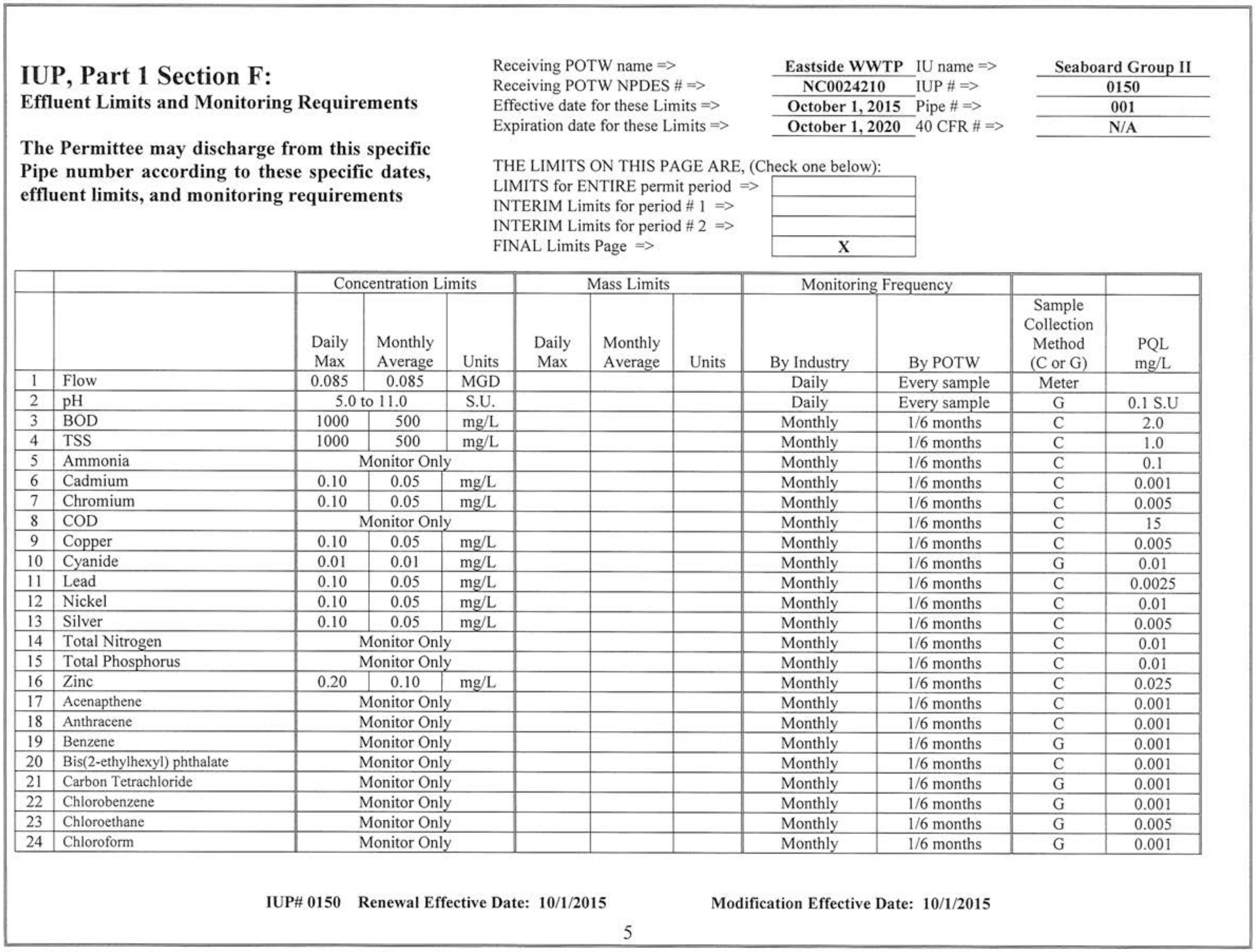
Specific Conditions

E.) Schematic and Monitoring Locations:

The facility schematic and description of monitoring location(s) given below must show enough detail such that someone unfamiliar with the facility could readily find and identify the monitoring location(s) and connection to the sewer. Include and identify all regulated pipes.







IUP, Part 1 Section F:
Effluent Limits and Monitoring Requirements

The Permittee may discharge from this specific Pipe number according to these specific dates, effluent limits, and monitoring requirements

Receiving POTW name =>	**Eastside WWTP**	IU name =>	**Seaboard Group II**
Receiving POTW NPDES # =>	**NC0024210**	IUP # =>	**0150**
Effective date for these Limits =>	**October 1, 2015**	Pipe # =>	**001**
Expiration date for these Limits =>	**October 1, 2020**	40 CFR # =>	**N/A**

THE LIMITS ON THIS PAGE ARE, (Check one below):

LIMITS for ENTIRE permit period =>	
INTERIM Limits for period # 1 =>	
INTERIM Limits for period # 2 =>	
FINAL Limits Page =>	X

		Concentration Limits			Mass Limits			Monitoring Frequency			
		Daily Max	Monthly Average	Units	Daily Max	Monthly Average	Units	By Industry	By POTW	Sample Collection Method (C or G)	PQL mg/L
1	Flow	0.085	0.085	MGD				Daily	Every sample	Meter	
2	pH	5.0 to 11.0		S.U.				Daily	Every sample	G	0.1 S.U
3	BOD	1000	500	mg/L				Monthly	1/6 months	C	2.0
4	TSS	1000	500	mg/L				Monthly	1/6 months	C	1.0
5	Ammonia	Monitor Only						Monthly	1/6 months	C	0.1
6	Cadmium	0.10	0.05	mg/L				Monthly	1/6 months	C	0.001
7	Chromium	0.10	0.05	mg/L				Monthly	1/6 months	C	0.005
8	COD	Monitor Only						Monthly	1/6 months	C	15
9	Copper	0.10	0.05	mg/L				Monthly	1/6 months	C	0.005
10	Cyanide	0.01	0.01	mg/L				Monthly	1/6 months	G	0.01
11	Lead	0.10	0.05	mg/L				Monthly	1/6 months	C	0.0025
12	Nickel	0.10	0.05	mg/L				Monthly	1/6 months	C	0.01
13	Silver	0.10	0.05	mg/L				Monthly	1/6 months	C	0.005
14	Total Nitrogen	Monitor Only						Monthly	1/6 months	C	0.01
15	Total Phosphorus	Monitor Only						Monthly	1/6 months	C	0.01
16	Zinc	0.20	0.10	mg/L				Monthly	1/6 months	C	0.025
17	Acenapthene	Monitor Only						Monthly	1/6 months	C	0.001
18	Anthracene	Monitor Only						Monthly	1/6 months	C	0.001
19	Benzene	Monitor Only						Monthly	1/6 months	G	0.001
20	Bis(2-ethylhexyl) phthalate	Monitor Only						Monthly	1/6 months	C	0.001
21	Carbon Tetrachloride	Monitor Only						Monthly	1/6 months	G	0.001
22	Chlorobenzene	Monitor Only						Monthly	1/6 months	G	0.001
23	Chloroethane	Monitor Only						Monthly	1/6 months	G	0.005
24	Chloroform	Monitor Only						Monthly	1/6 months	G	0.001

IUP# 0150 Renewal Effective Date: 10/1/2015 Modification Effective Date: 10/1/2015

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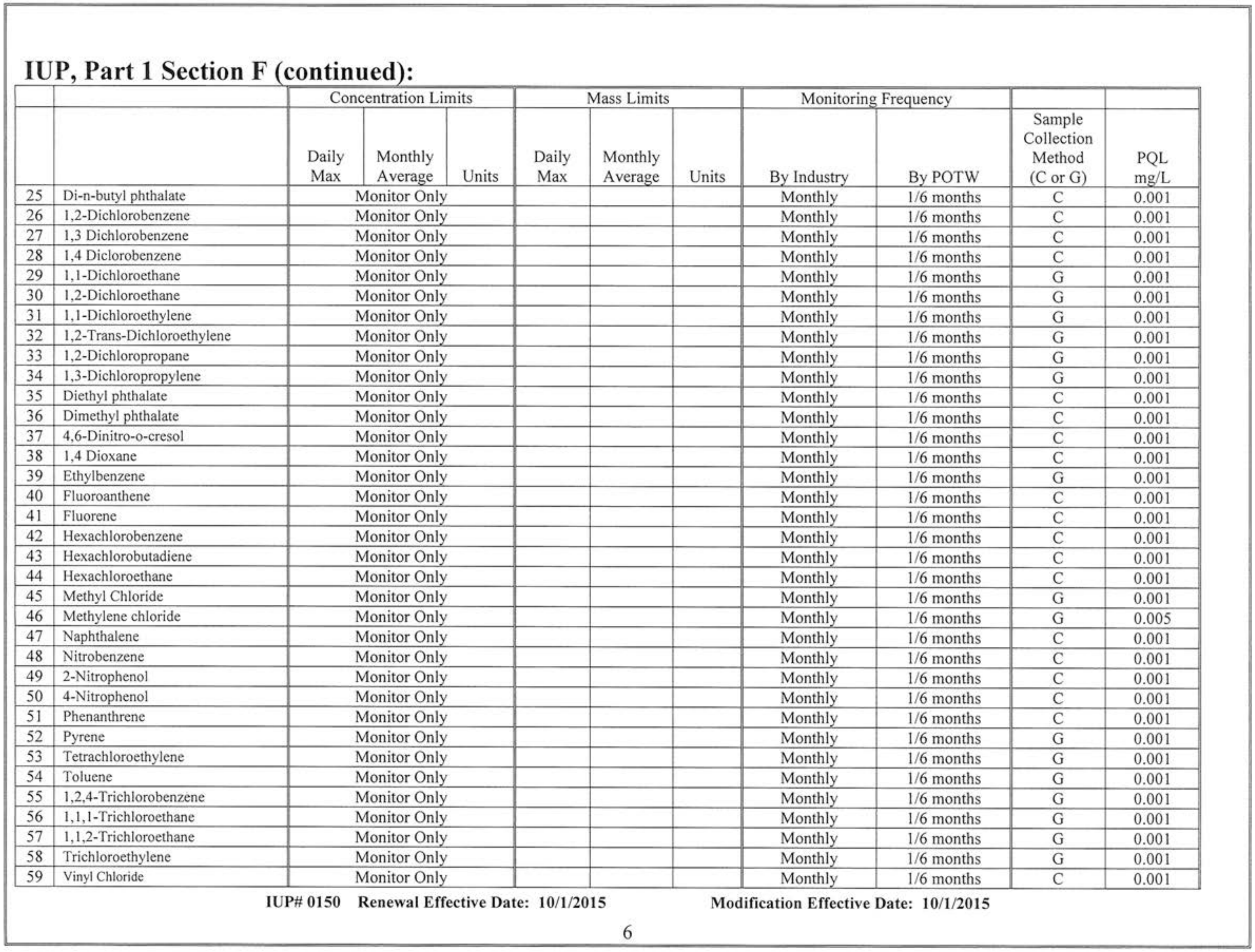
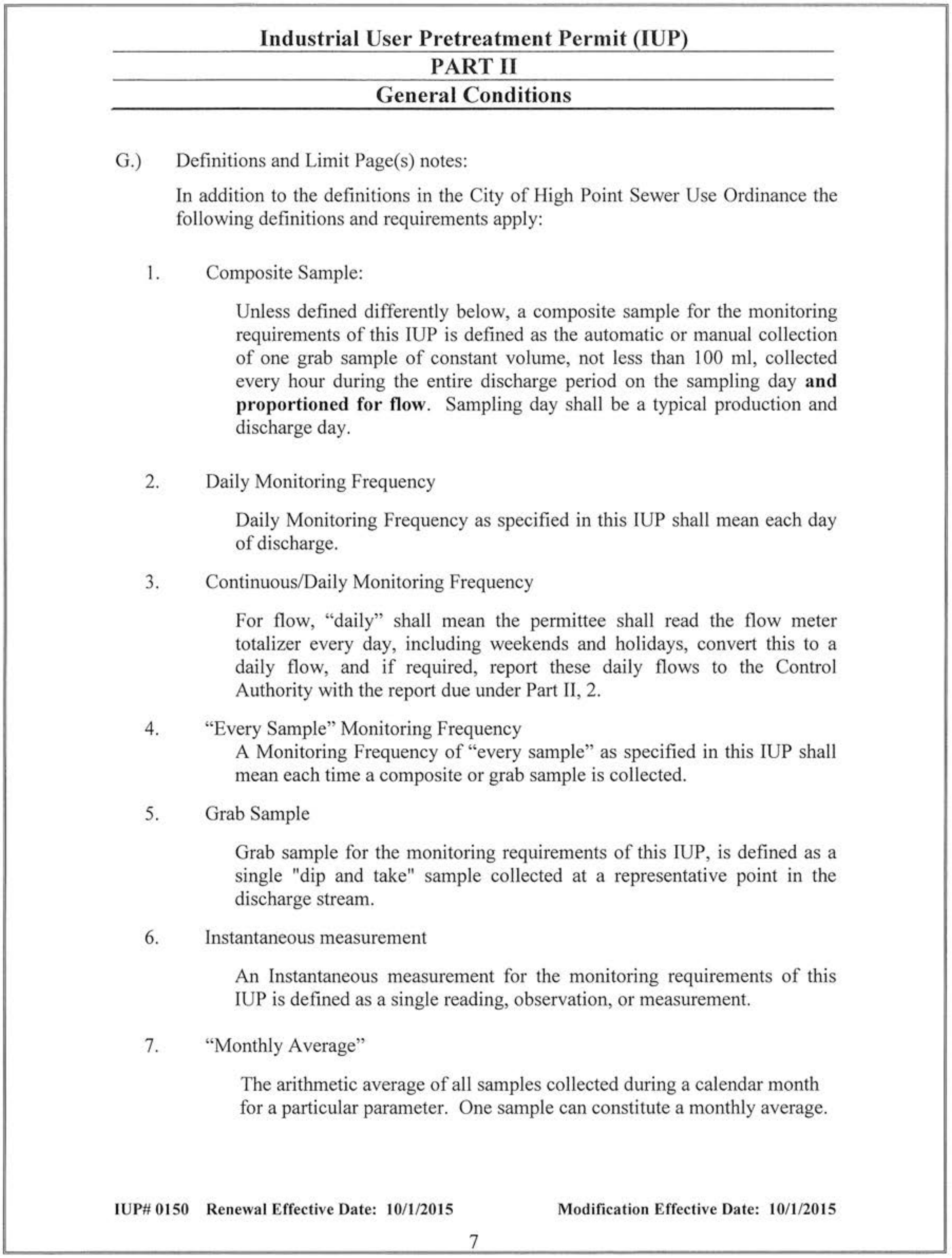


IUP, Part 1 Section F (continued):

		Concentration Limits			Mass Limits			Monitoring Frequency			
		Daily Max	Monthly Average	Units	Daily Max	Monthly Average	Units	By Industry	By POTW	Sample Collection Method (C or G)	PQL mg/L
25	Di-n-butyl phthalate	Monitor Only						Monthly	1/6 months	C	0.001
26	1,2-Dichlorobenzene	Monitor Only						Monthly	1/6 months	C	0.001
27	1,3 Dichlorobenzene	Monitor Only						Monthly	1/6 months	C	0.001
28	1,4 Diclorobenzene	Monitor Only						Monthly	1/6 months	C	0.001
29	1,1-Dichloroethane	Monitor Only						Monthly	1/6 months	G	0.001
30	1,2-Dichloroethane	Monitor Only						Monthly	1/6 months	G	0.001
31	1,1-Dichloroethylene	Monitor Only						Monthly	1/6 months	G	0.001
32	1,2-Trans-Dichloroethylene	Monitor Only						Monthly	1/6 months	G	0.001
33	1,2-Dichloropropane	Monitor Only						Monthly	1/6 months	G	0.001
34	1,3-Dichloropropylene	Monitor Only						Monthly	1/6 months	G	0.001
35	Diethyl phthalate	Monitor Only						Monthly	1/6 months	C	0.001
36	Dimethyl phthalate	Monitor Only						Monthly	1/6 months	C	0.001
37	4,6-Dinitro-o-cresol	Monitor Only						Monthly	1/6 months	C	0.001
38	1,4 Dioxane	Monitor Only						Monthly	1/6 months	C	0.001
39	Ethylbenzene	Monitor Only						Monthly	1/6 months	G	0.001
40	Fluoroanthene	Monitor Only						Monthly	1/6 months	C	0.001
41	Fluorene	Monitor Only						Monthly	1/6 months	C	0.001
42	Hexachlorobenzene	Monitor Only						Monthly	1/6 months	C	0.001
43	Hexachlorobutadiene	Monitor Only						Monthly	1/6 months	C	0.001
44	Hexachloroethane	Monitor Only						Monthly	1/6 months	C	0.001
45	Methyl Chloride	Monitor Only						Monthly	1/6 months	G	0.001
46	Methylene chloride	Monitor Only						Monthly	1/6 months	G	0.005
47	Naphthalene	Monitor Only						Monthly	1/6 months	C	0.001
48	Nitrobenzene	Monitor Only						Monthly	1/6 months	C	0.001
49	2-Nitrophenol	Monitor Only						Monthly	1/6 months	C	0.001
50	4-Nitrophenol	Monitor Only						Monthly	1/6 months	C	0.001
51	Phenanthrene	Monitor Only						Monthly	1/6 months	C	0.001
52	Pyrene	Monitor Only						Monthly	1/6 months	G	0.001
53	Tetrachloroethylene	Monitor Only						Monthly	1/6 months	G	0.001
54	Toluene	Monitor Only						Monthly	1/6 months	G	0.001
55	1,2,4-Trichlorobenzene	Monitor Only						Monthly	1/6 months	G	0.001
56	1,1,1-Trichloroethane	Monitor Only						Monthly	1/6 months	G	0.001
57	1,1,2-Trichloroethane	Monitor Only						Monthly	1/6 months	G	0.001
58	Trichloroethylene	Monitor Only						Monthly	1/6 months	G	0.001
59	Vinyl Chloride	Monitor Only						Monthly	1/6 months	C	0.001



G.) Definitions and Limit Page(s) notes:

In addition to the definitions in the City of High Point Sewer Use Ordinance the following definitions and requirements apply:

1. Composite Sample:

Unless defined differently below, a composite sample for the monitoring requirements of this IUP is defined as the automatic or manual collection of one grab sample of constant volume, not less than 100 ml, collected every hour during the entire discharge period on the sampling day **and proportioned for flow**. Sampling day shall be a typical production and discharge day.

2. Daily Monitoring Frequency

Daily Monitoring Frequency as specified in this IUP shall mean each day of discharge.

3. Continuous/Daily Monitoring Frequency

For flow, “daily” shall mean the permittee shall read the flow meter totalizer every day, including weekends and holidays, convert this to a daily flow, and if required, report these daily flows to the Control Authority with the report due under Part II, 2.

4. “Every Sample” Monitoring Frequency

A Monitoring Frequency of “every sample” as specified in this IUP shall mean each time a composite or grab sample is collected.

5. Grab Sample

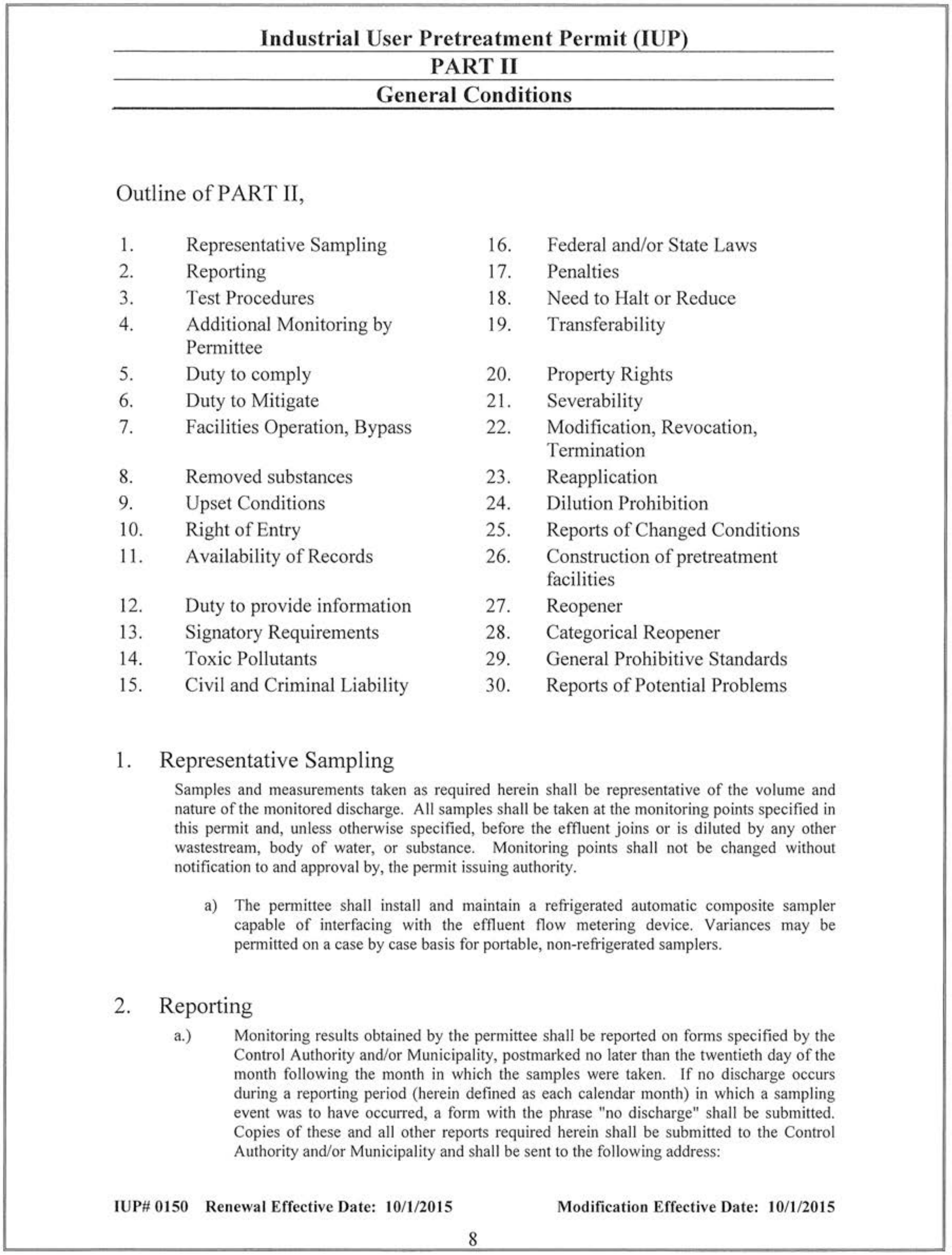
Grab sample for the monitoring requirements of this IUP, is defined as a single "dip and take" sample collected at a representative point in the discharge stream.

6. Instantaneous measurement

An Instantaneous measurement for the monitoring requirements of this IUP is defined as a single reading, observation, or measurement.

7. “Monthly Average”

The arithmetic average of all samples collected during a calendar month for a particular parameter. One sample can constitute a monthly average.



Industrial User Pretreatment Permit (IUP)
PART II
General Conditions

Outline of PART II,

1. Representative Sampling
2. Reporting
3. Test Procedures
4. Additional Monitoring by Permittee
5. Duty to comply
6. Duty to Mitigate
7. Facilities Operation, Bypass
8. Removed substances
9. Upset Conditions
10. Right of Entry
11. Availability of Records
12. Duty to provide information
13. Signatory Requirements
14. Toxic Pollutants
15. Civil and Criminal Liability
16. Federal and/or State Laws
17. Penalties
18. Need to Halt or Reduce
19. Transferability
20. Property Rights
21. Severability
22. Modification, Revocation, Termination
23. Reapplication
24. Dilution Prohibition
25. Reports of Changed Conditions
26. Construction of pretreatment facilities
27. Reopener
28. Categorical Reopener
29. General Prohibitive Standards
30. Reports of Potential Problems

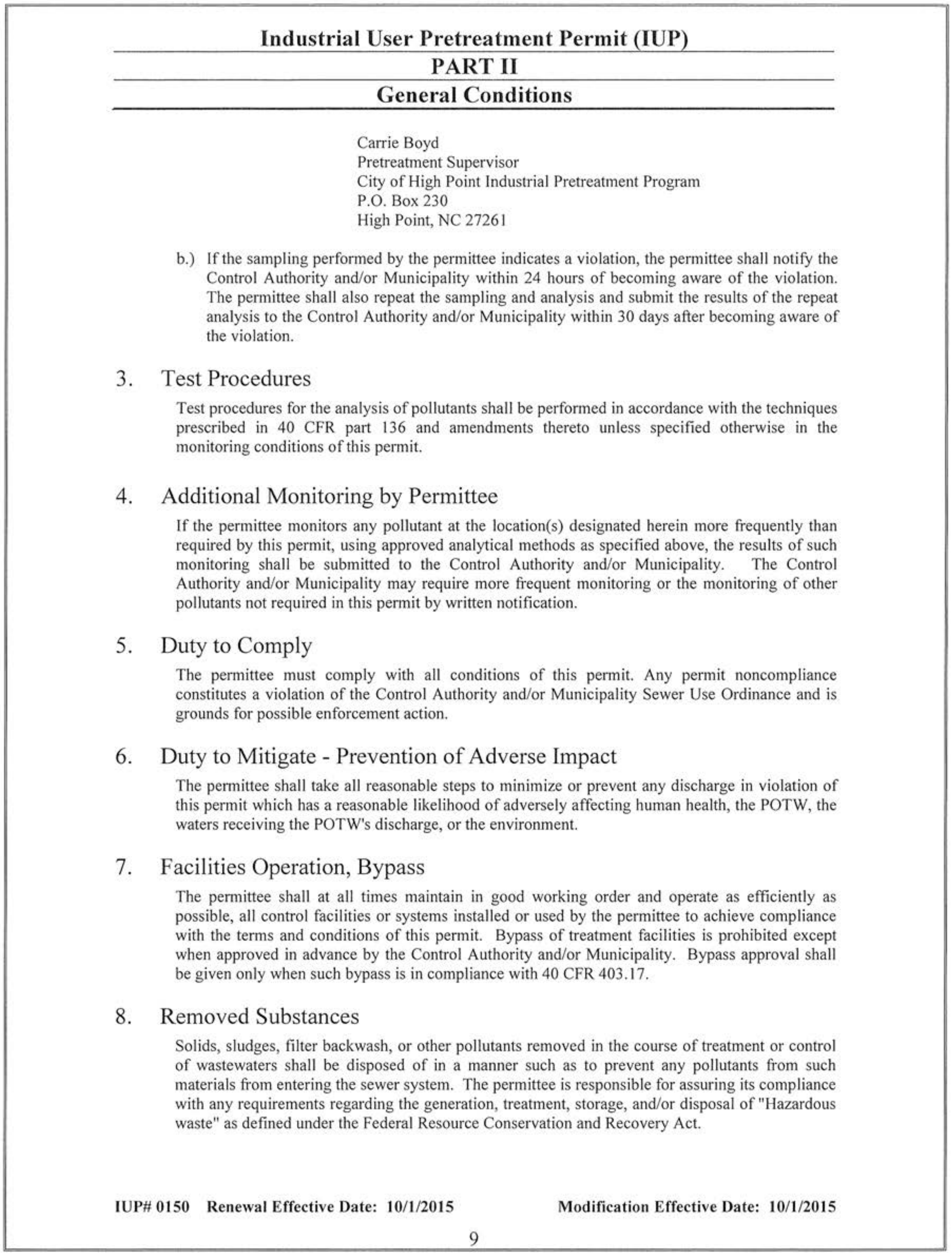
1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge. All samples shall be taken at the monitoring points specified in this permit and, unless otherwise specified, before the effluent joins or is diluted by any other wastestream, body of water, or substance. Monitoring points shall not be changed without notification to and approval by, the permit issuing authority.

a) The permittee shall install and maintain a refrigerated automatic composite sampler capable of interfacing with the effluent flow metering device. Variances may be permitted on a case by case basis for portable, non-refrigerated samplers.

2. Reporting

a.) Monitoring results obtained by the permittee shall be reported on forms specified by the Control Authority and/or Municipality, postmarked no later than the twentieth day of the month following the month in which the samples were taken. If no discharge occurs during a reporting period (herein defined as each calendar month) in which a sampling event was to have occurred, a form with the phrase "no discharge" shall be submitted. Copies of these and all other reports required herein shall be submitted to the Control Authority and/or Municipality and shall be sent to the following address:



Carrie Boyd
Pretreatment Supervisor
City of High Point Industrial Pretreatment Program
P.O. Box 230
High Point, NC 27261

b.) If the sampling performed by the permittee indicates a violation, the permittee shall notify the Control Authority and/or Municipality within 24 hours of becoming aware of the violation. The permittee shall also repeat the sampling and analysis and submit the results of the repeat analysis to the Control Authority and/or Municipality within 30 days after becoming aware of the violation.

3. Test Procedures

Test procedures for the analysis of pollutants shall be performed in accordance with the techniques prescribed in 40 CFR part 136 and amendments thereto unless specified otherwise in the monitoring conditions of this permit.

4. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be submitted to the Control Authority and/or Municipality. The Control Authority and/or Municipality may require more frequent monitoring or the monitoring of other pollutants not required in this permit by written notification.

5. Duty to Comply

The permittee must comply with all conditions of this permit. Any permit noncompliance constitutes a violation of the Control Authority and/or Municipality Sewer Use Ordinance and is grounds for possible enforcement action.

6. Duty to Mitigate - Prevention of Adverse Impact

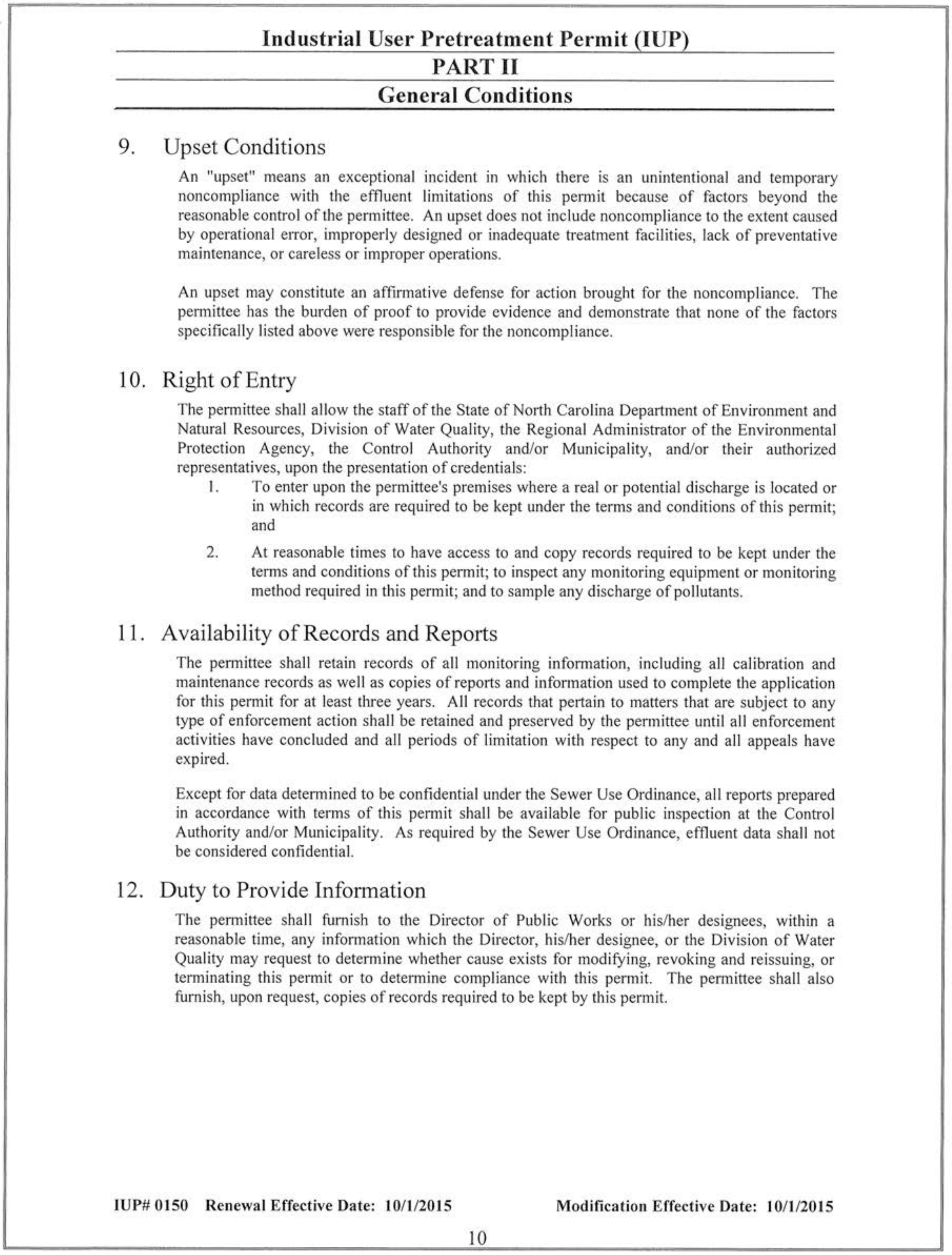
The permittee shall take all reasonable steps to minimize or prevent any discharge in violation of this permit which has a reasonable likelihood of adversely affecting human health, the POTW, the waters receiving the POTW's discharge, or the environment.

7. Facilities Operation, Bypass

The permittee shall at all times maintain in good working order and operate as efficiently as possible, all control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit. Bypass of treatment facilities is prohibited except when approved in advance by the Control Authority and/or Municipality. Bypass approval shall be given only when such bypass is in compliance with 40 CFR 403.17.

8. Removed Substances

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutants from such materials from entering the sewer system. The permittee is responsible for assuring its compliance with any requirements regarding the generation, treatment, storage, and/or disposal of "Hazardous waste" as defined under the Federal Resource Conservation and Recovery Act.



9. Upset Conditions

An "upset" means an exceptional incident in which there is an unintentional and temporary noncompliance with the effluent limitations of this permit because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed or inadequate treatment facilities, lack of preventative maintenance, or careless or improper operations.

An upset may constitute an affirmative defense for action brought for the noncompliance. The permittee has the burden of proof to provide evidence and demonstrate that none of the factors specifically listed above were responsible for the noncompliance.

10. Right of Entry

The permittee shall allow the staff of the State of North Carolina Department of Environment and Natural Resources, Division of Water Quality, the Regional Administrator of the Environmental Protection Agency, the Control Authority and/or Municipality, and/or their authorized representatives, upon the presentation of credentials:

1. To enter upon the permittee's premises where a real or potential discharge is located or in which records are required to be kept under the terms and conditions of this permit; and
2. At reasonable times to have access to and copy records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

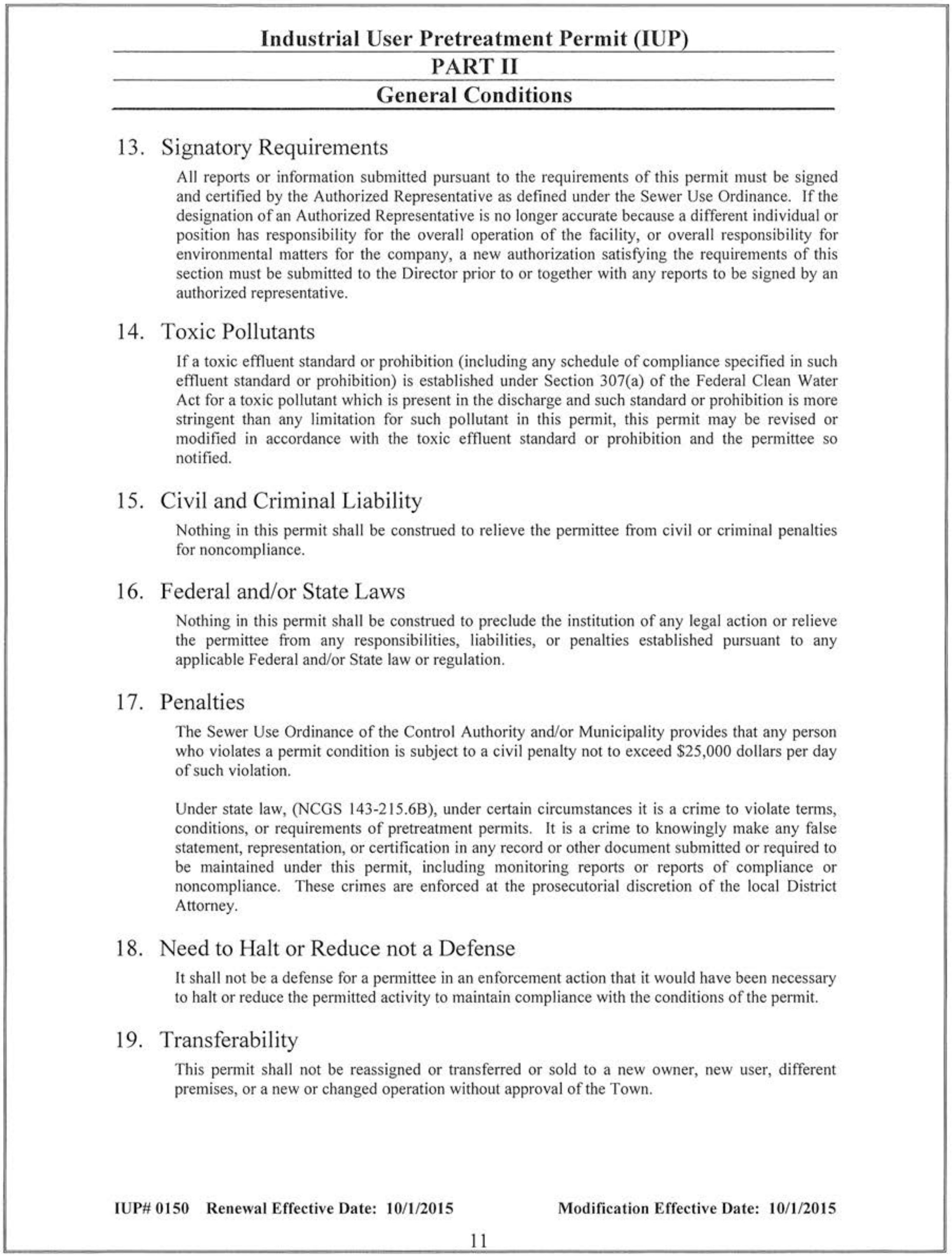
11. Availability of Records and Reports

The permittee shall retain records of all monitoring information, including all calibration and maintenance records as well as copies of reports and information used to complete the application for this permit for at least three years. All records that pertain to matters that are subject to any type of enforcement action shall be retained and preserved by the permittee until all enforcement activities have concluded and all periods of limitation with respect to any and all appeals have expired.

Except for data determined to be confidential under the Sewer Use Ordinance, all reports prepared in accordance with terms of this permit shall be available for public inspection at the Control Authority and/or Municipality. As required by the Sewer Use Ordinance, effluent data shall not be considered confidential.

12. Duty to Provide Information

The permittee shall furnish to the Director of Public Works or his/her designees, within a reasonable time, any information which the Director, his/her designee, or the Division of Water Quality may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit or to determine compliance with this permit. The permittee shall also furnish, upon request, copies of records required to be kept by this permit.



Industrial User Pretreatment Permit (IUP)

PART II

General Conditions

13. Signatory Requirements

All reports or information submitted pursuant to the requirements of this permit must be signed and certified by the Authorized Representative as defined under the Sewer Use Ordinance. If the designation of an Authorized Representative is no longer accurate because a different individual or position has responsibility for the overall operation of the facility, or overall responsibility for environmental matters for the company, a new authorization satisfying the requirements of this section must be submitted to the Director prior to or together with any reports to be signed by an authorized representative.

14. Toxic Pollutants

If a toxic effluent standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Federal Clean Water Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit may be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

15. Civil and Criminal Liability

Nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

16. Federal and/or State Laws

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties established pursuant to any applicable Federal and/or State law or regulation.

17. Penalties

The Sewer Use Ordinance of the Control Authority and/or Municipality provides that any person who violates a permit condition is subject to a civil penalty not to exceed $25,000 dollars per day of such violation.

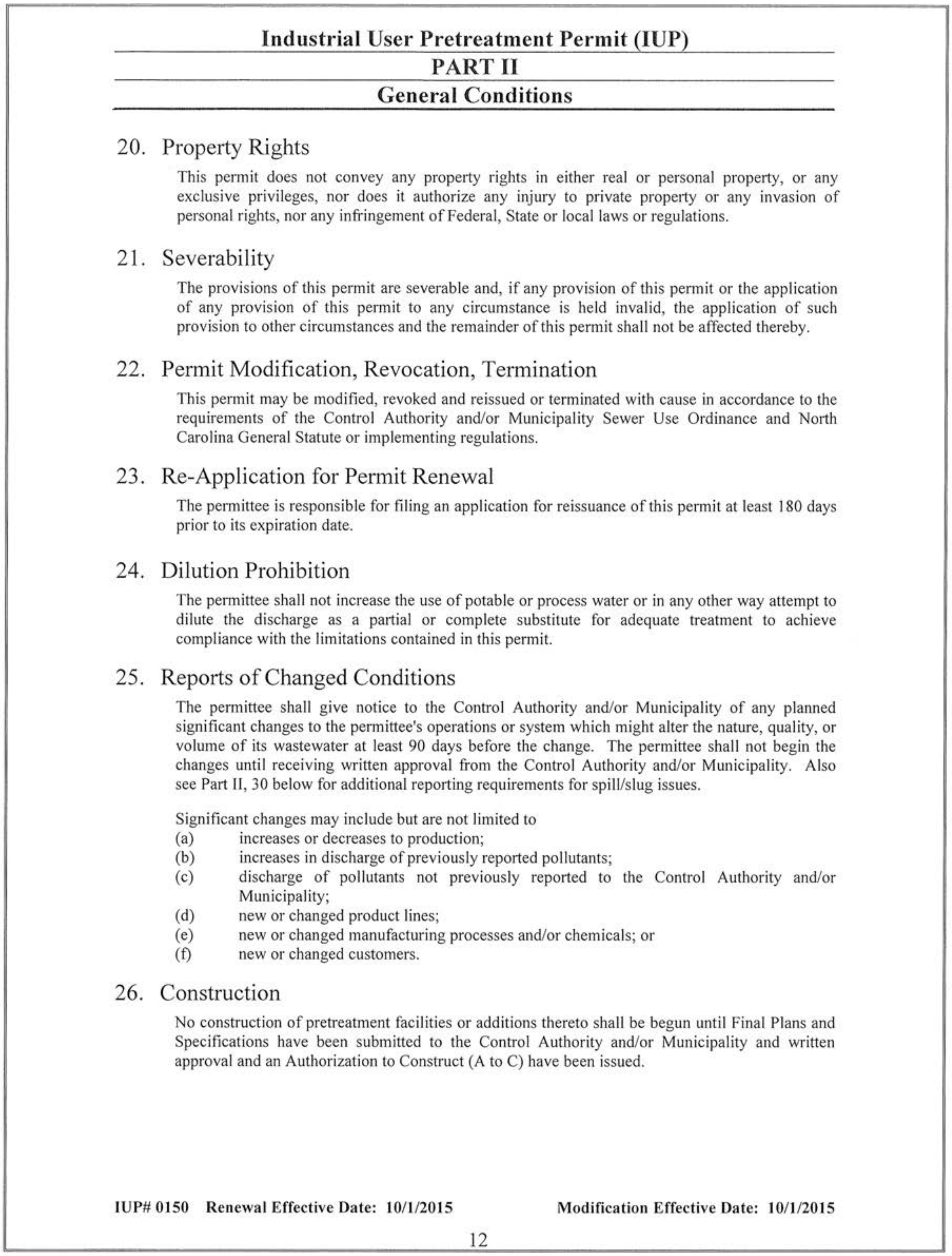
Under state law, (NCGS 143-215.6B), under certain circumstances it is a crime to violate terms, conditions, or requirements of pretreatment permits. It is a crime to knowingly make any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance. These crimes are enforced at the prosecutorial discretion of the local District Attorney.

18. Need to Halt or Reduce not a Defense

It shall not be a defense for a permittee in an enforcement action that it would have been necessary to halt or reduce the permitted activity to maintain compliance with the conditions of the permit.

19. Transferability

This permit shall not be reassigned or transferred or sold to a new owner, new user, different premises, or a new or changed operation without approval of the Town.



20. Property Rights

This permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

21. Severability

The provisions of this permit are severable and, if any provision of this permit or the application of any provision of this permit to any circumstance is held invalid, the application of such provision to other circumstances and the remainder of this permit shall not be affected thereby.

22. Permit Modification, Revocation, Termination

This permit may be modified, revoked and reissued or terminated with cause in accordance to the requirements of the Control Authority and/or Municipality Sewer Use Ordinance and North Carolina General Statute or implementing regulations.

23. Re-Application for Permit Renewal

The permittee is responsible for filing an application for reissuance of this permit at least 180 days prior to its expiration date.

24. Dilution Prohibition

The permittee shall not increase the use of potable or process water or in any other way attempt to dilute the discharge as a partial or complete substitute for adequate treatment to achieve compliance with the limitations contained in this permit.

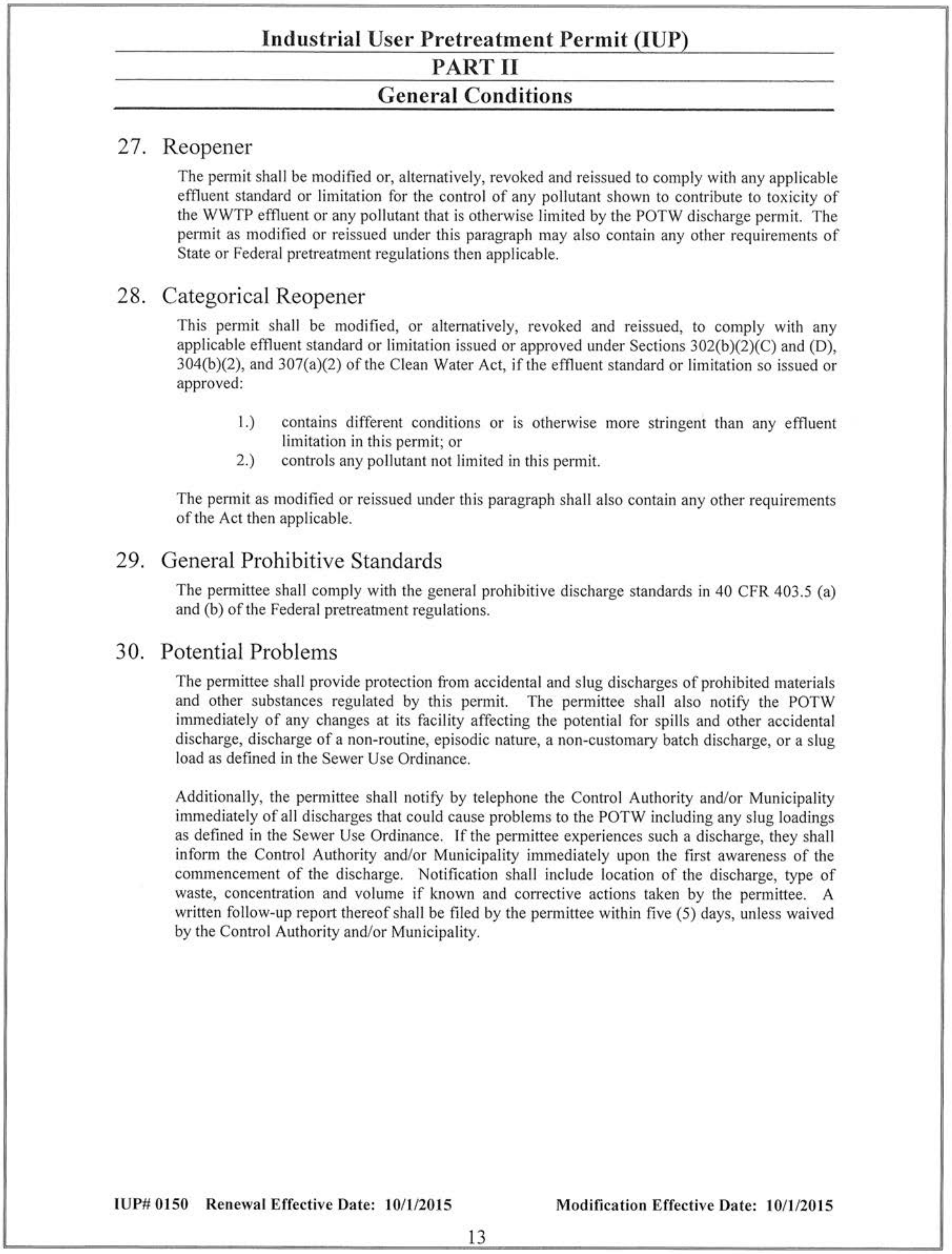
25. Reports of Changed Conditions

The permittee shall give notice to the Control Authority and/or Municipality of any planned significant changes to the permittee's operations or system which might alter the nature, quality, or volume of its wastewater at least 90 days before the change. The permittee shall not begin the changes until receiving written approval from the Control Authority and/or Municipality. Also see Part II, 30 below for additional reporting requirements for spill/slug issues.

Significant changes may include but are not limited to
(a) increases or decreases to production;
(b) increases in discharge of previously reported pollutants;
(c) discharge of pollutants not previously reported to the Control Authority and/or Municipality;
(d) new or changed product lines;
(e) new or changed manufacturing processes and/or chemicals; or
(f) new or changed customers.

26. Construction

No construction of pretreatment facilities or additions thereto shall be begun until Final Plans and Specifications have been submitted to the Control Authority and/or Municipality and written approval and an Authorization to Construct (A to C) have been issued.



27. Reopener

The permit shall be modified or, alternatively, revoked and reissued to comply with any applicable effluent standard or limitation for the control of any pollutant shown to contribute to toxicity of the WWTP effluent or any pollutant that is otherwise limited by the POTW discharge permit. The permit as modified or reissued under this paragraph may also contain any other requirements of State or Federal pretreatment regulations then applicable.

28. Categorical Reopener

This permit shall be modified, or alternatively, revoked and reissued, to comply with any applicable effluent standard or limitation issued or approved under Sections 302(b)(2)(C) and (D), 304(b)(2), and 307(a)(2) of the Clean Water Act, if the effluent standard or limitation so issued or approved:

1.) contains different conditions or is otherwise more stringent than any effluent limitation in this permit; or
2.) controls any pollutant not limited in this permit.

The permit as modified or reissued under this paragraph shall also contain any other requirements of the Act then applicable.

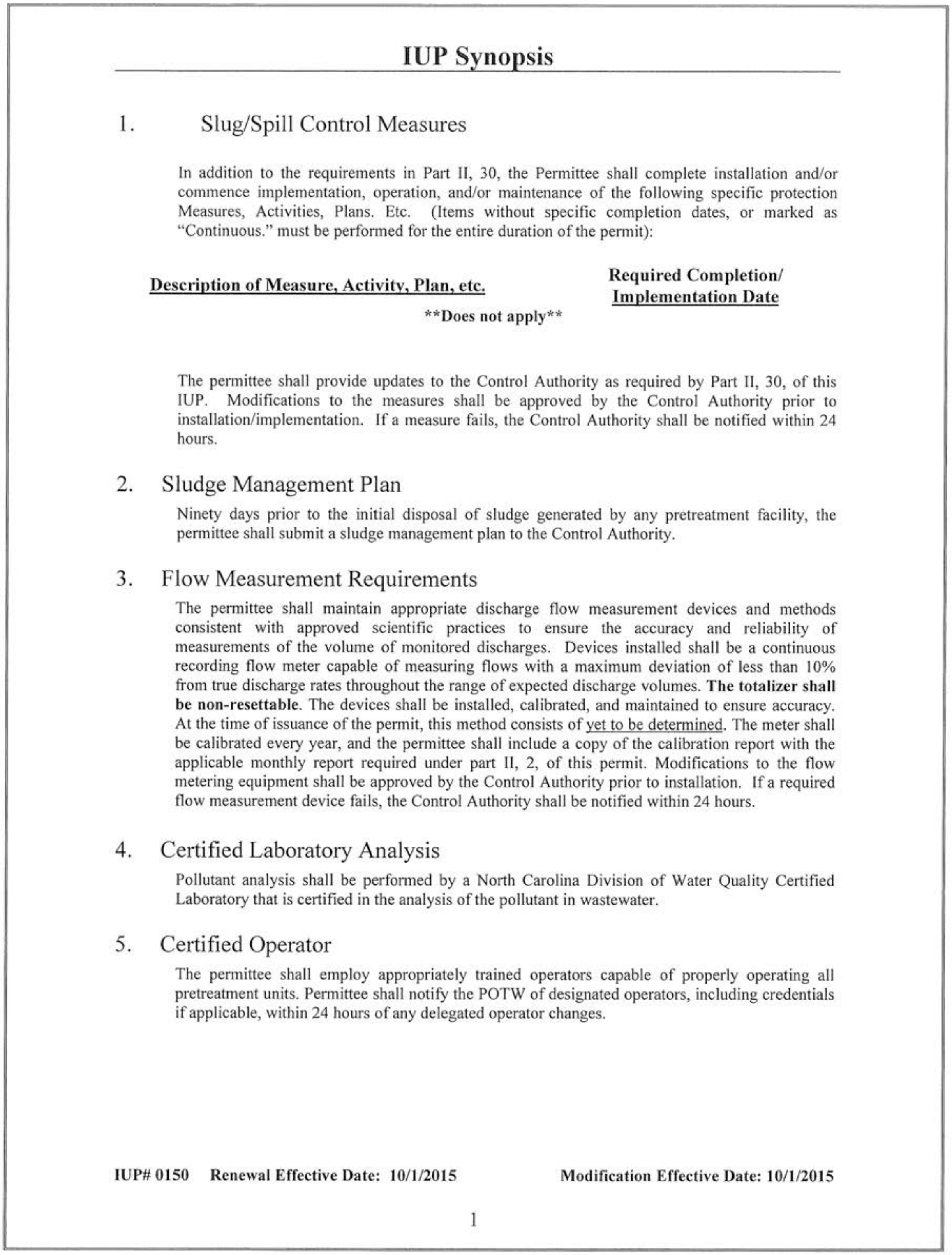
29. General Prohibitive Standards

The permittee shall comply with the general prohibitive discharge standards in 40 CFR 403.5 (a) and (b) of the Federal pretreatment regulations.

30. Potential Problems

The permittee shall provide protection from accidental and slug discharges of prohibited materials and other substances regulated by this permit. The permittee shall also notify the POTW immediately of any changes at its facility affecting the potential for spills and other accidental discharge, discharge of a non-routine, episodic nature, a non-customary batch discharge, or a slug load as defined in the Sewer Use Ordinance.

Additionally, the permittee shall notify by telephone the Control Authority and/or Municipality immediately of all discharges that could cause problems to the POTW including any slug loadings as defined in the Sewer Use Ordinance. If the permittee experiences such a discharge, they shall inform the Control Authority and/or Municipality immediately upon the first awareness of the commencement of the discharge. Notification shall include location of the discharge, type of waste, concentration and volume if known and corrective actions taken by the permittee. A written follow-up report thereof shall be filed by the permittee within five (5) days, unless waived by the Control Authority and/or Municipality.



IUP Synopsis

1. Slug/Spill Control Measures

In addition to the requirements in Part II, 30, the Permittee shall complete installation and/or commence implementation, operation, and/or maintenance of the following specific protection Measures, Activities, Plans. Etc. (Items without specific completion dates, or marked as "Continuous." must be performed for the entire duration of the permit):

Description of Measure, Activity, Plan, etc.	Required Completion/ Implementation Date
****Does not apply****	

The permittee shall provide updates to the Control Authority as required by Part II, 30, of this IUP. Modifications to the measures shall be approved by the Control Authority prior to installation/implementation. If a measure fails, the Control Authority shall be notified within 24 hours.

2. Sludge Management Plan

Ninety days prior to the initial disposal of sludge generated by any pretreatment facility, the permittee shall submit a sludge management plan to the Control Authority.

3. Flow Measurement Requirements

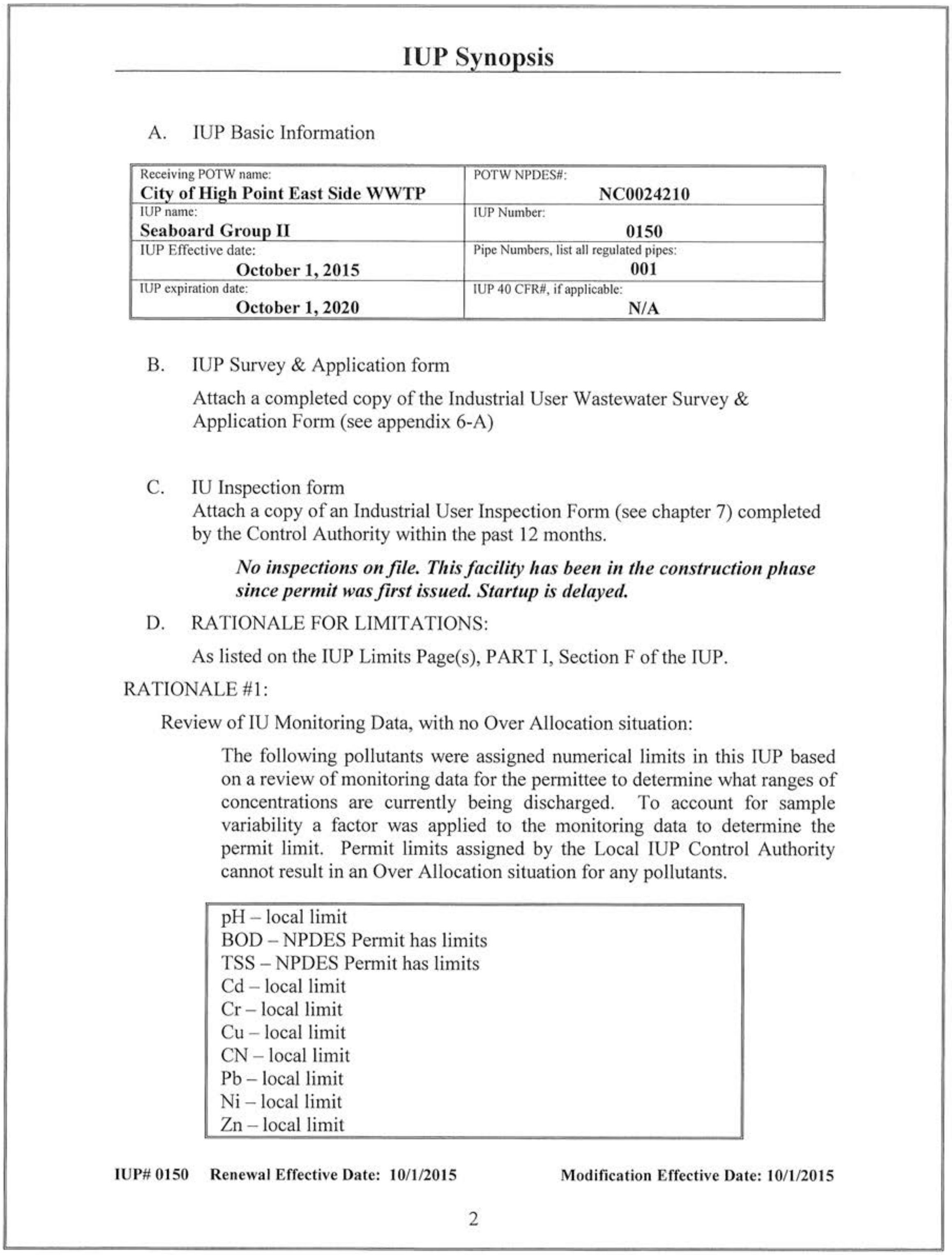
The permittee shall maintain appropriate discharge flow measurement devices and methods consistent with approved scientific practices to ensure the accuracy and reliability of measurements of the volume of monitored discharges. Devices installed shall be a continuous recording flow meter capable of measuring flows with a maximum deviation of less than 10% from true discharge rates throughout the range of expected discharge volumes. **The totalizer shall be non-resettable**. The devices shall be installed, calibrated, and maintained to ensure accuracy. At the time of issuance of the permit, this method consists of yet to be determined. The meter shall be calibrated every year, and the permittee shall include a copy of the calibration report with the applicable monthly report required under part II, 2, of this permit. Modifications to the flow metering equipment shall be approved by the Control Authority prior to installation. If a required flow measurement device fails, the Control Authority shall be notified within 24 hours.

4. Certified Laboratory Analysis

Pollutant analysis shall be performed by a North Carolina Division of Water Quality Certified Laboratory that is certified in the analysis of the pollutant in wastewater.

5. Certified Operator

The permittee shall employ appropriately trained operators capable of properly operating all pretreatment units. Permittee shall notify the POTW of designated operators, including credentials if applicable, within 24 hours of any delegated operator changes.



IUP Synopsis

A. IUP Basic Information

Receiving POTW name: **City of High Point East Side WWTP**	POTW NPDES#: **NC0024210**
IUP name: **Seaboard Group II**	IUP Number: **0150**
IUP Effective date: **October 1, 2015**	Pipe Numbers, list all regulated pipes: **001**
IUP expiration date: **October 1, 2020**	IUP 40 CFR#, if applicable: **N/A**

B. IUP Survey & Application form

Attach a completed copy of the Industrial User Wastewater Survey & Application Form (see appendix 6-A)

C. IU Inspection form
Attach a copy of an Industrial User Inspection Form (see chapter 7) completed by the Control Authority within the past 12 months.

No inspections on file. This facility has been in the construction phase since permit was first issued. Startup is delayed.

D. RATIONALE FOR LIMITATIONS:

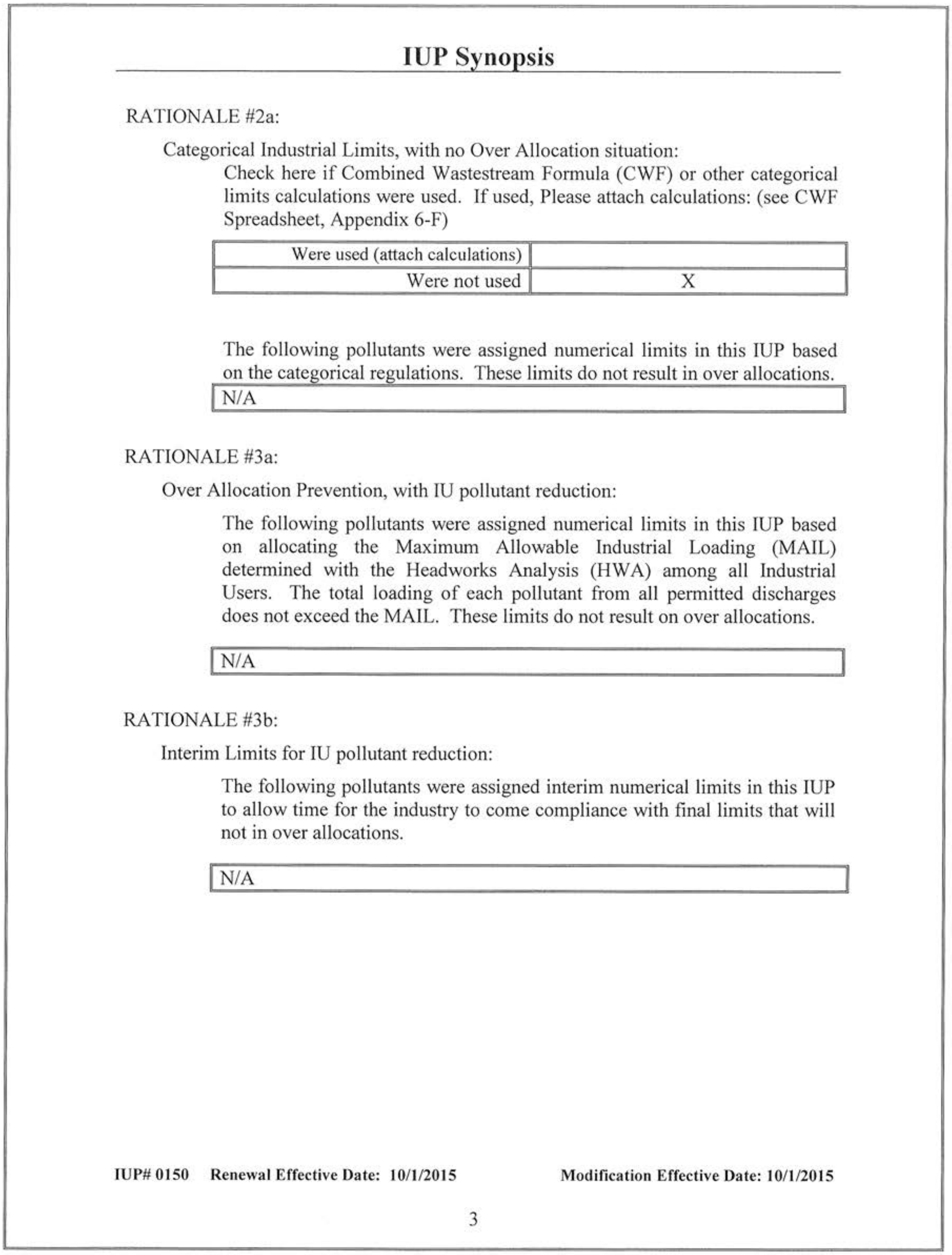
As listed on the IUP Limits Page(s), PART I, Section F of the IUP.

RATIONALE #1:

Review of IU Monitoring Data, with no Over Allocation situation:

The following pollutants were assigned numerical limits in this IUP based on a review of monitoring data for the permittee to determine what ranges of concentrations are currently being discharged. To account for sample variability a factor was applied to the monitoring data to determine the permit limit. Permit limits assigned by the Local IUP Control Authority cannot result in an Over Allocation situation for any pollutants.

pH – local limit
BOD – NPDES Permit has limits
TSS – NPDES Permit has limits
Cd – local limit
Cr – local limit
Cu – local limit
CN – local limit
Pb – local limit
Ni – local limit
Zn – local limit



IUP Synopsis

RATIONALE #2a:

Categorical Industrial Limits, with no Over Allocation situation:

Check here if Combined Wastestream Formula (CWF) or other categorical limits calculations were used. If used, Please attach calculations: (see CWF Spreadsheet, Appendix 6-F)

Were used (attach calculations)	
Were not used	X

The following pollutants were assigned numerical limits in this IUP based on the categorical regulations. These limits do not result in over allocations.

N/A

RATIONALE #3a:

Over Allocation Prevention, with IU pollutant reduction:

The following pollutants were assigned numerical limits in this IUP based on allocating the Maximum Allowable Industrial Loading (MAIL) determined with the Headworks Analysis (HWA) among all Industrial Users. The total loading of each pollutant from all permitted discharges does not exceed the MAIL. These limits do not result on over allocations.

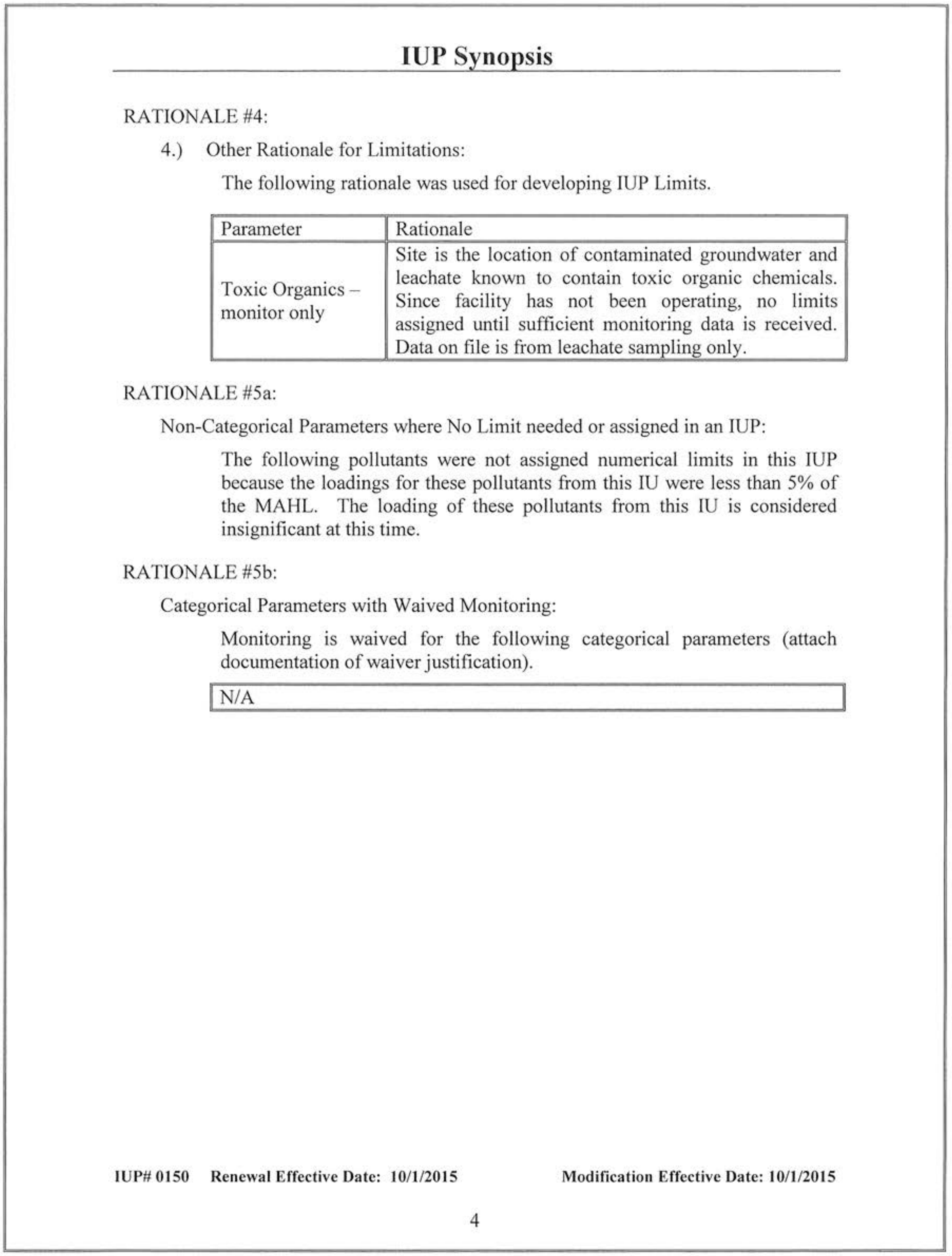
N/A

RATIONALE #3b:

Interim Limits for IU pollutant reduction:

The following pollutants were assigned interim numerical limits in this IUP to allow time for the industry to come compliance with final limits that will not in over allocations.

N/A



IUP Synopsis

RATIONALE #4:

4.) Other Rationale for Limitations:

The following rationale was used for developing IUP Limits.

Parameter	Rationale
Toxic Organics – monitor only	Site is the location of contaminated groundwater and leachate known to contain toxic organic chemicals. Since facility has not been operating, no limits assigned until sufficient monitoring data is received. Data on file is from leachate sampling only.

RATIONALE #5a:

Non-Categorical Parameters where No Limit needed or assigned in an IUP:

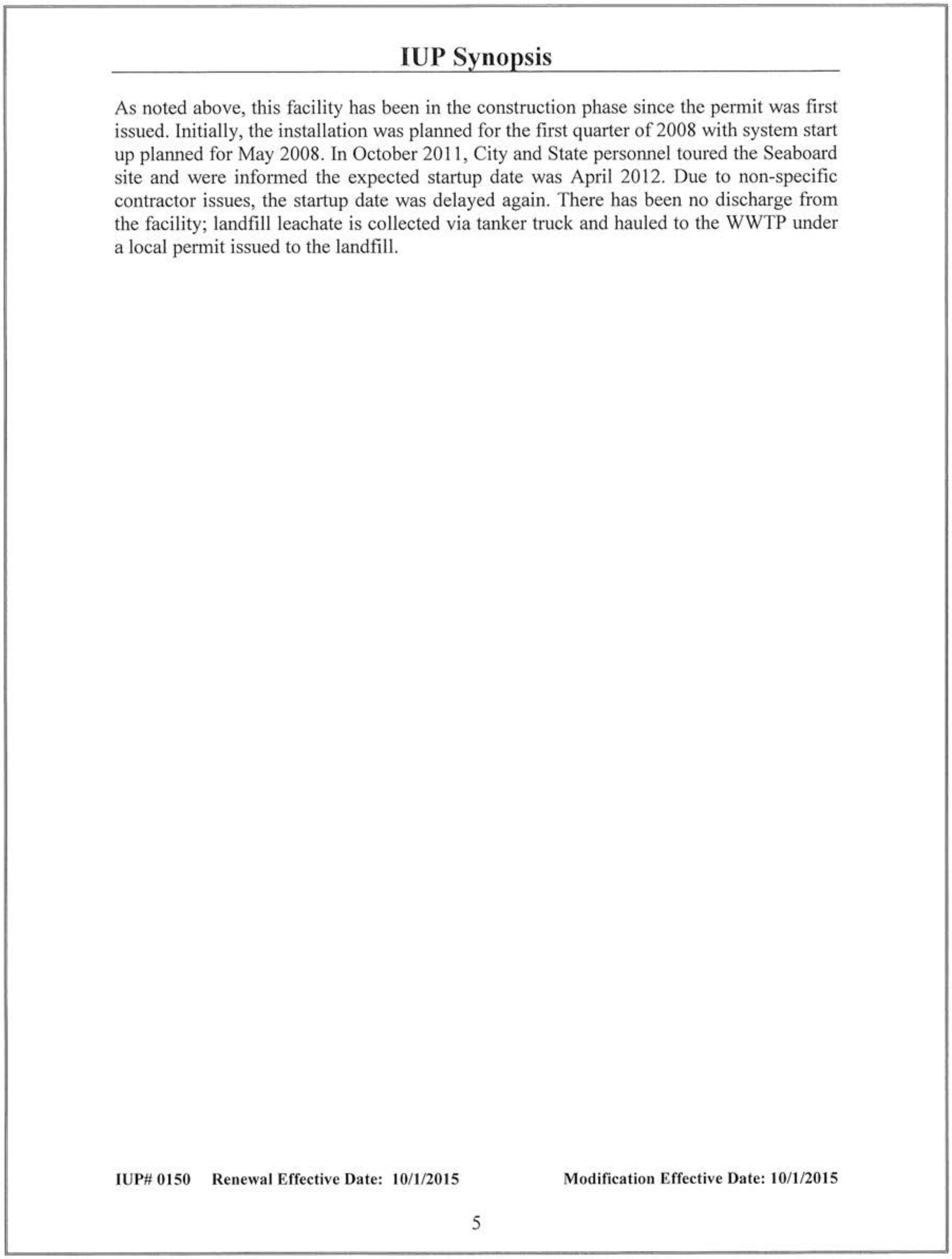
The following pollutants were not assigned numerical limits in this IUP because the loadings for these pollutants from this IU were less than 5% of the MAHL. The loading of these pollutants from this IU is considered insignificant at this time.

RATIONALE #5b:

Categorical Parameters with Waived Monitoring:

Monitoring is waived for the following categorical parameters (attach documentation of waiver justification).

N/A



IUP Synopsis

As noted above, this facility has been in the construction phase since the permit was first issued. Initially, the installation was planned for the first quarter of 2008 with system start up planned for May 2008. In October 2011, City and State personnel toured the Seaboard site and were informed the expected startup date was April 2012. Due to non-specific contractor issues, the startup date was delayed again. There has been no discharge from the facility; landfill leachate is collected via tanker truck and hauled to the WWTP under a local permit issued to the landfill.

ATTACHMENT 9

ERM PUMP TEST

REPORT

Seaboard Group II and City of High Point,
North Carolina

Report of Extraction Rate/ Capture Zone Test - August 2002

Former Seaboard Chemical/ Riverdale Drive Landfill Site Jamestown, North Carolina

April 16, 2004

Thomas M Wilson

Thomas M. Wilson, P.G.
Principal-in-Charge

ERM NC, PC
8000 Corporate Center Drive
Suite 200
Charlotte, NC 28226

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1.0 INTRODUCTION

Aquifer testing activities were conducted at the Seaboard Chemical/Riverdale Drive Landfill site during July and August 2002. The work was performed by ERM and Babb & Associates on behalf of the Seaboard Group II and the City of High Point. The activities were conducted in accordance with the approved scope of work described in the *Pre-Remedial Assessment Activities, Extraction Rate/Capture Zone* work plan dated May 28, 2002. The scope of work and results presented in this report supplement the initial Remedial Investigation which was conducted at the site from 1996 to 1998, and previous supplemental RI and annual monitoring activities which were conducted at the site in years 2000 and 2001. The remedial investigation and monitoring activities were conducted under an Administrative Order on Consent (AOC), dated June 30, 1996, with the North Carolina Department of Environment and Natural Resources (NCDENR), Division of Waste Management.

The aquifer testing was conducted to collect data needed to determine the number, locations and extraction (pumping) rates of recovery wells which may be used for ground water remediation at the site. The specific objectives of the aquifer testing are as follows:

- Determine if drawdown caused by pumping of existing well PW-DR1 will extend to, and induce flow from, the major discrete features that control contaminant migration at the site (namely the Regional Dike to the east and the Seaboard Dike to the west);
- Determine if the boundary effects of the Deep River are significant enough to limit drawdown, and hence the extent of the capture zone, created by pumping PW-DR1;
- Assess the vertical extent of the capture zone; and
- Determine if additional extraction wells will be necessary to intercept ground water in the Regional Dike and the Seaboard Dike, and if so, determine their locations and pumping rates.

This report summarizes the aquifer testing activities and presents the preliminary results.

2.0 AQUIFER TESTING ACTIVITIES

As part of the aquifer testing activities, two bedrock observation wells were installed near the Deep River, down-hole video logging of the new observation wells was performed and an aquifer test was performed by pumping existing well PW-DR1 at several discharge rates. In addition, flowmeter logging of the new observation wells was performed before and during the aquifer test. Details of each of these activities are discussed below.

2.1 OBSERVATION WELL INSTALLATION

In September 1997, an aquifer test was conducted at monitor well PW-DR1 as part of the RI activities. Although water-level drawdown was measured in wells within 80 feet of PW-DR1, there were no observation wells located at greater distances from the pumping well. Consequently, it was difficult to assess the lateral extent of the pumping influence during the 1997 aquifer test.

In order to accurately assess the extent of the area of influence, or capture zone, of well PW-DR1, two observation wells were installed in the vicinity of existing well PW-DR1. The locations of the new observation wells (OW-DR3 and OW-DR4) are shown in Figures 1 and 2 and are discussed below. The locations are on the City of High Point landfill property (outside the PTRWA right-of-way) and above the normal pool elevation of the Randleman Reservoir.

The new observation wells were installed on or near inferred locations of geological structures (see Figure 1), which serve as preferred migration pathways to the Deep River. The results of previous magnetic geophysical survey and geologic mapping were used to determine the location of the observation wells. One observation well, OW-DR3, was installed approximately 350 feet east of PW-DR1 near the west side of the Regional Dike at or near the inferred intersection of the Regional Dike and the Deep River Fault. The Regional Dike is a northeast-trending geologic structure which serves as a preferred migration pathway and which corresponds approximately with the eastern edge of the main mass of VOC-affected ground water migrating toward the east-west segment of the Deep River. The Deep River Fault is a south-dipping geologic structure that forms the east-west segment of the river and serves as a primary migration pathway to the Deep River. The OW-DR3 observation well was used to monitor whether the drawdown and the capture zone from pumping PW-DR1 would extend eastward to the Regional Dike.

The second observation well, OW-DR4, was installed approximately 400 feet west of PW-DR1, on the east side of the Seaboard Dike near the inferred intersection of the Seaboard Dike and the Deep River Fault. The Seaboard Dike is a northeast-trending geologic structure which serves as a preferred migration pathway and which corresponds approximately with the western edge of the main mass of VOC-affected ground water migrating toward the east-west segment of the Deep River. The OW-DR4 observation well was used to monitor whether the drawdown and the capture zone from pumping at PW-DR1 would extend westward to the Seaboard Dike.

The final locations of the new observation wells were constrained by the landfill cell, a subsurface sanitary sewer main and the steep topography. The location of OW-DR3 had to be adjusted approximately 35 feet to the southwest of the initial staked location to provide adequate offset from the sanitary sewer main.

Each monitor well borehole was advanced by drilling a 10-inch boring into the top of bedrock and installing a 6-inch surface casing. At OW-DR4, a 12-inch surface casing was also installed in a 24-inch boring to isolate a zone of landfilled waste that was encountered to a depth of 12 feet. The borings were continued as 6-inch boreholes to a total depth of approximately 160 feet below ground surface (bgs) at OW-DR3 and 165 feet bgs at OW-DR4. The proposed total depths correspond to a subsurface elevation of 550 feet mean sea level (msl). The 550-foot elevation is targeted because it is near the projected subsurface depth of the Deep River Fault beneath the proposed observation well locations and is within the depth zone of the highest concentrations of VOC-affected ground water based on discrete interval sampling at PW-5D (located adjacent to PW-DR1).

The observation wells were completed as 6-inch open borehole observation wells. The observation wells were completed with lockable stick-up well covers and 3 ft. by 3 ft. concrete pads. The locations and elevations of the observation wells were surveyed by a North Carolina registered surveyor.

Following the completion of the new observation wells, video logging of the wells was conducted to identify the possible locations of fractures that intersect them. The video logs were evaluated along with the geologist's drilling logs to determine the apparent major transmissive fracture zones.

In addition to video logging, both wells were logged using a down-hole flow meter. The flow meter was used to measure vertical flow rate in the wells under stressed (pumping) and unstressed (non-pumping) conditions. These measurements were used to indicate (1) where water-producing fractures are located, (2) the direction of the vertical hydraulic gradient in each well, and (3) the relative transmissivity of fractures intersecting the wells. The flow rate data were collected using an electromagnetic flowmeter tool (Century Geophysical model 9721). Flow rate measurements were made at approximately 5-foot intervals along the entire uncased portion of each well bore and at selected downhole fracture zones identified from the video log and drilling log. Flowmeter data for the non-pumping conditions were collected on August 20 at OW-DR3 and OW-DR4. Flowmeter data for the pumping conditions were collected during the extraction rate test on August 21 at OW-DR3, OW-DR4 and OW-DR1. The pumping rate was 37 to 40 gpm at test well PW-DR1 at the time of the flowmeter logging under pumping conditions at the observation wells.

The drilling logs for OW-DR3 and OW-DR4 are presented in Appendix A. The flowmeter logging data are also presented on the drilling logs. The new observation wells are also shown in a hydrogeologic cross-section presented in Figure 3.

2.2 *EXTRACTION RATE/CAPTURE ZONE TEST AT PW-DR1*

An extraction test was conducted at PW-DR1 in which the pumping rate was periodically increased and the resulting drawdown was monitored in nearby monitoring wells, including the newly installed wells OW-DR3 and OW-DR4. By observing and plotting the drawdown at different pumping rates, the capture zone for different extraction rates was determined. Determination of the extraction rate that will capture flow from the Regional Dike and the Seaboard Dike was of particular interest.

Prior to the aquifer tests, a submersible pump was set in well PW-DR1 to a depth of 100 feet (below the maximum anticipated drawdown). A gate valve and flow meter with totalizer were installed in the discharge pipe to regulate and monitor ground water discharge.

The water generated by the aquifer test was collected in tankers and transported to the former Seaboard Chemical facility site for treatment. The test water was pre-treated using portable activated carbon adsorption units prior to discharge to the City of High Point POTW. Authorization to discharge the treated ground water to the POTW was obtained from the City on August 30.

For two days prior to the aquifer test (August 19 and 20), water levels were monitored in the test well, four monitor/observation wells (OW-DR2, OW-DR3, OW-DR4, and PW-13I), the Deep River, and a piezometer DRP-2 (located below the bed in the Deep River). The pre-pumping water-level data was used to identify water level trends in the shallow bedrock aquifer and the river prior to the test. Rainfall was also measured during the 2-days prior to the test and no rainfall occurred. Immediately prior to the starting time for the aquifer test, water level data was collected from the test well and observation wells.

Drawdown was measured as a function of time after the start of pumping at 7:20 a.m. on August 21. Based on results of the September 1997 aquifer test, it was anticipated that the maximum yield of PW-DR1 would be 40 gallons per minute or more. The test well was pumped at successively higher pumping rates and the drawdown for each rate (step) was recorded. In the work plan, an initial pumping rate of 5 gallons per minute (gpm) was planned. However, at the time of the test, the plan was modified to allow an initial pumping rate of 10 gpm in order to increase the hydrologic stress on the aquifer system and improve the chance of seeing drawdown extend to the Seaboard Dike and the Regional Dike. The actual pumping rates and pumping time for each rate is summarized below.

Pumping Rate	Duration
10 gpm	2 hours
20 gpm	2 hours
37 gpm	2.3 hours
40 gpm	5.3 hours

Throughout the test, water level data was collected at predetermined time intervals. Water levels were measured to the nearest 0.01 feet. The planned time intervals for collecting the ground water levels at the beginning of each step are provided in the following table.

Time Since Pumping Started in Minutes	Time Intervals Between Measurements in Minutes
0-10	0.5
10-15	1
15-60	5
60-120	10
After 120	15

The pump was stopped at 7:20 p.m. on August 21. The total pumping time was 720 minutes. Water levels were measured during the recovery period, after pumping stopped, using a schedule similar to that in the table above.

Aquifer test data was recorded in the field on standardized forms and and/or on digital data loggers. In addition to the actual aquifer test data, precipitation was also monitored and there was no rainfall prior to and during the aquifer test.

The observation well network for the aquifer test consisted of the test well (PW-DR1), the two new observation wells (OW- DR3 & OW-DR4), existing monitor wells MW-3C, MW-4, MW-11, OW-DR2, PW-13I, PW-5D, PW-6I, PW-6D, PW-7I and piezometer DRP-2 at the Deep River. The work plan included monitor well PW-15D in the observation well network. However, permission to access the PW-15D location (located across the Deep River from the test well) through a private property could not be obtained prior to the test and PW-15D was omitted from the observation well network. The extraction test monitoring program is summarized in Table 1. Figure 2 provides the locations of the test well and the observation wells. The nearest observation well (OW-DR2) was located approximately 75 feet from the test well. The maximum distance of an observation well from the test well was 670 feet (MW- 11). The observation well network provided monitoring of aquifer response in the shallow bedrock aquifer.

A pressure transducer and data logger was placed each in PW-DR1, OW-DR3, OW-DR4, PW-6D, PW-6I, PW-7I and PW-13I. Manual measurements of water levels were made in the remaining monitor/observation wells, the Deep River staff gauge and piezometer DRP-2. In addition, manual measurements of water levels were obtained for the wells equipped with pressure transducers for backup purposes.

3.0 RESULTS

The aquifer test activities were conducted at the Seaboard Chemical and Riverdale Drive Landfill Site during the period of July - August 2002 . Figures 1 and 2 provide the locations of the test well, the observation wells and the major geologic structures. The drilling logs and flowmeter logging data for OW-DR3 and OW-DR4 are presented in Appendix A. A hydrogeologic cross section through the aquifer test area is presented in Figure 3. Time-drawdown plots are presented in Appendix B for monitor wells PW-DR1, OW-DR2, OW-DR3, OW-DR4, MW-3C, MW-4, MW-11, PW-5D, PW-6D, PW-6I, PW-7I and PW-13I, Deep River piezometer DRP-2 and Deep River staff gauge SW-DRP-2. Contour maps of the maximum drawdown observed near the end of each pumping rate step are presented in Figures 4A, 4B and 4C.

The major findings of the aquifer test activities at the Seaboard Chemical/Riverdale Drive Landfill site include the following:

- The drawdown caused by pumping of existing well PW-DR1 extended to the major discrete features that control contaminant migration at the site, namely the Regional Dike to the east and the Seaboard Dike to the west (Figures 4A, 4B & 4C). The drawdowns measured at the observation points at the end of each pumping rate step are summarized below.

Observation Point ID	Location Description	Distance from Pumping Well (ft)	Maximum Drawdown (Ft) @ 10 gpm	Maximum Drawdown (Ft) @ 20 gpm	Maximum Drawdown (Ft) @ 40 gpm
PW-DR1	Pumping Well at Deep River Fault & PW-5D Fault	-	8.3	15	36
OW-DR2	Deep River Fault	72	7.7	15	24.3
MW-3C	Shallow Bedrock Block	76	4	7.5	22
PW-5D	PW-5D Fault	90	2.4	4.8	13.8
DRP-2	Streambed Piezometer in Deep River	162	0	0	0
SW-DRP-2	Deep River Staff Gauge	162	0	0	0
OW-DR4	Seaboard Dike	240	7.8	11.5	23
OW-DR3	Regional Dike – West Side	330	0.1	0.1	0.1
MW-4	Saprolite Aquifer	418	0	0	0.1
PW-13I	West of Seaboard Dike	445	0.2	0.3	0.8
PW-7I	Shallow Bedrock Block	580	NDR	NDR	NDR
MW-11	West of Seaboard Dike	660	0	0	0
PW-6I	Regional Dike – East Side	670	0.02	0.05	0.16
PW-6D	Regional Dike – East Side	670	2.4	4	12

NDR = No Definitive Response

Drawdown in response to pumping was observed at seven of the thirteen observation points. At the Seaboard Dike, the approximate maximum drawdown measured at OW-DR4 near the end of the 10 gpm rate step was 7.8 feet. At PW-6D located on the east side of the Regional Dike, the approximate maximum drawdown measured at the end of the 10 gpm rate step was 2.4 feet. The drawdowns at OW-DR4 and PW-6D were observed to increase when the pumping rate at PW-DR1 was increased to 20 gpm and 40 gpm.

- Limited drawdown occurred at OW-DR3 located near the east side of the Regional Dike. Based on the drilling log and video log of OW-DR3, there were no major fracture zones or weathered zones encountered in the well borehole below the surface casing depth. A comparison of the flowmeter data for pumping and non-pumping conditions at OW-DR3 indicates a limited response to pumping at PW-DR1. These results indicate that the hydrologic connection between the OW-DR3 wellbore and the PW-DR1 wellbore was limited. This lack of connection may be the result of having to move the OW-DR3 well location by approximately 35 feet away from the Regional Dike (and associated fractures) in order to provide safe offset from an underground sanitary sewer line.

- No definitive response to pumping was observed at monitor wells MW-4, MW-11 and PW-7I. At MW-4, a shallow saprolite aquifer well, the results indicate that the hydrologic connection between the saprolite aquifer zone and the bedrock aquifer zone (pumping zone) is limited relative to the permeability within the fractured bedrock aquifer which served as the primary production zone for the duration of the pumping test. At MW-11, the results indicate an apparent lack of hydrologic connection with the pumping well. At PW-7I, a slight water level decline that was observed during the pumping phase of the test is not considered a definitive response to pumping because the decline continued after pumping stopped.

- No definitive drawdown occurred in the Deep River stream bed piezometer (DRP-2) or in the stage of the surface water in the Deep River (SW-DRP-2).

- Based on the drawdown data, and particularly the magnitude of the drawdown measured at OW-DR4 and PW-6D, there is no indication from the short-term pumping test that the extent of the capture zone was significantly limited by boundary (recharge) effects of the Deep River.

- Based on drawdowns observed at the deepest observation wells, PW-5D and PW-6D, the response to pumping at PW-DR1 (open borehole 38 – 185 ft bgs) extended to depths of 306.5 feet at PW-5D (screened interval 296.5 – 306.5 ft. bgs) and 275 feet at PW-6D (screened interval 260 – 275 ft. bgs). Based on historical ground water analytical results, the highest total VOC concentrations in the fractured bedrock aquifer near the Deep River occur in the 100 to 300-foot depth range. The extraction test results indicate that the PW-DR1 capture zone extends to the lower vertical portion of the VOC plume.

- The extraction rate test results indicate that, under the current hydrologic conditions, the VOC plume can be contained at the Deep River by pumping at a relatively low rate (10 - 20 gpm) at one extraction well, PW-DR1. The drawdown data indicate that pumping at a rate of 10 gpm at PW-DR1 will produce a capture zone which extends along the Deep River Fault to beyond the Seaboard Dike to the west and to beyond the Regional Dike to the east. The elongated capture zone from the single extraction well extends essentially along the entire length of the east-west segment of the Deep River and encompasses the width of the main VOC plume where it intersects the river (Figures 4A, 4B & 4C).

Tables

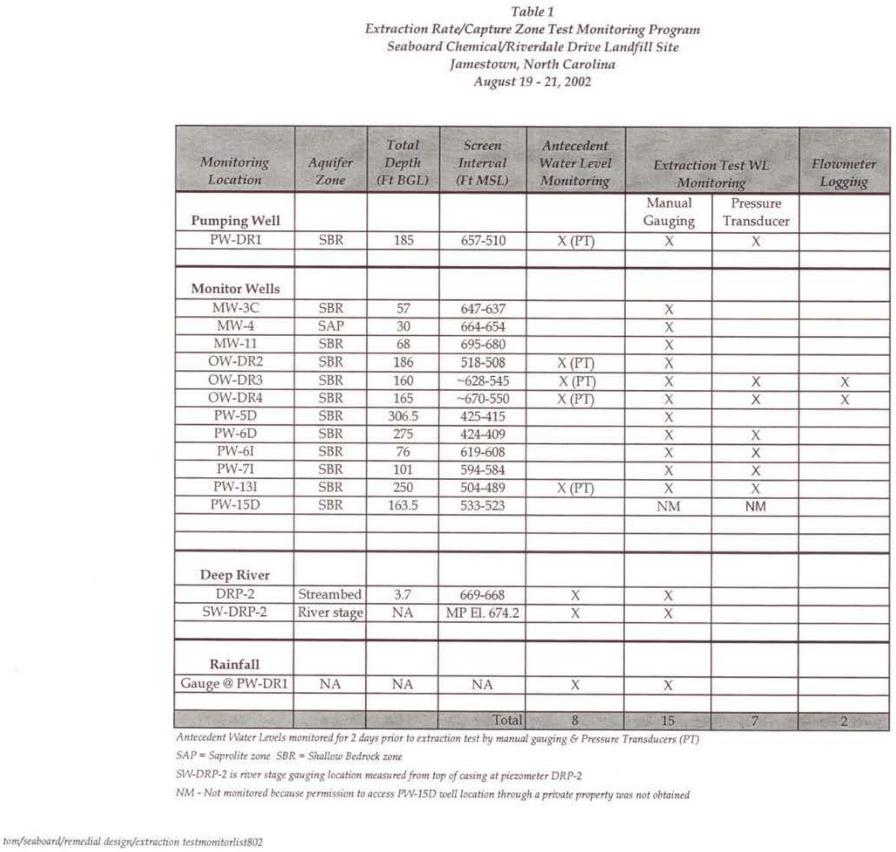


Table 1
Extraction Rate/Capture Zone Test Monitoring Program
Seaboard Chemical/Riverdale Drive Landfill Site
Jamestown, North Carolina
August 19 - 21, 2002

Monitoring Location	*Aquifer Zone*	*Total Depth (Ft BGL)*	*Screen Interval (Ft MSL)*	*Antecedent Water Level Monitoring*	*Extraction Test WL Monitoring*		*Flowmeter Logging*
Pumping Well					Manual Gauging	Pressure Transducer	
PW-DR1	SBR	185	657-510	X (PT)	X	X	
Monitor Wells							
MW-3C	SBR	57	647-637		X		
MW-4	SAP	30	664-654		X		
MW-11	SBR	68	695-680		X		
OW-DR2	SBR	186	518-508	X (PT)	X		
OW-DR3	SBR	160	~628-545	X (PT)	X	X	X
OW-DR4	SBR	165	~670-550	X (PT)	X	X	X
PW-5D	SBR	306.5	425-415		X		
PW-6D	SBR	275	424-409		X	X	
PW-6I	SBR	76	619-608		X	X	
PW-7I	SBR	101	594-584		X	X	
PW-13I	SBR	250	504-489	X (PT)	X	X	
PW-15D	SBR	163.5	533-523		NM	NM	
Deep River							
DRP-2	Streambed	3.7	669-668	X	X		
SW-DRP-2	River stage	NA	MP El. 674.2	X	X		
Rainfall							
Gauge @ PW-DR1	NA	NA	NA	X	X		
			Total	8	15	7	2

Antecedent Water Levels monitored for 2 days prior to extraction test by manual gauging & Pressure Transducers (PT)

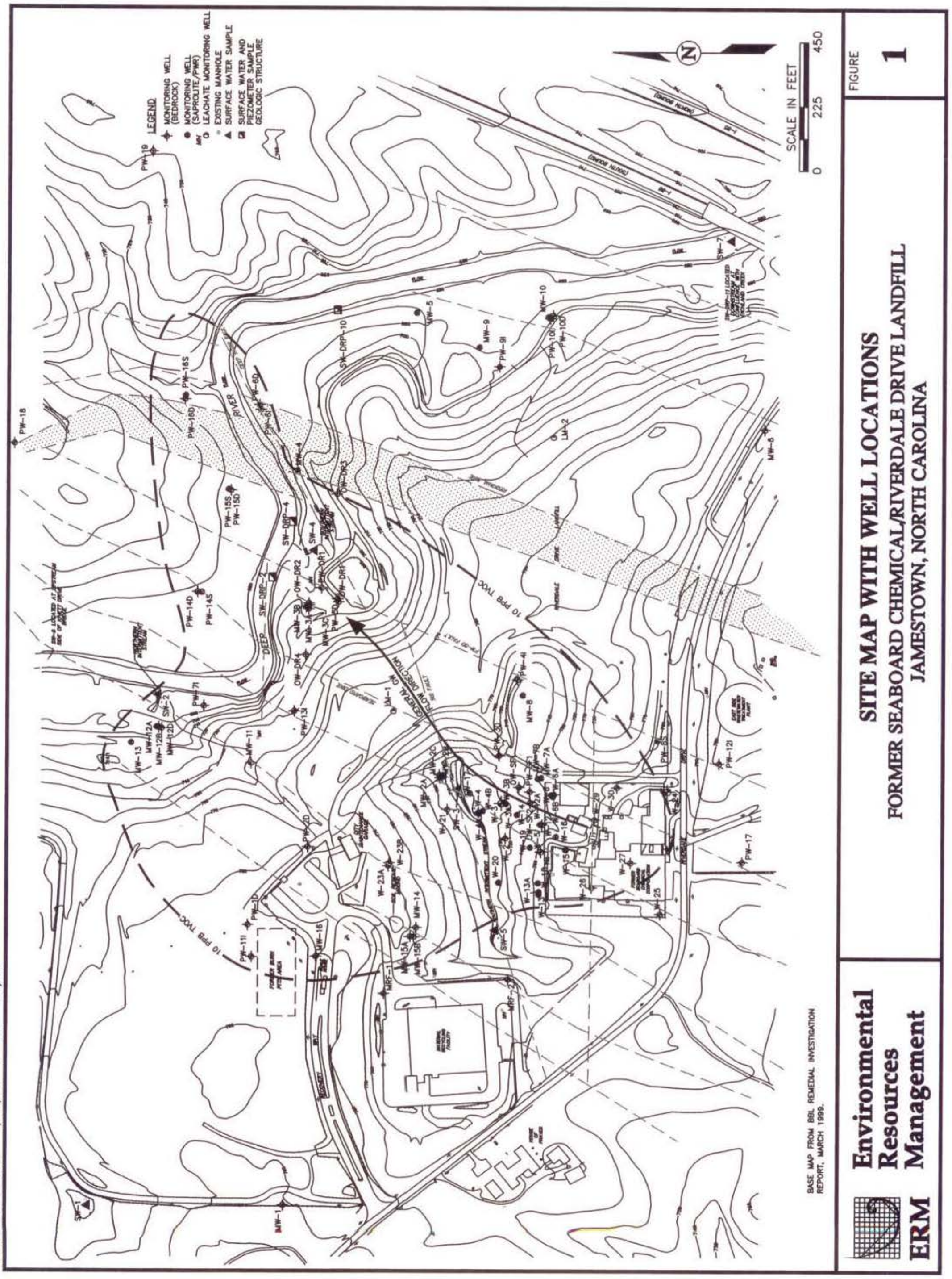
SAP = Saprolite zone SBR = Shallow Bedrock zone

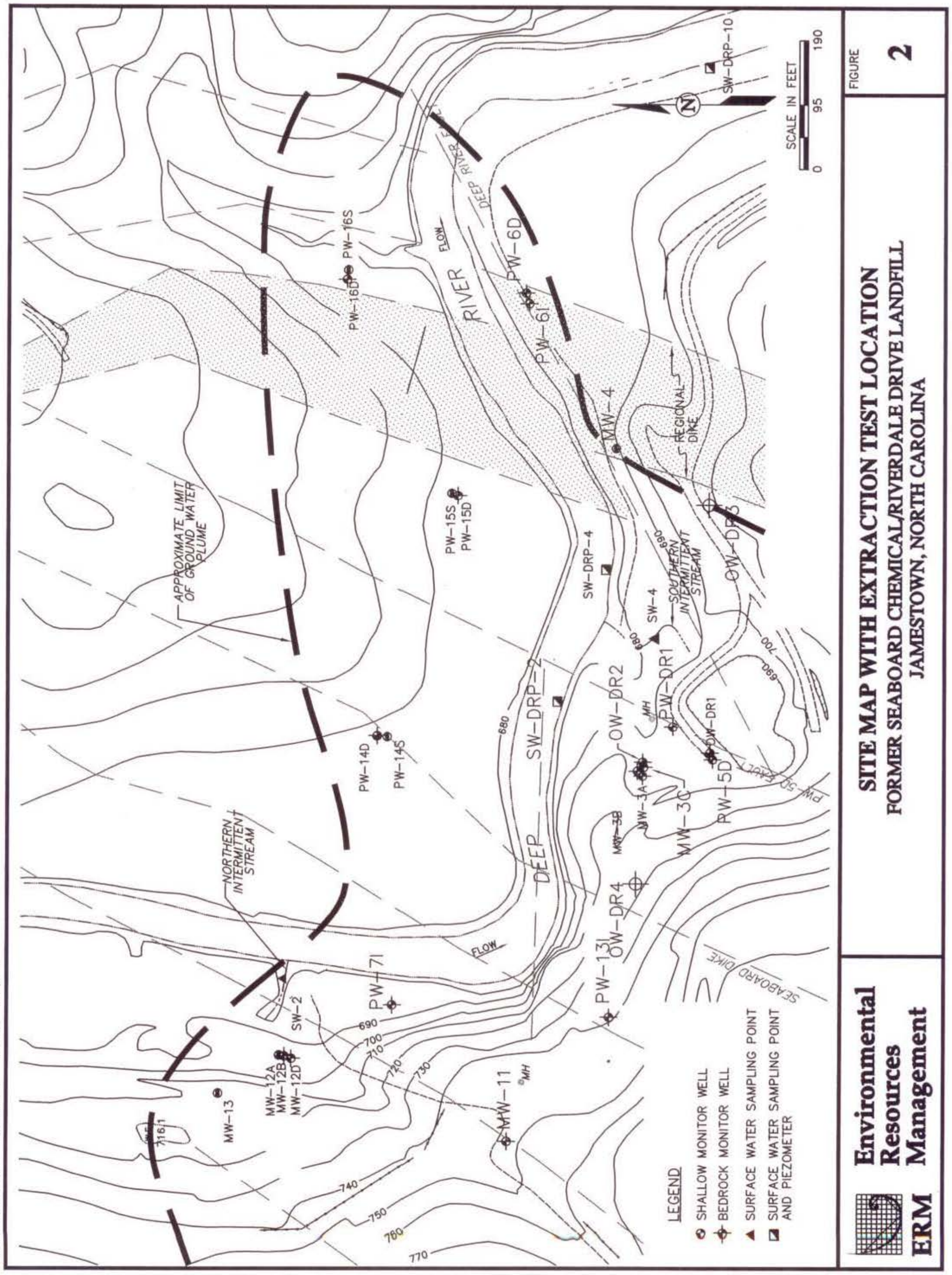
SW-DRP-2 is river stage gauging location measured from top of casing at piezometer DRP-2

NM - Not monitored because permission to access PW-15D well location through a private property was not obtained

tom/seaboard/remedial design/extraction testmonitorlist802

Figures


LEGEND
MONITORING WELL (BEDROCK)
MONITORING WELL (SAPROLITE/PWR)
LEACHATE MONITORING WELL
EXISTING MANHOLE
SURFACE WATER SAMPLE
SURFACE WATER AND PIEZOMETER SAMPLE
GEOLOGIC STRUCTURE
N
SCALE IN FEET
0
225
450
FIGURE
1
SITE MAP WITH WELL LOCATIONS
FORMER SEABOARD CHEMICAL/RIVERDALE DRIVE LANDFILL
JAMESTOWN, NORTH CAROLINA
Environmental
Resources
Management
ERM
BASE MAP FROM BBL REMEDIAL INVESTIGATION REPORT, MARCH 1999.
11743PROPOB.DWG
4/16/04
1=450
CH/TW
10 PPB TVOC
RIVER
PW-18
PW-19
PW-15S
PW-15D
PW-14D
PW-14S
PW-16D
PW-16S
PW-17
PW-12I
PW-11I
PW-10
PW-9I
PW-10I
PW-10D
MW-1
MW-5
MW-6
MW-9
MW-10
MW-11
MW-13
MW-14
MW-16
SW-1
SW-2
SW-4
SW-5
SW-7
SW-DRP-2
SW-DRP-4
SW-DRP-10
LM-1
LM-2


SITE MAP WITH EXTRACTION TEST LOCATION
FORMER SEABOARD CHEMICAL/RIVERDALE DRIVE LANDFILL
JAMESTOWN, NORTH CAROLINA
FIGURE
2
ERM
Environmental Resources Management
1174.3AMNEW.DWG
4/16/04
1=190
CH/AM
LEGEND
SHALLOW MONITOR WELL
BEDROCK MONITOR WELL
SURFACE WATER SAMPLING POINT
SURFACE WATER SAMPLING POINT AND PIEZOMETER
SCALE IN FEET
0
95
190
N
APPROXIMATE LIMIT OF GROUND WATER PLUME
NORTHERN INTERMITTENT STREAM
SOUTHERN INTERMITTENT STREAM
REGIONAL DIKE
SEABOARD DIKE
DEEP RIVER
FLOW
FLOW
PW-16D
PW-16S
PW-6D
PW-6I
MW-4
OW-DR3
SW-DRP-10
PW-15S
PW-15D
SW-DRP-4
SW-4
PW-DR1
OW-DR1
OW-DR2
SW-DRP-2
PW-14D
PW-14S
MW-3A
MW-3B
MW-3C
PW-5D
OW-DR4
PW-13I
PW-7I
SW-2
MW-12A
MW-12B
MW-12D
MW-13
MW-11
MH
MH
690
700
710
720
730
740
750
760
770
680
690
700
690
680

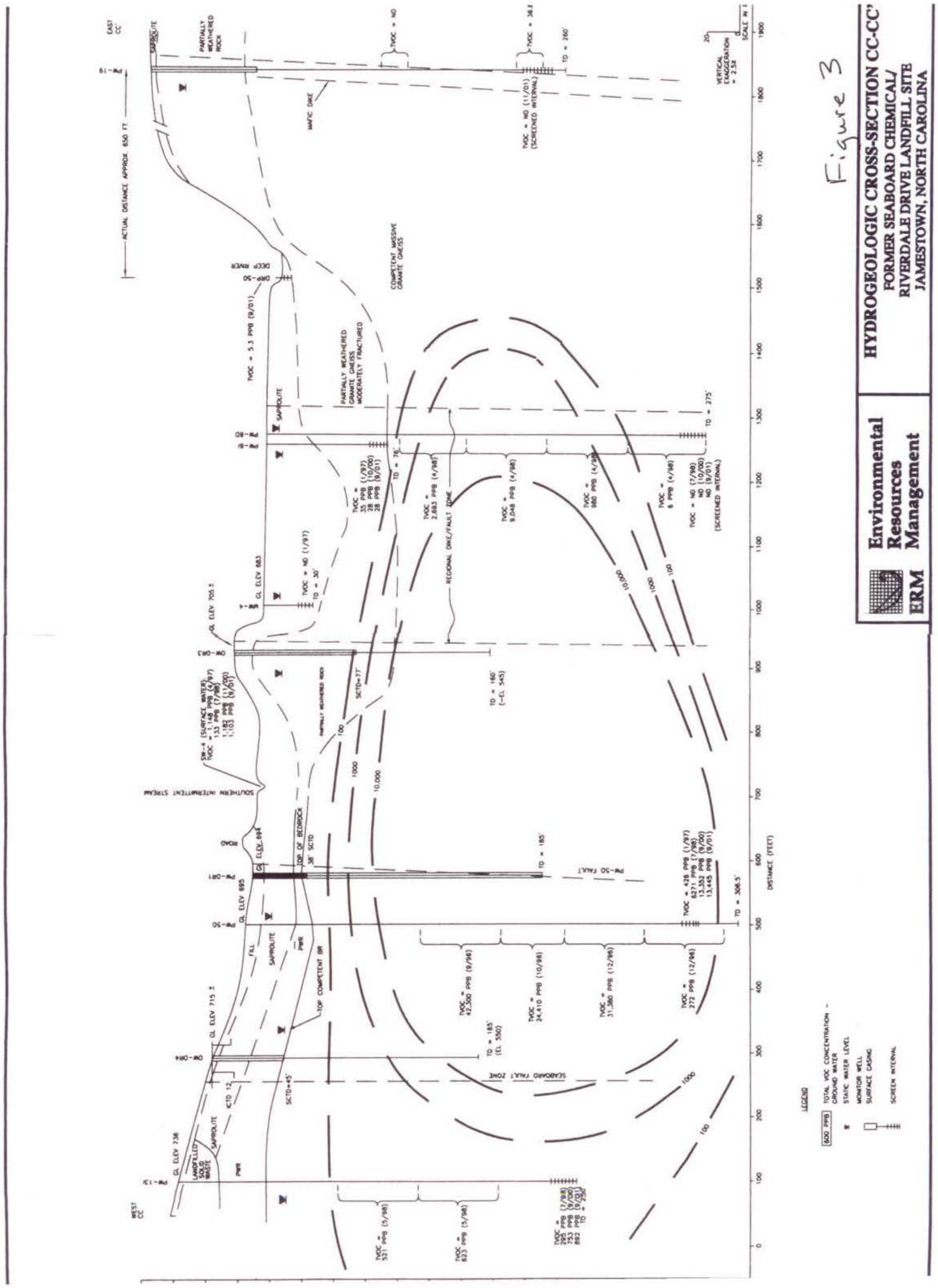
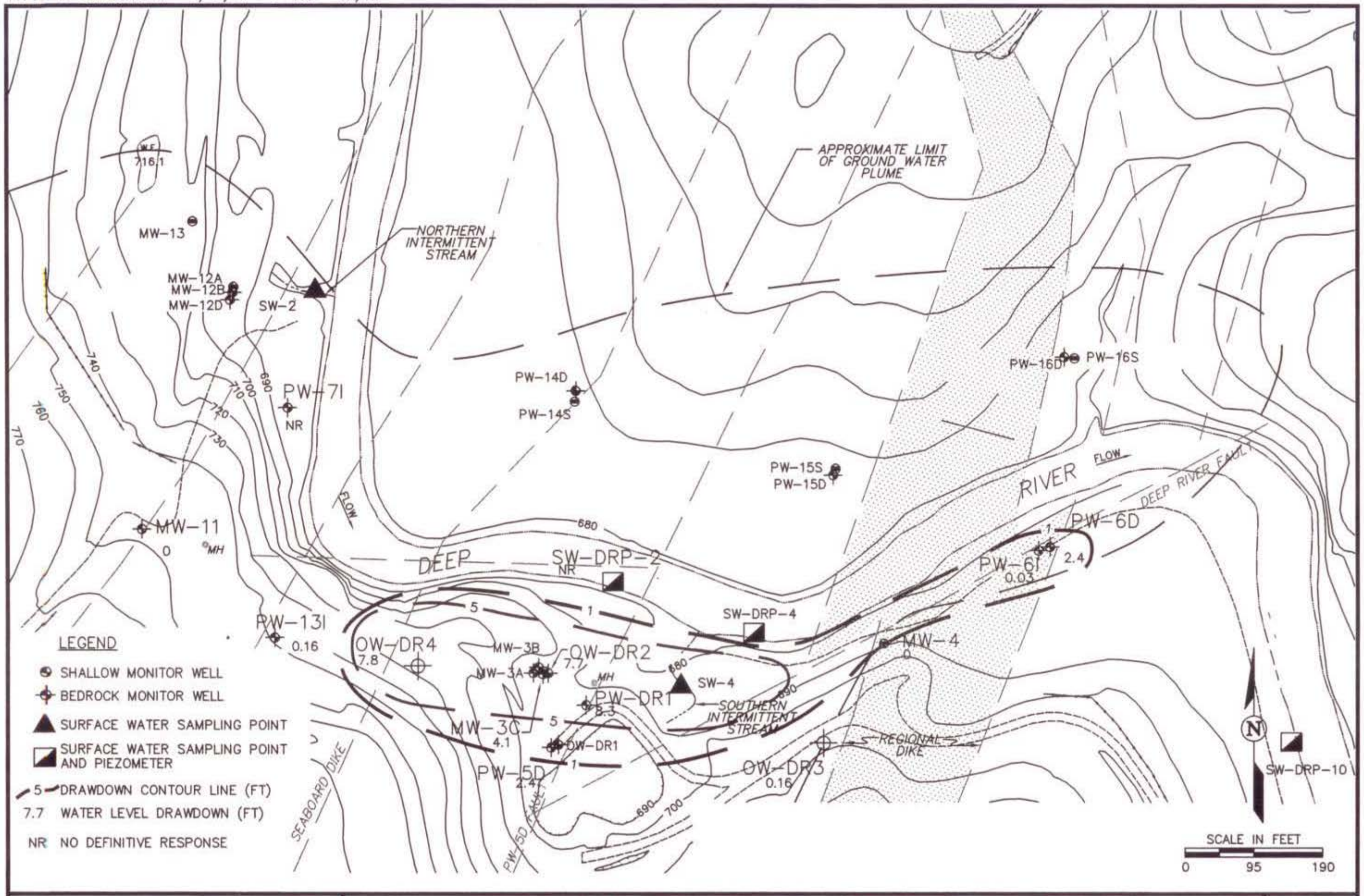


Figure 3

HYDROGEOLOGIC CROSS-SECTION CC-CC'
FORMER SEABOARD CHEMICAL/
RIVERDALE DRIVE LANDFILL SITE
JAMESTOWN, NORTH CAROLINA

Environmental Resources Management
ERM

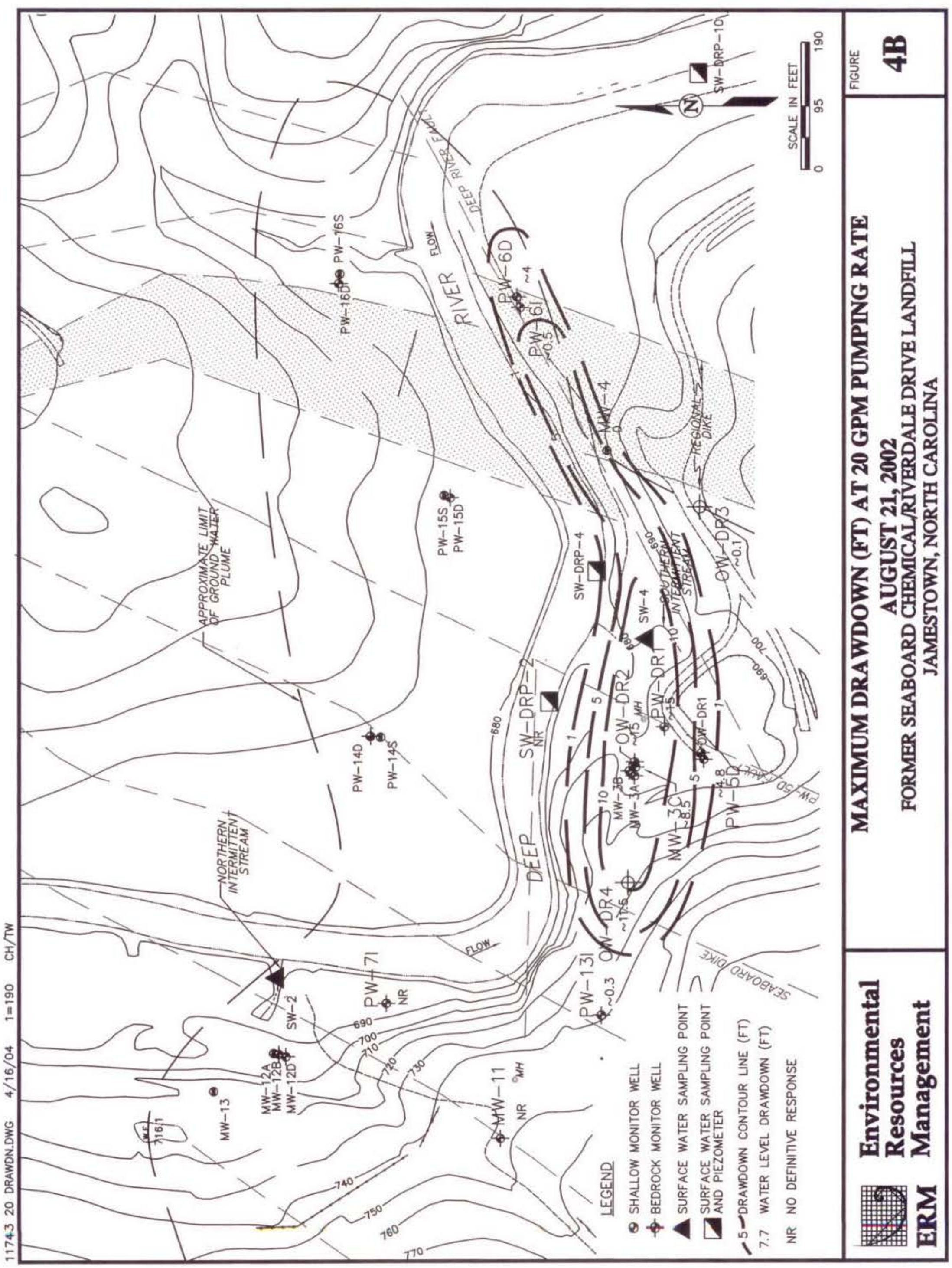
11743 10 DRAWDN1.DWG 4/16/04 1=190 CH/TW

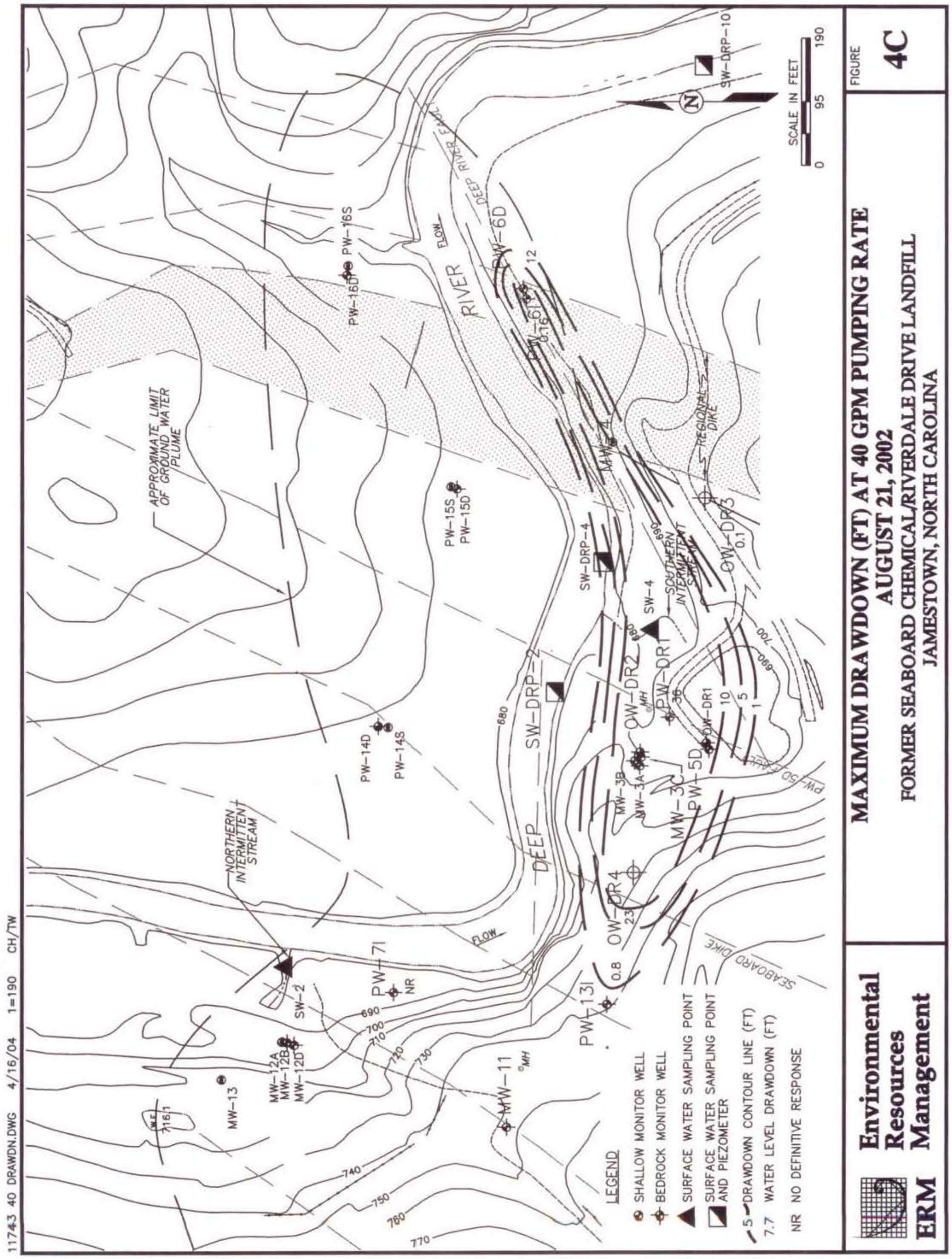


Environmental Resources Management
ERM

MAXIMUM DRAWDOWN (FT) AT 10 GPM PUMPING RATE
AUGUST 21, 2002
FORMER SEABOARD CHEMICAL/RIVERDALE DRIVE LANDFILL
JAMESTOWN, NORTH CAROLINA

FIGURE
4A


MAXIMUM DRAWDOWN (FT) AT 20 GPM PUMPING RATE
AUGUST 21, 2002
FORMER SEABOARD CHEMICAL/RIVERDALE DRIVE LANDFILL
JAMESTOWN, NORTH CAROLINA
FIGURE
4B
ERM
Environmental Resources Management
11743 20 DRAWDN.DWG 4/16/04 1=190 CH/TW
SCALE IN FEET
0
95
190
N
LEGEND
SHALLOW MONITOR WELL
BEDROCK MONITOR WELL
SURFACE WATER SAMPLING POINT
SURFACE WATER SAMPLING POINT AND PIEZOMETER
5 DRAWDOWN CONTOUR LINE (FT)
7.7 WATER LEVEL DRAWDOWN (FT)
NR NO DEFINITIVE RESPONSE
APPROXIMATE LIMIT OF GROUND WATER PLUME
NORTHERN INTERMITTENT STREAM
SOUTHERN INTERMITTENT STREAM
DEEP RIVER
DEEP RIVER FAULT
REGIONAL DIKE
SEABOARD DIKE
FLOW
PW-16S
PW-16D
PW-6D
PW-6I
PW-15S
PW-15D
PW-14D
PW-14S
PW-7I
PW-13I
PW-DR1
PW-5D
MW-4
MW-3A
MW-3B
MW-3C
MW-11
MW-12A
MW-12B
MW-12D
MW-13
OW-DR1
OW-DR2
OW-DR3
OW-DR4
SW-DRP-2
SW-DRP-4
SW-DRP-10
SW-2
SW-4
NR
~0.3
~0.5
~4
~0.1
~11.5
~15
~8.5
~4.8
690
700
710
720
730
740
750
760
770
680


11743 40 DRAWDN.DWG 4/16/04 1=190 CH/TW
MAXIMUM DRAWDOWN (FT) AT 40 GPM PUMPING RATE
AUGUST 21, 2002
FORMER SEABOARD CHEMICAL/RIVERDALE DRIVE LANDFILL
JAMESTOWN, NORTH CAROLINA
FIGURE
4C
ERM
Environmental Resources Management
SCALE IN FEET
0
95
190
N
LEGEND
SHALLOW MONITOR WELL
BEDROCK MONITOR WELL
SURFACE WATER SAMPLING POINT
SURFACE WATER SAMPLING POINT AND PIEZOMETER
5 DRAWDOWN CONTOUR LINE (FT)
7.7 WATER LEVEL DRAWDOWN (FT)
NR NO DEFINITIVE RESPONSE
APPROXIMATE LIMIT OF GROUND WATER PLUME
NORTHERN INTERMITTENT STREAM
SOUTHERN INTERMITTENT STREAM
DEEP RIVER
DEEP RIVER FAULT
REGIONAL DIKE
SEABOARD DIKE
FLOW
PW-16S
PW-16D
PW-15S
PW-15D
PW-14D
PW-14S
PW-7I
NR
PW-13I
0.8
PW-6D
PW-6I
0.16
12
MW-4
OW-DR3
0.1
SW-DRP-4
SW-DRP-2
SW-DRP-10
SW-4
SW-2
PW-DR1
OW-DR1
OW-DR2
OW-DR4
23
35
PW-5D
MW-3A
MW-3B
MW-3C
MW-11
MW-12A
MW-12B
MW-12D
MW-13
MH
10
5
1
680
690
700
710
720
730
740
750
760
770

REPORT

Seaboard Group II and City of High Point,
North Carolina

Report of Extraction Rate/ Capture Zone Test - August 2002

Former Seaboard Chemical/ Riverdale Drive Landfill Site Jamestown, North Carolina

April 16, 2004

Thomas M Wilson

Thomas M. Wilson, P.G.
Principal-in-Charge

ERM NC, PC
8000 Corporate Center Drive
Suite 200
Charlotte, NC 28226

ATTACHMENT 10

CERTIFIED INDUSTRIAL HYGENIST'S REPORT

MATRIX
Health & Safety Consultants, L.L.C.

March 11, 2017

Jamestown Engineering Group, Inc.
PO Box 365
117 E. Main St.
Jamestown, NC 27282

Attention: Mr. Rich Glover

Subject: Limited Industrial Hygiene Sampling Survey
Seaboard Chemical Site, Jamestown, NC
Matrix Project # 170241

Dear Mr. Glover:

Matrix Health & Safety Consultants, L.L.C. (Matrix) is pleased to provide this report of the limited industrial hygiene sampling assessment performed at the Seaboard Chemical Remediation Site in Jamestown, in North Carolina.

The sampling was conducted by Matthew Seibert, Industrial Hygienist with Matrix, on February 21 & February 22, 2017. 16 Volatile Organics Profile samples, and 16 Metals Profile samples, were collected from the Seaboard Chemical Remediation Site. Each day, 8 Volatile Organics sampling badges and 8 Metals sampling pumps, were set up in specific locations that Mr. Glover requested throughout the site. All airborne exposure samples were collected using calibrated sampling pumps, as well as ChemDisk personal sampler badges, and laboratory supplied media. All samples were shipped to SGS Galson Laboratories under chain-of-custody procedures. SGS Galson is accredited by the American Industrial Hygiene Association. The laboratory analysis report for each sample is included with this report.

Sampling Locations & Analysis

31-VOC Profile

Each day, (Tuesday February 21, 2017 & Wednesday February 22, 2017), 8 ChemDisk sampler badges were strategically placed at the same specific, and stationary locations. The samples were positioned at LS2-Control Room, LS2-Lab, Filtration Building, Maintenance Building, the ground between Filtration & Maintenance Building, Clarifier, Tipper, and LS1. Each sample was tested for 31 different volatile organic compounds. (these can be found in the Laboratory Analysis Report from Galson Laboratories, in the attachments) All samples were below the limit of Quantitation for both sample days.

Industrial Hygiene Sampling Survey
Seaboard Chemical Site
Jamestown, NC

March 11, 2017

21-Metal Profile

Each day, (Tuesday February 21, 2017 & Wednesday February 22, 2017), 8 cassettes attached to low flow pumps were strategically placed at the same specific, and stationary locations. The samples were positioned at LS2-Control Room, LS2-Lab, Filtration Building, Maintenance Building, the ground between Filtration & Maintenance Building, Clarifier, Tipper, and LS1. Each sample was tested for 21 different metals. (these can be found in the Laboratory Analysis Report from Galson Laboratories, in the attachments) All of the samples were below the limit of Quantitation for both sample days, except for one. That sample came from the ground between the buildings, and was just over the detection limit of Quantitation and far below the PEL. Laboratory analysis showed a total of 7.8ug of Aluminum on the sample with a concentration of 0.010mg/m^3. The OSHA PEL, standard TWA for Aluminum is 15mg/m^3.

Based on observations and sampling data, exposures to constituents sampled were below current OSHA Permissible Exposure Limits. Should conditions, procedures change additional assessment is also recommended.

An effort was made to provide as complete and comprehensive an evaluation as professionally practical. Observations, findings, results, and conclusions are limited to those conditions apparent at the time. It should not be construed that actions taken as a result of this work will achieve complete compliance with every regulatory standard nor prevent every possible accident or loss.

Matrix appreciates this opportunity to provide our services for this project. If you have any questions, please feel free to contact us at (919) 833-2520.

Sincerely,
Matrix Health & Safety Consultants, L.L.C.

C. Britt Wester, CIH
Principal

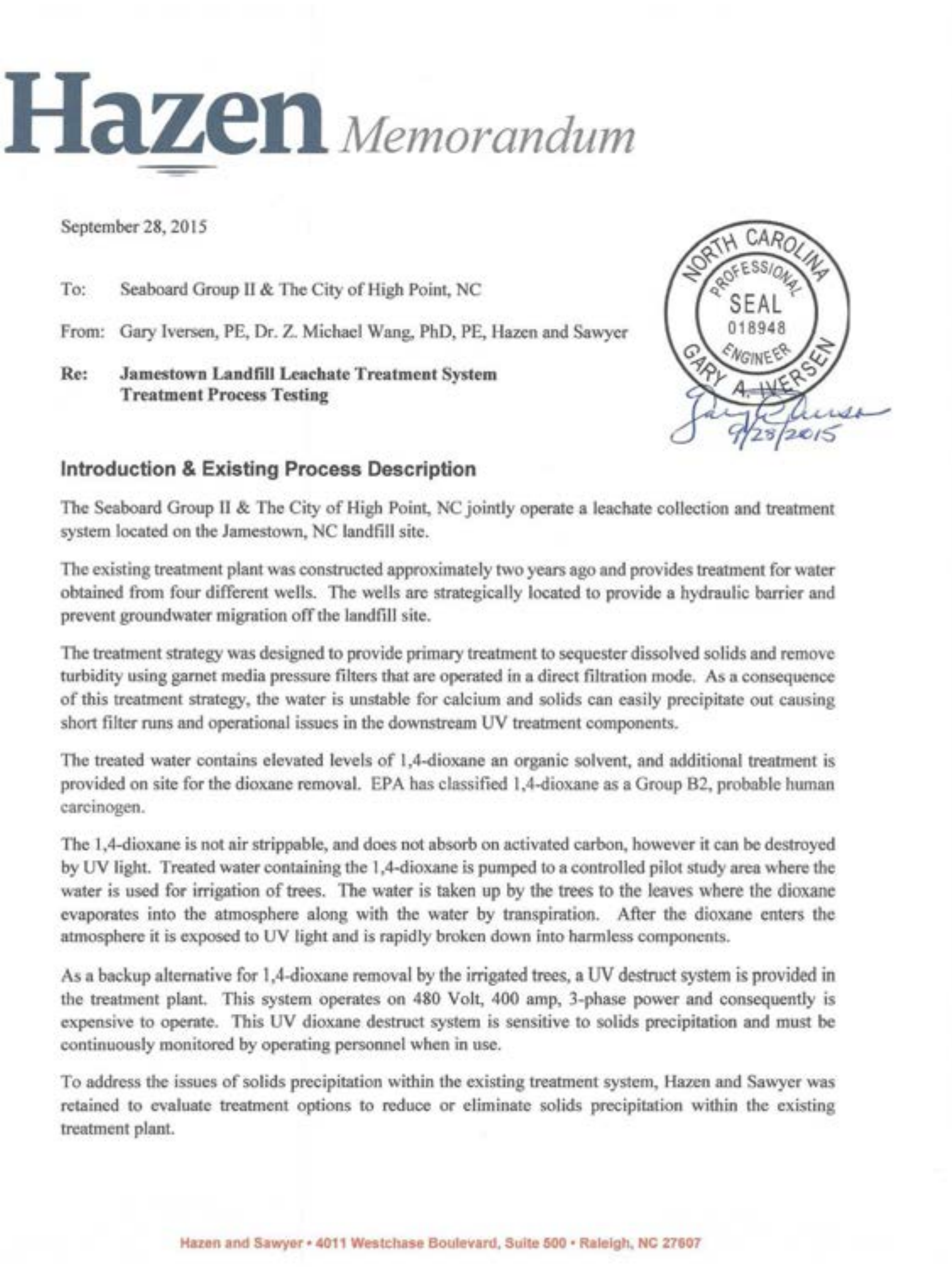
Attachment: Laboratory Analysis Reports

Laboratory Analysis Reports

Laboratory Data
Intentoionally Omitted

ATTACHMENT 11

HAZEN AND SAWYER REPORT



Hazen *Memorandum*

September 28, 2015

To: Seaboard Group II & The City of High Point, NC

From: Gary Iversen, PE, Dr. Z. Michael Wang, PhD, PE, Hazen and Sawyer

Re: Jamestown Landfill Leachate Treatment System
Treatment Process Testing

018948
GARY A. IVERSEN
9/28/2015

Introduction & Existing Process Description

The Seaboard Group II & The City of High Point, NC jointly operate a leachate collection and treatment system located on the Jamestown, NC landfill site.

The existing treatment plant was constructed approximately two years ago and provides treatment for water obtained from four different wells. The wells are strategically located to provide a hydraulic barrier and prevent groundwater migration off the landfill site.

The treatment strategy was designed to provide primary treatment to sequester dissolved solids and remove turbidity using garnet media pressure filters that are operated in a direct filtration mode. As a consequence of this treatment strategy, the water is unstable for calcium and solids can easily precipitate out causing short filter runs and operational issues in the downstream UV treatment components.

The treated water contains elevated levels of 1,4-dioxane an organic solvent, and additional treatment is provided on site for the dioxane removal. EPA has classified 1,4-dioxane as a Group B2, probable human carcinogen.

The 1,4-dioxane is not air strippable, and does not absorb on activated carbon, however it can be destroyed by UV light. Treated water containing the 1,4-dioxane is pumped to a controlled pilot study area where the water is used for irrigation of trees. The water is taken up by the trees to the leaves where the dioxane evaporates into the atmosphere along with the water by transpiration. After the dioxane enters the atmosphere it is exposed to UV light and is rapidly broken down into harmless components.

As a backup alternative for 1,4-dioxane removal by the irrigated trees, a UV destruct system is provided in the treatment plant. This system operates on 480 Volt, 400 amp, 3-phase power and consequently is expensive to operate. This UV dioxane destruct system is sensitive to solids precipitation and must be continuously monitored by operating personnel when in use.

To address the issues of solids precipitation within the existing treatment system, Hazen and Sawyer was retained to evaluate treatment options to reduce or eliminate solids precipitation within the existing treatment plant.

Hazen

September 28, 2015

Bench Scale Testing

Hazen and Sawyer recently conducted process testing at the Seaboard & High Point leachate treatment system in Jamestown, NC from September 11th through September 19th.

One of the primary issues of the solids precipitation were the short filter runs. In some cases the high levels of solids resulted in filter runs of 1 hour or less, effectively shutting down the treatment process. Over time, it appears that calcium precipitation in the pipelines from the well to the treatment process and within the process components, and the filtered water piping from the filters to the tree irrigation area is causing increasing headloss. Eventually, the deposition of calcium will cause higher and higher head losses requiring that all the piping be replaced.

To provide a treatment process to remove the solids and stabilize calcium so that precipitation will be either significantly reduced or eliminated, it appears that the best alternative would be to provide primary clarification that includes precipitative softening and coagulation to reduce turbidity.

Bench-scale testing was performed using Phipps and Bird 6-gang mixers, with 2-liter square jars equipped with sample taps located at a fixed depth. Prepared chemical stock solutions were added to the test jars using biological syringes for accuracy.

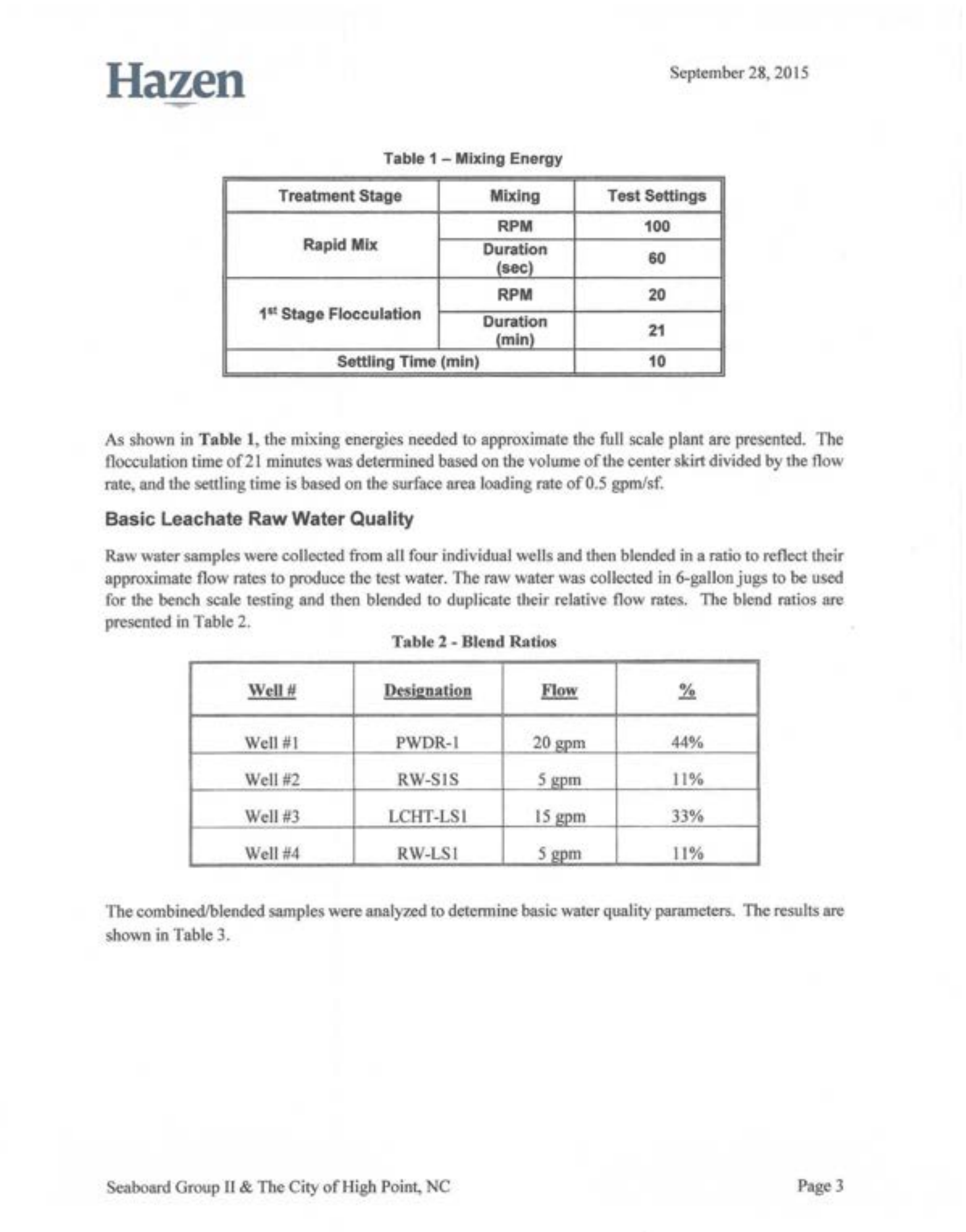
Typically, bench scale jar testing procedures for flocculation and clarification basins are developed using the surface area loading rates and the hydraulic detention times in those basins, and the mixing energy is determined by trial and error. Sedimentation settling time is determined based on surface area loading rate (plant flow/basin surface area). The equation used to convert the settling rates in the 2-liter jars to the full-scale basin loading rate to establish similitude with a full scale plant is:

(Settling rate in cm/min)(1 ft/30.48 cm)(1440 min/day)(7.48 gal/cf) = gpd/sf

However, since the goal of this testing was to determine if primary clarification could provide for solids removal and calcium stabilization a jar test strategy was used to duplicate the treatment of an existing clarifier previously modeled at another landfill leachate treatment site.

To simulate the full-scale plant in the jars, various mixing conditions were tested, and settled water results from the jar tests were compared to the settled water from the clarifier until a good match was obtained.

The mixing times and energies selected that simulate an existing full-scale leachate treatment clarifier are presented in Table 1.



September 28, 2015

Table 1 – Mixing Energy

Treatment Stage	Mixing	Test Settings
Rapid Mix	RPM	100
	Duration (sec)	60
1st Stage Flocculation	RPM	20
	Duration (min)	21
Settling Time (min)		10

As shown in **Table 1**, the mixing energies needed to approximate the full scale plant are presented. The flocculation time of 21 minutes was determined based on the volume of the center skirt divided by the flow rate, and the settling time is based on the surface area loading rate of 0.5 gpm/sf.

Basic Leachate Raw Water Quality

Raw water samples were collected from all four individual wells and then blended in a ratio to reflect their approximate flow rates to produce the test water. The raw water was collected in 6-gallon jugs to be used for the bench scale testing and then blended to duplicate their relative flow rates. The blend ratios are presented in Table 2.

Table 2 - Blend Ratios

Well #	Designation	Flow	%
Well #1	PWDR-1	20 gpm	44%
Well #2	RW-S1S	5 gpm	11%
Well #3	LCHT-LS1	15 gpm	33%
Well #4	RW-LS1	5 gpm	11%

The combined/blended samples were analyzed to determine basic water quality parameters. The results are shown in Table 3.

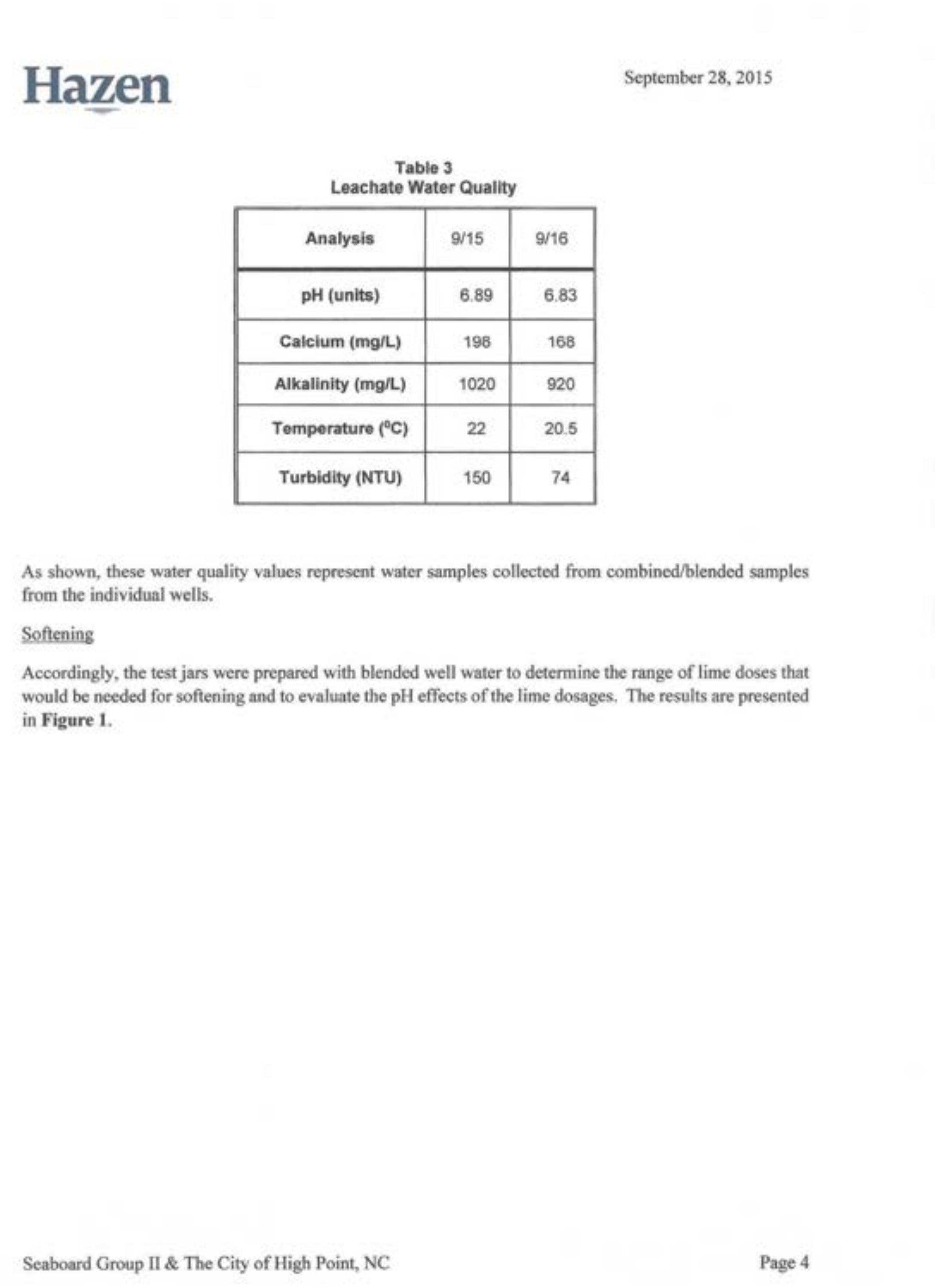


Table 3
Leachate Water Quality

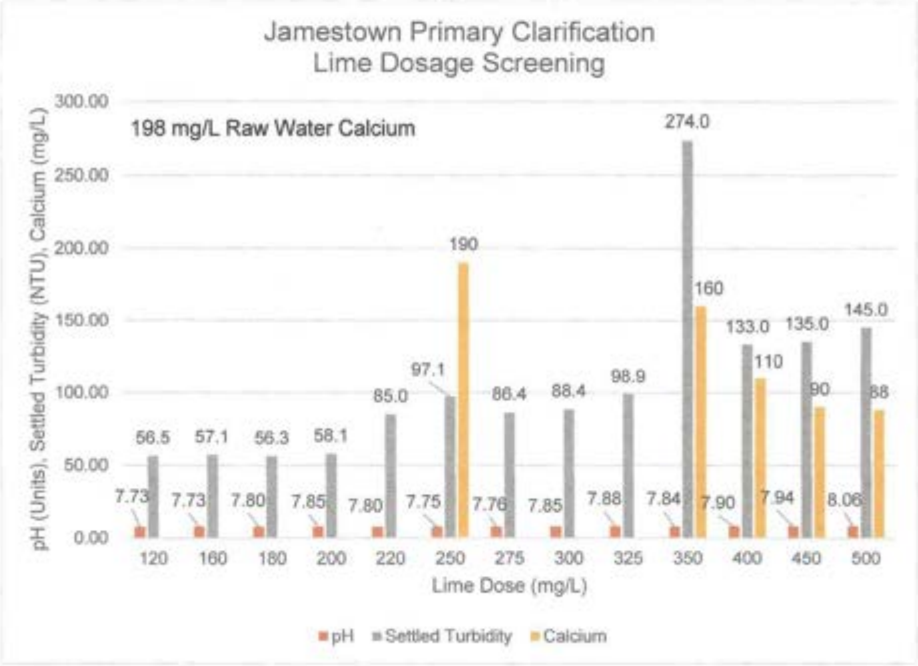
Analysis	9/15	9/16
pH (units)	6.89	6.83
Calcium (mg/L)	198	168
Alkalinity (mg/L)	1020	920
Temperature (°C)	22	20.5
Turbidity (NTU)	150	74

As shown, these water quality values represent water samples collected from combined/blended samples from the individual wells.

Softening

Accordingly, the test jars were prepared with blended well water to determine the range of lime doses that would be needed for softening and to evaluate the pH effects of the lime dosages. The results are presented in **Figure 1**.

Figure 1
Lime Dosage Screening

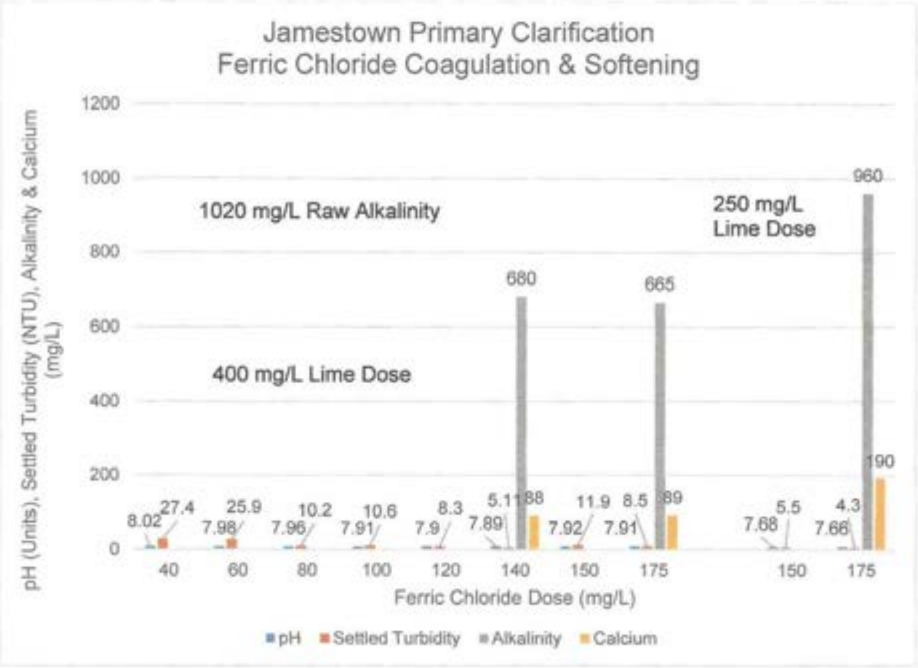


As shown, because the alkalinity was high at 1020 mg/L, lime doses of 250 mg/L or higher were necessary to raise pH sufficiently to initiate calcium precipitation. At a dose of 400 mg/L dissolved calcium was reduced by approximately 45% with a pH of 7.9. Higher doses were tested and addition calcium was removed, however, it was likely that the 400 mg/L lime dose was sufficient to stabilize calcium in the water. Settled water turbidity was high over the range of lime doses tested and would not be acceptable. At the 400 mg/L lime dose settled water turbidity was 133 NTU, indicating that softening cannot be used unless settled turbidity can be reduced.

Accordingly, ferric chloride and ferric sulfate coagulants were tested to determine their performance in helping to reduce turbidity and alkalinity, Samples were obtained for testing from Kemira, a manufacturer of ferric chloride (Kemira 67%) and ferric sulfate (Kemira, 65%). These products are NSF approved for drinking water treatment.

The results of the ferric chloride testing are presented in **Figure 2**.

Figure 2
Ferric Chloride Screening



As shown ferric chloride was tested over a range of doses, from 40 mg/L to 175 mg/L to determine performance. Lime was also dosed at the same time at a dose of 400 mg/L for 8 of the test jars. The other two test jars shown on the right side of the graph show ferric chloride doses of 150 and 175 mg/L, but with a lime dose of only 250 mg/L.

The best ferric chloride performance with a lime dose of 400 mg/L was obtained with a 140 mg/L ferric dose, providing a settled water turbidity of 5.1 NTU.

The best ferric chloride performance with a lime dose of 250 mg/L was obtained with both ferric doses tested. Ferric chloride doses of 150 and 175 mg/L provided settled water turbidity values of 5.5 and 4.3 NTU, respectively.

Ferric sulfate was tested with a 400 mg/L lime dose at ferric doses of 60 to 160 mg/L. The ferric sulfate test results are presented in **Figure 3**.

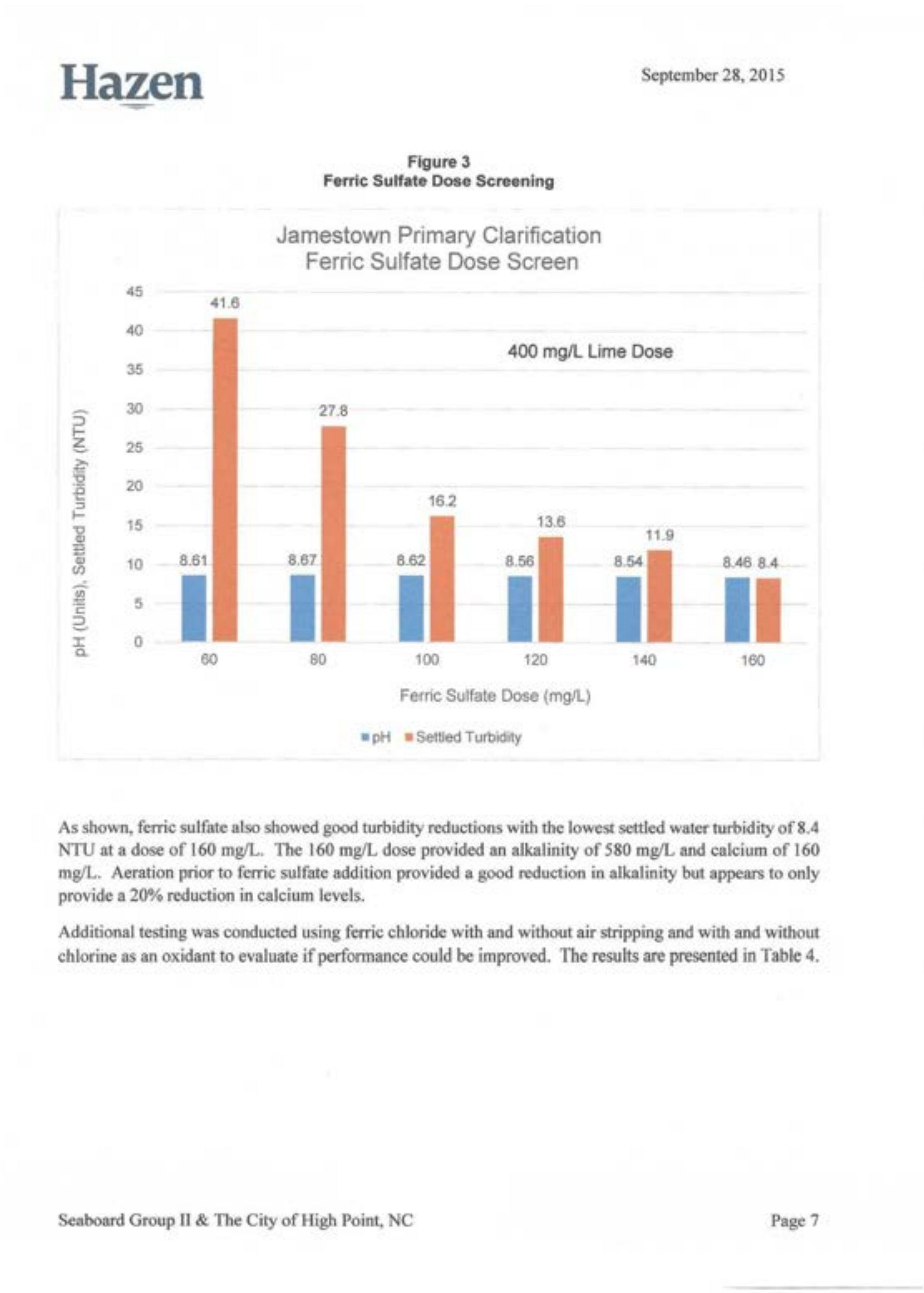


Figure 3
Ferric Sulfate Dose Screening

As shown, ferric sulfate also showed good turbidity reductions with the lowest settled water turbidity of 8.4 NTU at a dose of 160 mg/L. The 160 mg/L dose provided an alkalinity of 580 mg/L and calcium of 160 mg/L. Aeration prior to ferric sulfate addition provided a good reduction in alkalinity but appears to only provide a 20% reduction in calcium levels.

Additional testing was conducted using ferric chloride with and without air stripping and with and without chlorine as an oxidant to evaluate if performance could be improved. The results are presented in Table 4.

Table 4
Additional Testing

Chemical Doses	No Aeration			Aerated		
Chlorine (mg/L)	10	-	-	10	-	-
Lime (mg/L)	400	400	500	400	400	500
Ferric Chloride (mg/L)	140	140	140	140	140	140
pH (Units)	7.85	7.86	8.06	7.88	7.91	8.14
Turbidity (NTU)	12.4	9.26	13.3	18.5	16.5	17.0
Alkalinity (mg/L)	680	720	650			
Calcium (mg/L)	140	116	96			

As shown, when chlorine is added or when the water is aerated prior to chemical dosing the settled water turbidity levels increase. The chlorine dosing also appears to interfere with calcium precipitation. Based on the results of this testing raw water should not be aerated prior to chemical dosing, and chlorine should not be used.

To determine if the water was stable and that no additional solids would precipitate, test water that was treated using a 400 mg/L lime dose and a 140 mg/L ferric chloride dose was filtered, and then vigorously aerated and held overnight to determine if additional solids would precipitate. The next day the aerated sample was observed to have no sediments, indicating that the water was stable and there were no precipitates present.

Existing Solids Handling

Currently filter backwash solids and precipitated solids from the existing process basins are treated using grade level slow sand filters. After the solids are placed on the sand filter and the water drains, the solids and some of the sand is manually shoveled for transport to the landfill. Since some of the sand filter material is also removed the sand is periodically replaced as needed to maintain the slow sand filter. The high levels of solids and the frequency of filter backwashes can generally be managed, however, it the cold weather months, the wet sand freezes and water can no longer drain from the solids, effectively taking the sand filter out of service leaving no alternative for solids handling.

Recommendations

Based on the results of the bench scale testing and jar test mixing energy and settling strategy used to duplicate an existing full scale clarifier it appears that a conventional circular clarifier can be used to provide for solids removal and calcium stabilization. The recommended clarifier should be designed for gravity settling and equipped with continuous sludge removal and a center mixing cone providing approximately 20 minutes of flocculation time at a design flow of 100 gpm. The mixing/flocculation zone should be equipped with a variable speed drive mixer to allow for changes in mixing energy to optimize floc formation and settled water turbidity performance.

The design flow rate is slightly higher than the calculated actual flows consisting of the combined flow rate of the four wells at 50 gpm, plus gravity thickener supernatant recycle that includes the clarifier underflow and the filter backwash water estimated at 25 gpm. The additional 25 gpm in capacity will allow for flow surges and additional backwash water if needed.

The proposed clarifier should have a side water depth of 12 to 15 feet and a basin area sufficient to provide a surface area loading rate of 0.5 gpm/sf at the design flow of 100 gpm. This translates to a minimum diameter of 16 feet, however, this small size may require custom fabrication and a larger stock unit may be more economical. A basin that is larger than actually needed may be beneficial in that the lower surface area loading rate would provide lower settled water turbidity.

It is expected that this strategy will provide good treatment and allow for calcium precipitation and stabilization, and will allow solids to precipitate prior to the existing treatment process significantly extend filter run times.

Liquid hydrated lime and ferric chloride are the recommended treatment chemicals.

Preliminary calculations of solids that will be generated in the clarification process are estimated at approximately 500 lb of dry solids per day. At a 2% concentration these solids will result in a volume of approximately 3000 gallons per day. To handle these additional precipitated solids and also treat the filter backwash water on a year round basis, solids handling equipment is recommended.

A gravity thickener should be provided for the first step in solids dewatering. The thickener would also act as an equalization basin for filter backwash water. The solids from the gravity thickener could be further dewatered to the desired concentration using a small variable flow, variable speed centrifuge. Supernatant from the thickener would be recycled to head of the proposed clarifier using a variable speed pump to maintain constant flows in the clarifier.

Centrate from the centrifuge would also be recycled to the thickener, and in turn recycled to head of the clarifier. In this way, centrate would be diluted by the underflow water from the clarifier (to the thickener) and would be less likely to cause an upset.

The dewatered sludge solids would be disposed of on the landfill site as is currently permitted.

Hazen

September 28, 2015

Test Jars showing leachate dosed with lime and ferric chloride:

Test Jars showing settled solids: