DIN 25599
Approved by SWS 2/8/2016

Water Quality Monitoring Plan

Lincoln County Landfill, Phase 4

Crouse, Lincoln County, North Carolina

Prepared for

Lincoln County
Solid Waste Division
Crouse, North Carolina

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MESCO Project Number: G15141.6

Pre-Construction Plan Submitted: November 3, 2015

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The North Carolina Solid Waste Management Rules 15A NCAC 13B .1623(b)(3) and .1617(a)(1)(f) require that a Water Quality Monitoring Plan be submitted in the application for the Permit to Construct a new Subtitle D solid waste landfill. This water quality monitoring plan has been prepared for the proposed Phase 4 municipal solid waste landfill (MSWLF) for Lincoln County North Carolina. The site is located at 5291 Crouse Road in Crouse, North Carolina (Figures 1 and 2).

The information in this plan is designed to assist the Division of Solid Waste Management, the Operations Personnel and its agents in evaluation of potential impact to groundwater quality. Included in this plan are sections concerning groundwater, surface water and leachate monitoring locations, monitoring well construction, sampling procedures, analytical procedures, reporting requirements and data assessment. Sampling and analytical procedures shall be performed in accordance with the Division's rules and policies which can generally be referenced on their website. This plan is intended to conform to the NCDENR *Solid Waste Section Guidelines for Groundwater, Soil, and Surface Water Sampling* referenced here within as *SWS Guidelines Document*. This Phase 4 plan is divided into 1) a Groundwater Monitoring Plan, 2) a Surface Water Monitoring Plan and 3) a Leachate Monitoring Plan.

1.0 Groundwater Monitoring

The purpose of the groundwater monitoring program is to monitor the quality of the groundwater in the uppermost portion of the aquifer underlying the Phase 4 landfill and surface water adjacent to Phase 4 during operation of the landfill. This monitoring plan is designed to effectively detect a potential release from the landfill into the uppermost aquifer as a release would migrate to areas downgradient of the Phase 4 landfill. The findings of a study contained in a Design Hydrogeologic Study, transmitted under separate cover in October 2015, was used to develop this plan which is intended to provide early detection of a release into ground or surface waters. Boring logs and records of proposed monitoring wells are included in Appendix A, hydrogeologic drawings are included in Appendix B and a copy of the *SWS Guidelines Document* is in Appendix C.

In addition to proposed Lined Phase 4 the entire solid waste management facility consists of three existing lined units (Phases 1, 2 & 3), an unlined unit (Area"E"), construction and demolition (C&D) landfill units (Phases 1 & 2) and the abandoned leachate lagoon. The water quality monitoring system in place beyond Phase 4 is not pertinent to this monitoring plan; thus, effectiveness was not evaluated in formation of this plan. Water quality will continue to be monitored site-wide per the area's respective monitoring plan. Phase 4 will be monitored on the same semi-annual schedule as the other portions of the facility.

1.1 Monitoring Well Network

The proposed monitoring well locations (PMW's) for the Phase 4 landfill are shown on the Water Quality Monitoring Plan (Sheet 1). Please note the "P" prefix is used to denote proposed in this plan and the "P" will be dropped following plan approval. The proposed monitoring well network consists of one facility wide upgradient background well (existing well MW-lA), two crossgradient wells (PMW-37, PMW-40) and two downgradient wells (PMW-38 and PMW-39). The well locations were selected for characterization of groundwater quality and to enable the detection of changes in groundwater quality in the vicinity of the Phase 4 area. The proposed four monitoring wells are planned to be converted from existing observation wells with IDs referenced as PMW-37/OW4-2, PMW-38/OW4-3S, PMW-39/OW4-6S and PMW-40/OW4-8 with survey and well construction data on Table 1. The proposed locations are all within about 160 linear feet from the future Phase 4 waste boundary and positioned as to enable early detection of constituents that may release from the landfill. The spacing and locations of the wells were selected based on landfill limits, surface drainage features, geologic conditions, groundwater flow directions and future site development features.

Existing monitoring well MW-1A will continue to serve as an upgradient or background water quality monitoring point. Proposed monitoring wells PMW-37 through PMW-40 are located downgradient or side gradient of the proposed Phase 4 area and will be compliance monitoring points. As indicated by the groundwater contours on the Groundwater Surface Map (Sheet 2), the groundwater flow is generally towards the surface water features to the south, southeast and southwest of the landfill that serves as the major discharge boundary for the uppermost aquifer beneath the site.

Proposed monitoring wells PMW-37 and PMW-38 will monitor groundwater flowing towards the east. Proposed PMW-38 is positioned to monitor groundwater flowing to the south. Proposed PMW-40 will monitor flow to the southwest cross-gradient of the designed Phase 4 sump.

1.2 Monitoring Well Construction

The four observation wells to be converted to monitoring wells are Type II wells constructed in accordance with the North Carolina Well Construction Standards (15A NCAC 2C .0108) and the requirements of the North Carolina Water Quality Monitoring Guidance Document for Solid Waste Facilities. A typical Type II monitoring well schematic is shown on Figure 3. The screened intervals for the wells intended to monitor the surficial aquifer, were selected based on actual field conditions during installation such that the wells are screened across the groundwater surface. Well construction logs and construction records for each of the observation wells proposed to be converted to monitoring wells are provided in Appendix A.

1.3 Well Installation Procedures

Boreholes shall be drilled and the wells constructed by a North Carolina licensed well driller. All equipment used for drilling and completion of the wells shall be properly cleaned prior to use at each location. At a minimum:, this should consist of high pressure steam cleaning of the downhole drilling equipment prior to performing each boring. Boreholes shall be a minimum of 6 inches in diameter.

All monitoring wells shall be constructed of 2-inch A.D., NSF Grade PVC (meeting ASTM D-178S and F480) Schedule 40 flush-joint threaded casing and 0.01-inch machine slotted screen. Only casing with water-tight joints shall be used. All well construction materials shall be installed directly from factory-sealed packaging.

Once the borehole has been drilled, the project manager shall approve the monitoring well construction based on site-specific hydrogeologic conditions and the following general criteria:

1) The upper surficial aquifer monitoring well screen intervals shall be 10-15 feet in length and located so that the estimated seasonal high water table transects the screened interval. The proposed depths of the screen intervals are provided on Tables 1 & 3. For areas with high groundwater levels (i.e., less than 4 feet below land surface), the top of screen shall be placed at a depth of 6 feet to allow adequate seal (5-feet minimum) and to allow sufficient grout and concrete collar to secure the protective casing.

2) The annular space between the borehole wall and the well casing shall be backfilled with clean, well rounded, washed, high grade silica sand appropriately sized to the formation material and screen. The sand pack shall be placed to two feet above the slotted screen using a tremie pipe. A minimum of one foot of sand above the screen may be used where the top of the screen depth is shallow to allow for an adequate seal. The temporary casing, if used, shall be incrementally withdrawn while the filter pack is placed. The filter pack level shall be frequently sounded and kept at the base of the augers or temporary casing until the desired length of filter pack is in place. The well shall be pre-developed, by bailing, prior to the placement of the bentonite seal.

3) A 1-to 2-foot pelletized bentonite seal shall be placed above the filter pack and hydrated with clean water for either a minimum of 2 hours or per the manufacturer’s recommended time period if longer. The seal shall be placed with a tremie pipe unless conditions prevent such practice. The bentonite pellets shall be carefully tamped into a wet, cohesive clay mass before placement of the grout seal. Care should be taken so that the augers or temporary steel casing is withdrawn above the top of the pellets to prohibit the bentonite pellet seal from sticking to the auger or casing.

4) The remainder of the annular space shall be filled with cement or bentonite grout from the top of the bentonite seal to near (approximately 3 feet below) ground surface. The grout shall be slowly pumped into the tremie pipe at a constant rate to prevent dilution or differential settling. The cement slurry is to be mixed with six gallons of potable water for each 94 pound sack of Portland cement and 3 to 5 pounds of powdered bentonite. Bentonite grout should be mixed to a ratio of no more than 24 gallons of water to 50 pounds of bentonite. The mixing water shall have a low sulfate content and a total dissolved solids content less than 2,000 parts per million and free of organics. No aggregate materials are to be included in the slurry. The temporary casing, if used, shall be removed as the grout is placed in the borehole. Subsequent to set up, additional grout may be required for "topping off" the grout seal to near ground surface. After grouting, no work shall be permitted on the well for a minimum of 24 hours while the grout is setting.

5) Four-inch square metal protective casing with a locking cap shall be placed over the well's riser pipe. The protective casing will extend no more than 3.5 feet above ground surface. The protective casing shall be placed on the well casing following the initial grouting. The protective casing shall be sealed and immobilized in a concrete collar placed around the protective casing. The protective casing shall be primed, painted, and provided with a permanently affixed name plate with the following information as required in the 2C well standards:

   A. Well identification number
   B. Drilling contractor name and registration number
   C. Total depth of well
   D. Depth of screen interval
   E. Depth to groundwater following well completion
   F. A warning that the well is not for water supply and that the groundwater may contain hazardous materials

6) A concrete slab or pad sloping gently away from the well in all directions shall be constructed. The slab will serve as anchorage and to prevent surface water from migrating along the wall of the casing.

7) The location, installation methods and construction details of the wells may be modified depending on field conditions (i.e. shallow groundwater). Any modifications, other than for high groundwater conditions, shall be discussed with NC Solid Waste Section prior to the construction of the monitoring well.

8) It is the responsibility of the owner/operator of this landfill to insure that the groundwater monitoring system described in these plans is installed under the direction of a geologist or geotechnical engineer licensed to practice in the State of North Carolina.

9) Records of the well construction should be maintained by the owner.

1.4 Well Maintenance

The wells and surrounding area shall be maintained in such a way to ensure access to the wells for sampling and to maintain the integrity of the wells. The monitoring wells shall be accessible by at least a four-wheel drive vehicle. Well cases should remain locked between monitoring events and locks should only be maintained with environmentally safe non-hydrocarbon based lubricants. Brush and weeds shall be cleared from around the wells as needed. Surface water run-on controls shall be provided, where necessary, to prohibit erosion of or undermining of the concrete pads. The concrete pads and cases shall be evaluated at least semi-annually for integrity and repairs performed as needed.

Following well installation, the monitoring wells will be developed in order to remove clay, silt, sand and other fines which may have been introduced into the formation or sand pack during drilling and well installation and to establish equilibrium of the well with the aquifer. Well development will be performed as soon as possible after well construction (no sooner than 24 hours) and will continue until the suspended solids are removed from the sand pack and well, and turbidity is reduced.

1.5 Well Purging and Sampling

Portable sampling methodologies will be employed at each well since a dedicated system is not in place at the site.

The laboratory performing the groundwater analysis shall supply all necessary coolers, pre-cleaned containers, trip blanks, chemical preservatives, labels, custody seals, chain-of-custody and shipping forms. Adequate instructions to the laboratory shall be given in advance of each monitoring event. Details concerning any changes to the monitoring plan and/or procedures shall be given to the laboratory in writing prior to the field sampling personnel arriving on the site. A specific contact person shall be established at both the facility (and facilities agent) and contract laboratory for communication between the two (2) parties.

Sample containers need to be constructed of a material compatible and non-reactive with the material it is to contain. As noted above, the contract laboratory performing the analysis shall supply all required containers. In special circumstances when the facility must obtain its own containers, these containers shall be purchased from local container distributors with the exception of the septum vials and PTFE (e.g. Teflon™) lined caps required for organic analyses which are available from laboratory supply companies. Metal lids shall not be utilized for any sample containers.

A complete set of pre-cleaned and pre-labeled sample bottles shall be removed from the cooler, and a groundwater sample from a laboratory pre-cleaned or disposable bailer will be poured into a fresh container. Preservatives shall be added as necessary (in accordance with EPA Methods SW-846) to the sample bottles either by the laboratory or in the field immediately prior to sampling. At least one quality control trip blank prepared by the laboratory shall be analyzed for each sampling event.

Prior to the initial well sampling, the highest point on the top of casing for each well shall be surveyed by a state registered land surveyor. The casing elevation shall be referenced to the site benchmark in order to calculate the elevation of the groundwater surface. The wells shall also be surveyed for horizontal control. Survey coordinates of the proposed monitoring wells are on Table 1.

Prior to the well purging for each sampling event, the depth to water and total well depth shall be determined with the use of an electronic water level indicator. The water level indicator shall be decontaminated at each well with a non-phosphate detergent followed by multiple deionized water rinses. The water level shall be measured by turning the instrument on and slowly lowering the instrument probe into the well until the water level indictor contacts the water activating an alarm and then lowering the probe to the base of the well. The depth to the water and well depth from the highest point on the well casing shall be measured and recorded to the nearest 0.01 foot and the amount of water within the well casing shall be calculated. For a two-inch diameter monitoring well, the volume of water present will be determined using the following equation:

$$\textit{Well Volume (Gallons)} = 0.174h$$

As an example, a two-inch diameter monitoring well with a total depth of 24.50 feet and a groundwater level of 17.75 feet below the top of the well casing would contain the following volume:

$$\textit{Water Volume (Gallons)} = 0.174 \times (24.50/feet - 17.75feet) = 1.17 \textit{ Gallons}$$

Groundwater monitoring wells shall be purged a minimum of three well volumes (or to dryness) with individually-wrapped, laboratory-decontaminated Teflon bailers, disposable Teflon bailers or pump(s). Pumps used to purge may be of the types that are above ground, submersible or variable speed bladder pumps but must adhere to the specifications listed throughout the *SWS Guidelines Document*. Although the *SWS Guidelines Document* provides for scenarios that allow sample collection directly from a pump discharge, a onetime use disposable bailer should be used instead to maintain sample integrity. Pumps and tubing must be decontaminated. Field parameters to be measured during each purge event include pH, temperature, and conductivity. In addition to the minimum purge volume described above, each monitoring well shall be purged until the pH, temperature, and conductivity stabilize, unless purged to dryness. Monitoring of temperature, pH and conductivity, for stabilization shall be recorded on a field log or field data sheet.

Equipment should be prepared prior to site arrival for a specific monitoring event and between each well. This equipment preparation includes decontamination for water level indicator(s), pH/temperature meter and specific conductivity meter.

The monitoring wells shall be sampled when recharged to at least 90% static level. In any event, the time interval between completion of well purge and sample collection shall not exceed 24 hours which is contrary to the six hours recommended in the *SWS Guidelines Document*. In the unlikely event recharge is not sufficient to fill containers within 24 hours, the well will be noted as “dry” and sampling attempted again during the next scheduled semi-annual event. Groundwater samples shall be collected with the same bailer used for purging.

Groundwater samples will be collected in the following order:

1. Volatile Organics
2. Semi-Volatile Organics
3. Metals
4. Cations and Anions
5. Indicator Parameters (i.e. BOD, COD, etc.)
6. Other Parameters (i.e. IDS, etc)

The sample shall be handled in a way to minimize aeration. No air bubbles or "head-space" shall be allowed in the containers used for volatile organic compound analyses. All samples collected for compliance purposes must be analyzed for total concentrations and field filtration is not permitted. Additional samples may be analyzed for dissolved constituents by laboratory filtration if elevated levels of sediment are found in the containers. The dissolved analysis is in addition to, not in lieu of, testing for total form of the parameter. Sample and project information shall be placed on the container labels prior to sampling.

The filled sample bottles and trip blanks shall then be securely placed into a pre-cleaned cooler and a chain-of-custody form completed and placed with the samples prior to shipping to a North Carolina certified laboratory for analysis. Finally, the well shall be capped and secured.

1.6 Quality Control and Reporting Requirements

A primary concern during collection of water samples is to insure that samples are not altered or contaminated by sediment or other debris that may affect the analytical results. All field equipment that is to be exposed to samples must be decontaminated before and between sampling locations to ensure collection of representative samples and to prevent the potential spread of contamination. Field equipment decontamination protocols to be followed are detailed in Appendix A of the *SWS Guidelines Document.* A set of sample bottles that have been pre cleaned in the laboratory shall be removed from the cooler and the water sample poured into a fresh container. Preservatives shall be added as necessary to the sample bottles at the laboratory or immediately prior to samples being placed in them. At least one blank must be analyzed and reported for the same analytes targeted in the water samples during each semi-annual monitoring event. Samples should be collected in order from lowest to highest contamination levels and samples segregated when applicable to reduce potential for false positives attributed to cross-contamination. The sample bottles shall then be securely placed into pre-cleaned coolers, kept on ice below 4 degrees C and delivered to the laboratory under chain of custody protocols within method specified hold times.

1.7 Sampling Frequency

The first semi-annual sampling event for the proposed Phase 4 area will be performed following or during construction of the landfill but prior to waste placement into the landfill. The wells for the proposed Phase 4 area shall then be sampled three more times within the first six months of waste placement so that baseline water quality can be established for future evaluation of the water quality data. Unless otherwise required by the NCDENR, sampling subsequent to the first six months shall be on a semi-annual basis with the existing monitor wells for the other landfill phases. Following the four baseline events, Phase 4 will be monitored in conjunction with the other portions of the facility on the established semi-annual schedule which is typically April and October.

1.8 Field Analysis and Reporting Requirements

The sample collector shall maintain a field book or log to record all pertinent information regarding the purging and sampling of monitoring wells. The field data shall be recorded and retained in the project files and copies submitted to the appropriate State agencies. Samples should always be kept on ice in a protective cooler under chain-of-custody.

Laboratory analysis should consist of targeting constituents listed in 40 CFR 258 Appendix I, current list shown on Table 2, during each compliance sampling event. The suite of parameters listed in 40 CFR 258 Appendix I shall be analyzed for all samples and blanks. Sample analyses shall be performed by a North Carolina Division of Environmental Management "certified" laboratory. All data shall be subjected to strict quality assurance and quality control protocols. Certified laboratory QC/QA protocols are reviewed and kept on file by the North Carolina Wastewater/Groundwater Laboratory Certification (NC WW/GW LC) program. Only analytical methods that are acceptable to the Solid Waste Management Division shall be used by the laboratory selected to perform the analyses. All lab data must be reported to the lab specific Method Detection Limit (MDL) which must be at or below the Solid Waste Section Limits (SWSL). Current SWSL are referenced on Table 2.

1.9 Data Evaluation and Reporting

In order to estimate groundwater flow direction and rate at each monitoring well, the horizontal hydraulic gradient, the hydraulic conductivity, and the effective porosity shall be used. The hydraulic gradient and direction shall be estimated based on the water level elevations from water level measurements recorded during each sampling event. The hydraulic conductivity for the aquifer interval monitored shall be estimated based on an in-situ permeability test performed following installation of the monitoring well and prior to the submittal of the initial monitoring report. The effective porosity shall be based on tests performed on soil samples from the screened interval collected during the installation of the monitoring well or estimated from soil classification.

All groundwater quality monitoring data shall be compared to the North Carolina Standards 15A NCAC 2L .0200 and or other regulatory compliance Standards adopted by the SWS such as Groundwater Protection Standards (GWP), where applicable. Current regulatory groundwater compliance Standards are referenced on Table 2. Statistical analysis of the data is not required per Rule 15ANCAC 13B .1632 revised January 1, 2011. However, if Lincoln County chooses to perform statistical analysis, methods must adhere to Rule 15ANCAC 13B .1632(g).

All analytical reports shall be completed and submitted to the appropriate State agency within 120 days of the event per Rule or sooner if stipulated in the Permit to Operate. The report package, as described, shall provide field observations relating to the condition of the monitoring wells, field data, lab data, tables of detections compared to regulatory Standards, statistical analysis (if chosen to use), sampling methodologies, quality assurance and quality control data, a groundwater surface map, information on ground-water flow direction, calculations of ground-water flow rate for each well any constituents that exceed ground-water standards as defined in Rule .1634(g) through (h) and any other pertinent information related to the sampling event. Additionally, laboratory Electronic Data Delivery (EDD) spreadsheets must be submitted to the SWS in the formats specified by the SWS. Water quality monitoring reports should include the SWS issued Environmental Monitoring Report Form which includes the notifications and signed certifications as instructed.

2.0 Surface Water Monitoring

2.1 Surface Water Monitoring Locations

The facility wide written surface water monitoring plan has five surface water monitoring locations (SW-1 through SW-5). The surface water quality monitoring system in place upstream of Phase 4 which includes SW-1, SW-2 and SW-5 is not pertinent to this monitoring plan; thus, effectiveness was not evaluated in formation of this plan. Surface water quality of existing units at points SW-1, SW-2 and SW-5 will continue to be monitored in accordance with previously approved plans. Surface water points SW-3 and SW-4 were also established in previous plans but are proximal to proposed Phase 4, therefore, addressed in this plan. SW-3 is plotted on drawings downstream of the spring identified near the northeast portion of proposed Phase 4. Water monitored at point SW-3 likely does not originate from proposed Phase 4 drainage area rather upgradient closer to Phase 3. SW-3 will continue to be monitored at the established location. SW-4 is plotted on drawings as along an intermittent stream that flanks the west side of proposed Phase 4. We propose to discontinue monitoring of SW-4 and replace it with a new point (PSW-7) planned further downstream to ensure that the west discharge feature is more effectively monitored once proposed Phase 4 and future Phase 5 is constructed. The two surface water points (SW-3 and PSW-7) proposed to monitor the Phase 4 drainage area are shown on Sheet 1 with location details on Table 3.

2.2 Surface Water Sampling Procedures

The following sampling procedures are intended to conform to the *SWS Guidelines Document*. The sampling point should be staked and labeled in the field to ensure data consistency. The specific portion of the stream or creek shall be in an area of minimal turbulence and aeration. The sampling point shall not be located at a constriction (where creek narrows), immediately upstream or downstream of a confluence with a tributary, nor immediately upstream or downstream of any significant structure in the creek that may result in turbulence. To the extent possible, a single grab sample shall be taken at mid-depth, at the center of the channel, in an area that exhibits the greatest degree of cross-sectional homogeneity.

Manual surface grab samples taken directly from the creek are the most desirable method of collection but a laboratory cleaned Teflon bailer or dipper may be used. The sample container should be rinsed with the water to be sampled prior to filling the container, unless preservatives have been added. The sample container, bailer or dipper shall be lowered to the desired depth in the creek and the sampling device or container removed. Care should be taken not to allow sediment or other debris to enter the sample container. If the stream flow is not deep enough to submerse the sample container in the water, a temporary depression may be created and used to collect the sample.

The surface water sampling quality control, sampling frequency, laboratory analysis parameters, field reporting, and reporting of the data shall be the same as that of the groundwater samples discussed in Section 1.5 through 1.9. Surface water features at the site include Indian Creek and its unnamed tributaries which are classified as Class C water bodies. Surface water data should be evaluated for regulatory compliance by comparison with North Carolina 15A NCAC 2B surface water standards, EPA established National criteria standards and or any standards adopted by the Solid Waste Section at the time of the event.

3.0 Leachate Monitoring

Leachate from all lined landfills at this facility gravity drains through a network of buried pipes to a pump station. The manhole contains a dedicated submersible pump that lifts leachate to the above ground leachate tanks. The lift station is located south of proposed Phase 4. A leachate sampling point was previously established at the lift station with an assigned sample ID ("Lift Station"). We propose to continue to monitor leachate quality at the Lift Station with location shown on Sheet 1.

3.1 Leachate Sampling

Manual surface grab samples should be taken directly from the manhole with a laboratory cleaned Teflon bailer or dipper. Under no circumstances should personnel descend the ladder inside the manhole. Samples should be collected with same procedures as a monitoring well as outlined in Section 1.5 except purging should not be performed. The bailer or dipper shall be lowered slowly to no more than 3 feet below static level and the sampling device removed. Care should be taken not to allow sediment or other debris to enter the sample container. Leachate samples should be collected at the end of a day after ground and surface water samples and stored in a separate cooler to avoid potential cross contamination and to meet short hold time requirements.

The leachate sampling frequency, field reporting requirements and reporting of the data/ results shall be the same as that of the groundwater samples discussed in Section 1.5 through 1.9. Leachate samples should be analyzed for constituents listed in 40 CFR 258 Appendix A plus chemical oxygen demand, biological oxygen demand, phosphorus, sulfate and nitrate as listed on Table 2. Pre-treated leachate is not to be compared to water quality standards for regulatory compliance purposes.

Tables

Table 1
Survey and Well Construction Data

Well ID	Nothing	Easting	Ground Elevation	Top of Casing Elevation	Stickup	Riser Interval		Screen Interval		Filter Pack Interval		Seal Bentonite Interval		Grout Interval		Estimated top of Bedrock		Groundwater Seasonal High	
						From	To	From	To	From	To	From	To	From	To				
			(ft msl)	(ft msl)	(ft als)	(ft bls)		(ft bls)		(ft bls)		(ft bls)		(ft bls)		(ft-msl)	(ft-bls)	(ft-msl)	(ft-bls)
PMW-37	615787.48	1298299.66	812.43	815.43	3.00	0.00	15.78	15.78	30.78	14.00	31.50	12.00	14.00	0.00	12.00	754.98	57.45	795.85	16.58
PMW-38	615570.15	1298065.54	824.05	827.05	3.00	0.00	30.95	30.95	45.95	29.50	46.50	27.00	29.50	0.00	27.00	761.54	62.51	793.72	30.33
PMW-39	615719.11	1297614.98	814.97	817.97	3.00	0.00	17.05	17.05	32.05	16.00	32.50	14.00	16.00	0.00	14.00	736.34	78.63	800.52	14.45
PMW-40	615912.50	1297179.34	808.81	811.81	3.00	0.00	9.04	9.04	24.04	8.00	25.00	6.00	8.00	0.00	6.00	761.81	47.00	798.81	10.00

NOTES:

1. Stick-Ups are 3.00 feet. Riser was meticulously measured from natural land surface prior to cutting. Top of casing was then surveyed.
   This procedure maintains consistency since land elevation is subjective and subject to change after drilling due to depth of concrete pad.
2. All wells are Type II (2" nominal PVC) with locking steel protective cases and concrete pads.
3. Wells surveyed on May 6, 2015.

P = Proposed. "P" Prefix will be dropped following plan approval

Table 2

Chemicals and Standards to Evaluate Water Quality

Groundwater and Surface Water Samples

CAS #	SWS ID	Chemical Name	NC SWSL	NCAC 2L std.	NC GWP std.
7440-36-0	13	Antimony(Total)	6	NE	1
7440-38-2	14	Arsenic(Total)	10	10	NE
7440-39-3	15	Barium(Total)	100	700	NE
7440-41-7	23	Beryllium(Total)	1	NE	4
7440-43-9	34	Cadmium(Total)	1	2	NE
7440-47-3	51	Chromium(Total)	10	10	NE
7440-48-4	53	Cobalt(Total)	10	NE	1
7440-50-8	54	Copper(Total)	10	1000	NE
7439-92-1	131	Lead (Total)	10	15	NE
7440-02-0	152	Nickel(Total)	50	100	NE
7782-49-2	183	Selenium(Total)	10	20	NE
7440-22-4	184	Silver(Total)	10	20	NE
7440-28-0	194	Thallium(Total)	5.5	NE	0.28
7440-62-2	209	Vanadium(Total)	25	NE	0.3
7440-66-6	213	Zinc(Total)	10	1000	NE
630-20-6	190	1,1,1,2-Tetrachloroethane	5	NE	1
71-55-6	200	1,1,1-Trichloroethane;	1	200	NE
79-34-5	191	1,1,2,2-Tetrachloroethane	3	0.2	0.18
79-00-5	202	1,1,2-Trichloroethane	1	NE	0.6
75-34-3	75	1,1-Dichloroethane; Ethyldidene	5	6	NE
75-35-4	77	1,1-Dichloroethylene; 1,1-	5	7	NE
96-18-4	206	1,2,3-Trichloropropane	1	0.005	NE
96-12-8	67	1,2-Dibromo-3-chloropropane; DBCP	13	0.04	NE
106-93-4	68	1,2-Dibromoethane; Ethylene dibromide;	1	0.02	NE
107-06-2	76	1,2-Dichloroethane; Ethylene	1	0.4	NE
78-87-5	82	1,2-Dichloropropane	1	0.6	NE
591-78-6	124	2-Hexanone; Methyl butyl ketone	50	NE	40
108-10-1	147	4-Methyl-2-pentanone; Methyl isobutyl	100	NE	560
67-64-1	3	Acetone	100	6000	NE
107-13-1	8	Acrylonitrile	200	NE	NE
71-43-2	16	Benzene	1	1	NE
74-97-5	28	Bromochloromethane;	3	NE	0.6
75-27-4	29	Bromodichloromethane;	1	0.6	NE
75-25-2	30	Bromoform; Tribromomethane	3	4	NE
75-15-0	35	Carbon disulfide	100	700	NE
56-23-5	36	Carbon tetrachloride	1	0.3	NE
108-90-7	39	Chlorobenzene	3	50	NE
75-00-3	41	Chloroethane; Ethyl chloride	10	3000	NE
67-66-3	44	Chloroform; Trichloromethane	5	70	NE
156-59-2	78	cis-1,2-Dichloroethylene; cis-1,2-	5	70	NE
10061-01-5	86	cis-1,3-Dichloropropene	1	0.4	NE
124-48-1	66	Dibromochloromethane;	3	0.4	0.41
100-41-4	110	Ethylbenzene	1	600	NE
74-83-9	136	Methyl bromide; Bromomethane	10	NE	10

CAS #	SWS ID	Chemical Name	NC SWSL	NCAC 2L std.	NC GWP std.
74-87-3	137	Methyl chloride; Chloromethane	1	3	NE
78-93-3	141	Methyl ethyl ketone; MEK; 2-	100	4000	NE
74-88-4	142	Methyl iodide; Iodomethane	10	NE	NE
74-95-3	139	Methylene bromide;	10	NE	70
75-09-2	140	Methylene chloride;	1	5	NE
95-50-1	69	o-Dichlorobenzene; 1,2-	5	20	NE
106-46-7	71	p-Dichlorobenzene; 1,4-	1	6	NE
100-42-5	186	Styrene	1	70	NE
127-18-4	192	Tetrachloroethylene; Tetrachloroethene;	1	0.7	NE
108-88-3	196	Toluene	1	600	NE
156-60-5	79	trans-1,2-Dichloroethylene; trans-1,2-	5	100	NE
10061-02-6	87	trans-1,3-Dichloropropene	1	0.4	NE
110-57-6	73	trans-1,4-Dichloro-2-butene	100	NE	NE
79-01-6	201	Trichloroethylene; Trichloroethene	1	3	NE
75-69-4	203	Trichlorofluoromethane; CFC-11	1	2000	NE
108-05-4	210	Vinyl acetate	50	NE	88
75-01-4	211	Vinyl chloride; Chloroethene	1	0.03	NE
1330-20-7	346	Xylene (total)	5	500	NE

Leachate Samples

CAS #	SWS ID	Chemical Name	NC SWSL	NCAC 2L std.	NC GWP std.
-	-	Same as Ground and Surface Waters	-	-	-
NE	316	Biological Oxygen Demand (BOD)	NE	-	-
NE	317	Chemical Oxygen Demand (COD)	NE	-	-
7723-14-0	412	Phosphorus	NE	-	-
14808-79-8	315	Sulfate	250000	-	-
14797-55-8	303	Nitrate	10000	-	-

NOTES:

1. Data downloaded from SWS Website on October 6, 2015. SWS Last updated June 13, 2011.

2. All Units in ug/L

3. NE = Not Established

4. Data in this table is subject to change in the future. Reference website for any changes.

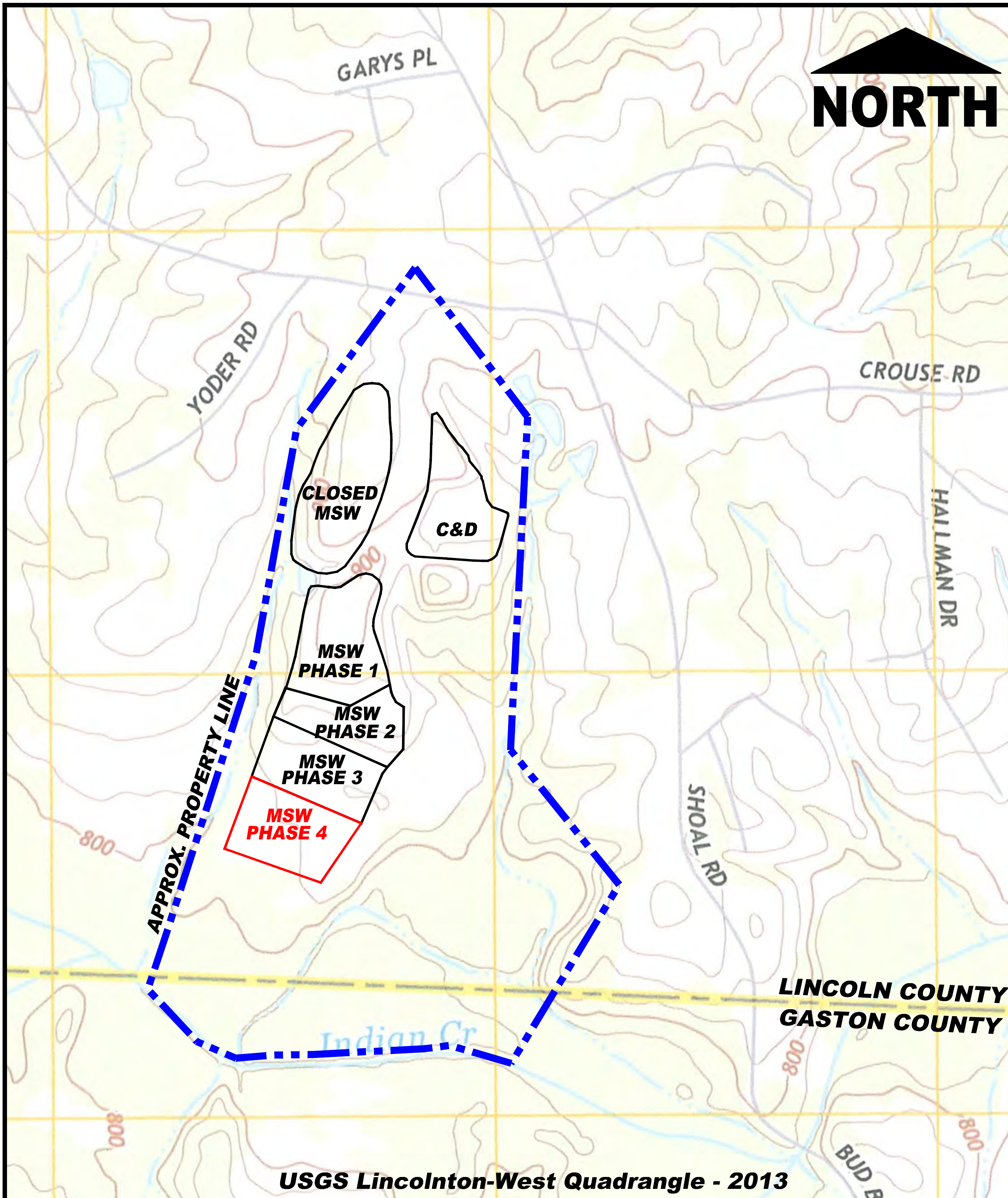
Table 3
Surface Water Points Summary

ID	Northing	Easting	Units/Areas Point Monitors	Comments
SW-3	615759.18	1298656.00	Lined Phases 1-4	On previously established Plan
SW-4	616129.34	1297109.64	Area “E” Unlined MSWLF plus Lined Phases 1-4	Discontinue and replace with PSW-7
PSW-7	614860.57	1296628.18	Area “E” Unlined MSWLF plus Lined Phases 1-4	New point downstream to replace SW-4

P = Proposed. “P” Prefix will be dropped following plan approval

Figures

Figures



Municipal Services Engineering Company, P.A.

P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393

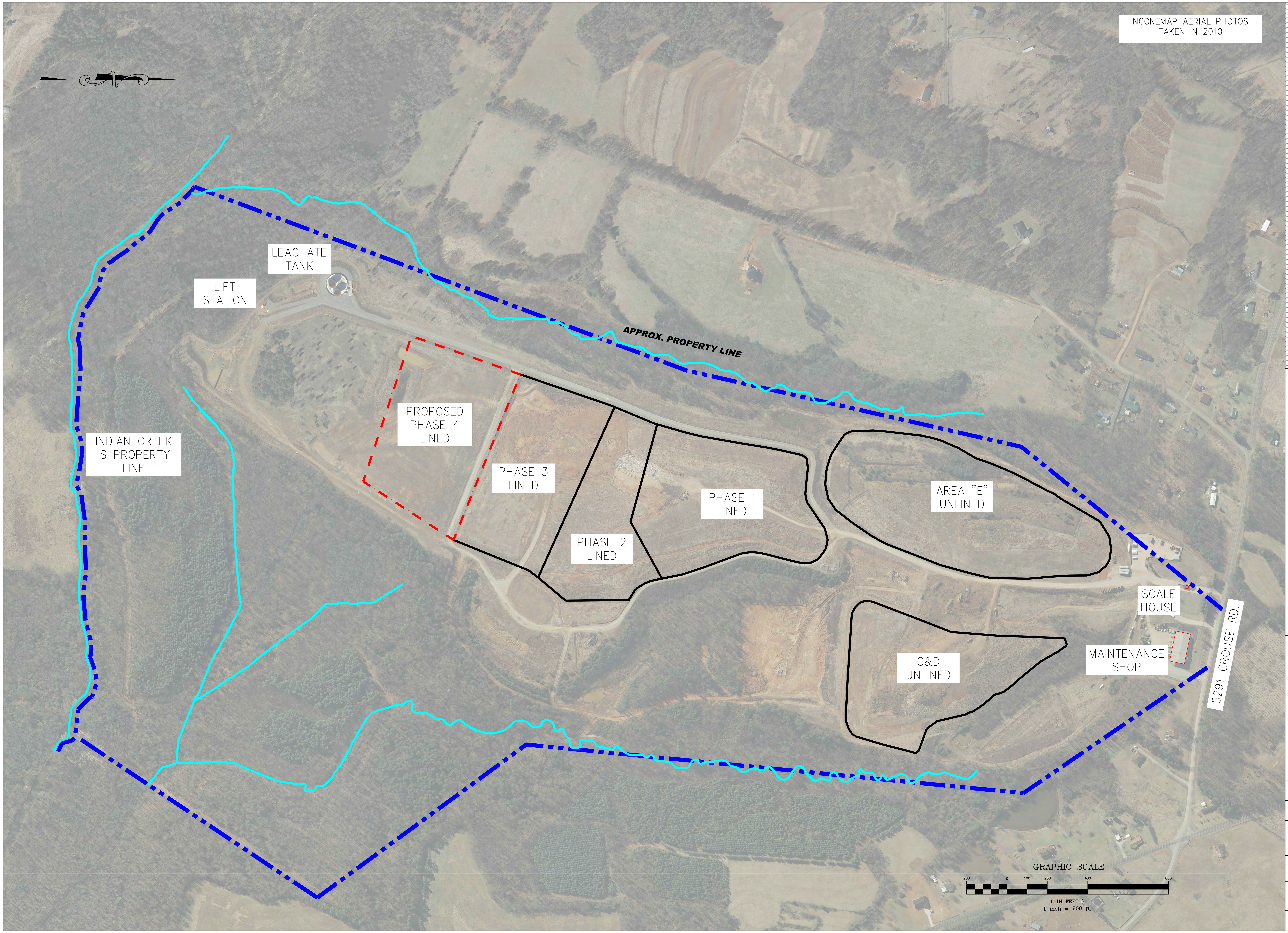
P.O. BOX 349 BOONE, N.C. 28607
(828) 262-1767

LICENSE NUMBER: C-0281

FIGURE 1
SITE LOCATION (USGS TOPO)

Lincoln County Landfill, Phase 4
Crouse, North Carolina

SCALE:	DATE:	PROJECT NO.:
1" = 1000'	8/10/2015	G15041



Municipal Engineering Services Company, P.A.

P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393

P.O. BOX 349 BOONE, N.C. 28607
(828) 262-1767

LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LINCOLN COUNTY
CROUSE, NORTH CAROLINA

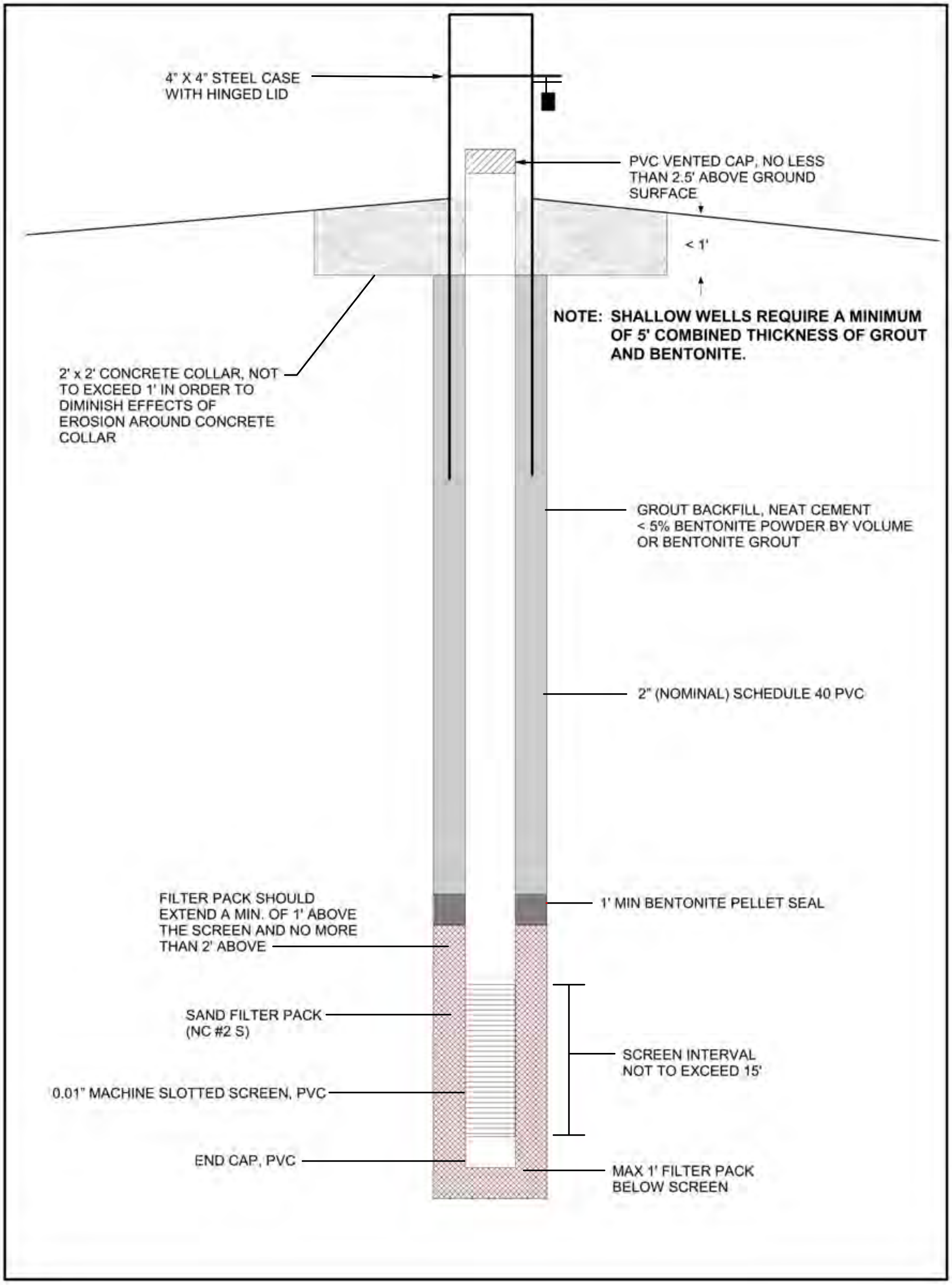
REV.	DATE	BY	DESCRIPTION
			SITE LOCATION AERIAL

SCALE: 1" = 200'
DATE: 10-12-2015
DRWN. BY: R.MOSS
CHKD. BY: W. SULLIVAN

PROJECT NUMBER
G15141.6

DRAWING NO.

SHEET NO.
FIG. 2



Municipal Services **Engineering Company, P.A.**

P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393

P.O. BOX 349 BOONE, N.C. 28607
(828) 262-1767

LICENSE NUMBER: C-0281

FIGURE 3

TYPICAL TYPE II MONITORING WELL SCHEMATIC

Lincoln County Landfill, Phase 4
Crouse, North Carolina

SCALE:	DATE:	PROJECT NO.:
NOT TO SCALE	8/10/2015	G15041

Appendix A

PMW-37

Proposed to be converted from OW4-2

LOG OF BORING: OW4-2

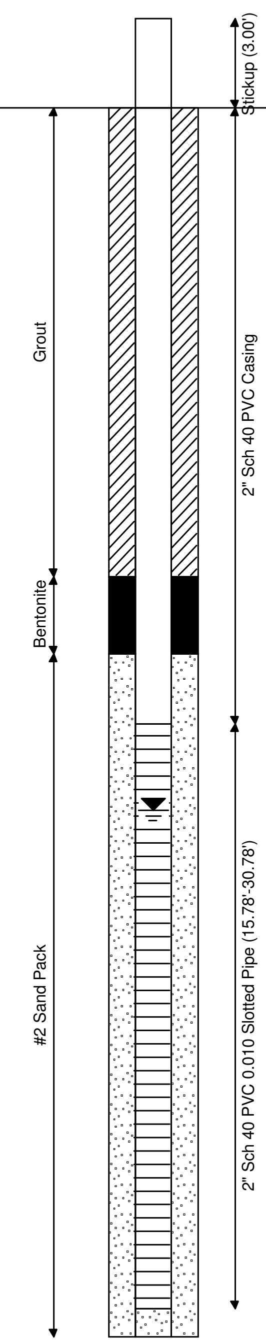
Lincoln Co. MSWSLF Ph. 4 **Project No. G15141.6**

Drilling contractor:	Bluestone	Date started:	3/23/2015
Drill rig & method:	8.5" OD HSA w/ SPT	Date ended:	3/23/2015
Logged by:	J. Pfohl	Completion depth:	31.50 ft
		Stickup height:	3.00 ft

Surface elevation:	812.43 ft (MSL)
Top of pipe elevation:	815.43 ft (MSL)
Depth to water (TOB):	18.50 ft
Depth to water (24hrs):	18.01 ft

Depth (ft)	SPT (bpf)	Description of Material & Remarks
	7	RESIDUUM; (SM), MB SILTY SAND, loose density, non-uniform medium to coarse grains, organic root debris, dry.
5	7	RESIDUUM; (SM), MYB SILTY SAND, loose density, fine grains, faint relict structure, trace micas., dry.
10	10	SAPROLITE; (SM) MYB SILTY SAND, low plastic, loose density, relict structure, white feldspar and black manganeze partings, uniform fine grained sand, trace medium grained sands, micas., no mottles, dry.
15	10	SAPROLITE; (SM) MYB SILTY SAND, low plastic, loose density, relict structure, white feldspar and black manganeze partings, uniform fine grained sand, trace medium grained sands, micas., no mottles, dry.
20	12	SAPROLITE; (SM) MYB SILTY SAND, non-plastic, loose density, trace white feldspar and black manganese partings, no mottles, micas., moist.
25	13	SAPROLITE; (SM) MYB SILTY SAND, non-plastic, medium density, micas., moist. BULK SAMPLE - Lab Tested as (SM) "Tan Silty Sand" (52.5% sand, 22.3% silt, 25.2% clay).
30	15	SAPROLITE; (SM) DYB SILTY FINE SAND, non-plastic, medium density, micas., saturated.
		NO Auger Refusal - Neither PWR nor Bedrock encountered >781.65 ft amsl
		Boring terminated at 31.5 feet

Well Diagram



PMW-37

Proposed to be converted from OW4-2

WELL CONSTRUCTION RECORD

This form can be used for single or multiple wells

1. Well Contractor Information:

John Thompson

Well Contractor Name

3579-A

NC Well Contractor Certification Number

Bluestone Environmental, LLC

Company Name

2. Well Construction Permit #: ____________________

List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:

- ☐Agricultural
- ☐Municipal/Public
- ☐Geothermal (Heating/Cooling Supply)
- ☐Residential Water Supply (single)
- ☐Industrial/Commercial
- ☐Residential Water Supply (shared)
- ☐Irrigation

Non-Water Supply Well:

- ☑Monitoring
- ☐Recovery

Injection Well:

- ☐Aquifer Recharge
- ☐Groundwater Remediation
- ☐Aquifer Storage and Recovery
- ☐Salinity Barrier
- ☐Aquifer Test
- ☐Stormwater Drainage
- ☐Experimental Technology
- ☐Subsidence Control
- ☐Geothermal (Closed Loop)
- ☐Tracer
- ☐Geothermal (Heating/Cooling Return)
- ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 3/23/15 **Well ID#** OW4-2

5a. Well Location:

Lincoln Co MSWLF, Ph 4 (future)

Facility/Owner Name

Facility ID# (if applicable)

5291 Crouse Rd Crouse NC 28033

Physical Address, City, and Zip

Lincoln

County

2691874263

Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.419208 N 81.355372 W

6. Is (are) the well(s): ☐**Permanent** or ☑**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**

If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1

*For multiple injection or non-water supply wells **ONLY** with the **same construction**, you can submit one form.*

9. Total well depth below land surface: Screen 30.78, Sand 31.50 **(ft.)**

For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 21.01 (24 hrs. after set) **(ft.)**

If water level is above casing, use "+"

11. Borehole diameter: 8.5 **(in.)**

12. Well construction method: auger

(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) ____________ **Method of test:** ____________

13b. Disinfection type: ____________ **Amount:** ____________

For Internal Use ONLY:

14. WATER ZONES

FROM	TO	DESCRIPTION
18.01 ft.	>31.50 ft.	Unconfined uppermost aquifer in soil
ft.	ft.	

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
+3.00 ft.	15.78 ft.	2 in.	Sch 40	PVC flush thread
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
15.78 ft.	30.78 ft.	2 in.	0.01"	Sch 40	PVC
ft.	ft.	in.	1/4" space		

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0.0 ft.	3.0 ft.	Concrete	Gravity >200 lbs. solids
3.0 ft.	12.0 ft.	Bent. Grout	Tremie 50 lbs. solids
12.0 ft.	14.0 ft.	Bent. Chips	Gravity 55 lbs. hydrated

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
14.0 ft.	31.5 ft.	#2 Silica Sand	Gravity
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0.0 ft.	31.5 ft.	SOIL; Brown, soft
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	2'X2' concrete pad with locked steel case

21. REMARKS

Temporary observation well for hydrogeologic study

for future MSWLF Phase 4

22. Certification:

[signature] 3/30/15

Signature of Certified Well Contractor — Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:

You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

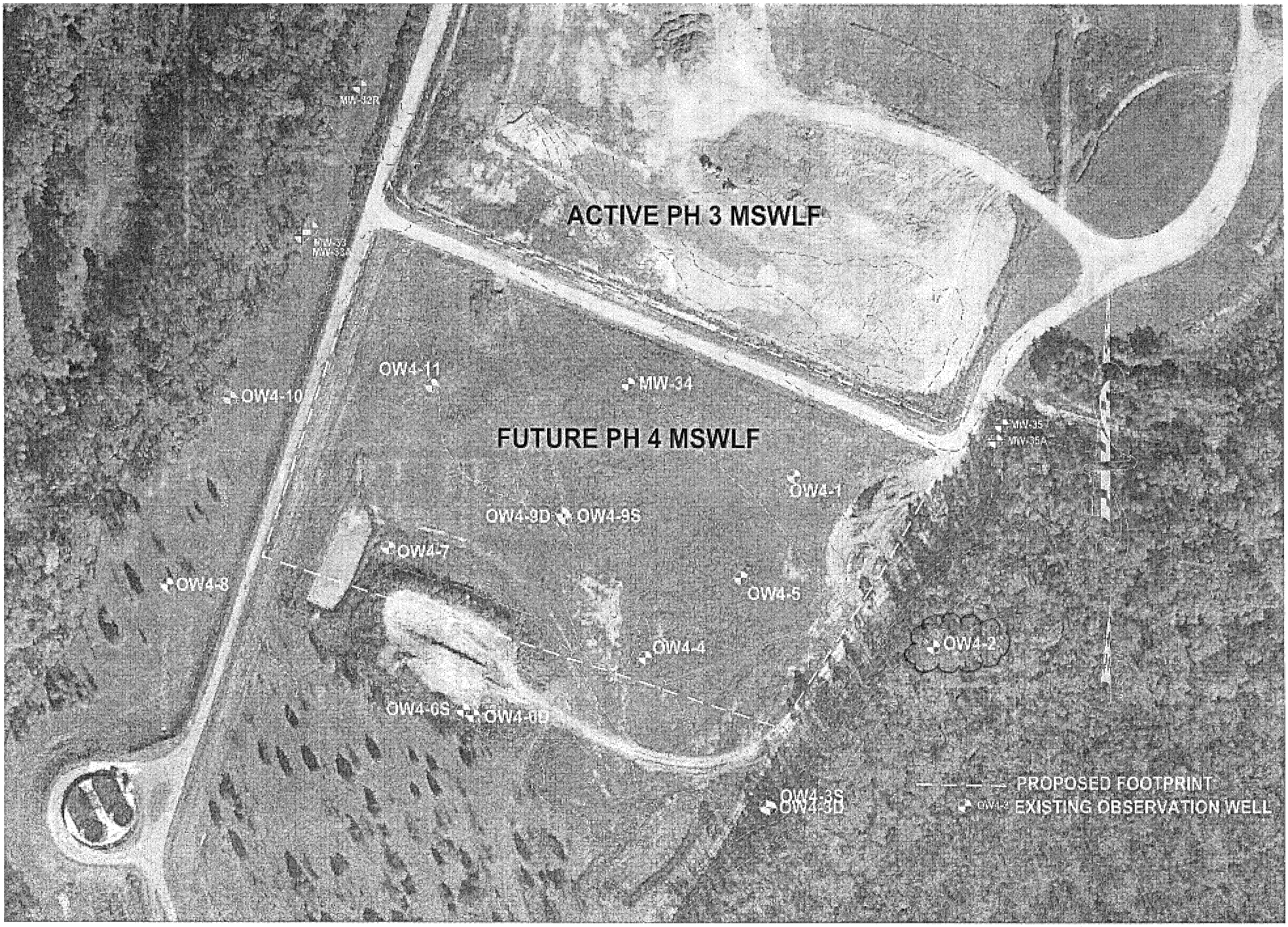
**Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617**

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

**Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636**

24c. For Water Supply & Injection Wells:

Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.



Lincoln Co. MSWLF
5291 Crouse Rd
Crouse NC 28033

N

Proposed to be converted from OW4-3S

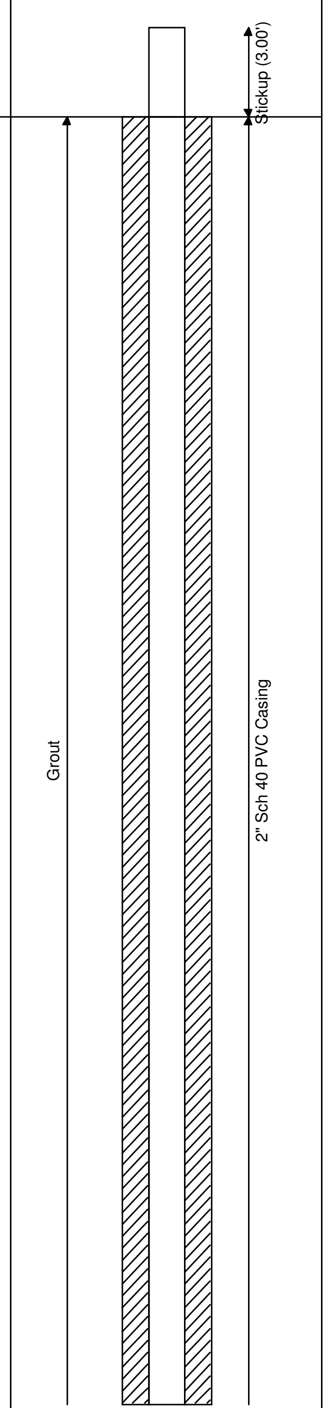
LOG OF BORING: OW4-3S

Lincoln Co. MSWSLF Ph. 4 | **Project No. G15141.6**

Drilling contractor:	Bluestone	Date started:	3/23/2015	Surface elevation:	824.05 ft (MSL)
Drill rig & method:	8.5" OD HSA NO SPT	Date ended:	3/23/2015	Top of pipe elevation:	827.05 ft (MSL)
Logged by:	J. Pfohl	Completion depth:	46.50 ft	Depth to water (TOB):	36.00 ft
		Stickup height:	3.00 ft	Depth to water (24hrs):	35.63 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
				NO SPT PERFORMED IN OW4-3S. HOWEVER SPT PERFORMED IN ADJACENT OW4-3D AND DESCRIPTIONS RE-TRANSCRIBED.
	19			SAPROLITE; (SM) MYB SILTY SAND w/ clay, low plastic, moderate density, black manganese partings, dry.
5				
	19			SAPROLITE; (SM) LB SILTY SAND, fine grained, black manganese partiings, 2" white coarse angular grained quartz seam, medium density, dry.
10				
	18			SAPROLITE; (SM) LB SILTY SAND, cap-graded fine & medium grained, pronounced relict structure, white feldspar & black manganese partings, medium density, dry.
15				
	22			SAPROLITE; (SM) LB SILTY SAND, cap-graded fine & medium grained, pronounced relict structure, white feldspar & black manganese partings, medium density, dry.
20				
	16			SAPROLITE; (SM) LB SILTY SAND, cap-graded fine & medium grained, pronounced relict structure, white feldspar & black manganese partings, medium density, dry.
25				

Well Diagram



Municipal Engineering Services Company, P.A.
Operation/Construction Managers Civil/Sanitary Engineers Environmental Studies
PO Box 97, Garner, North Carolina 27529 (919) 772-5393 PO Box 349, Boone, North Carolina 28607 (828) 262-1767

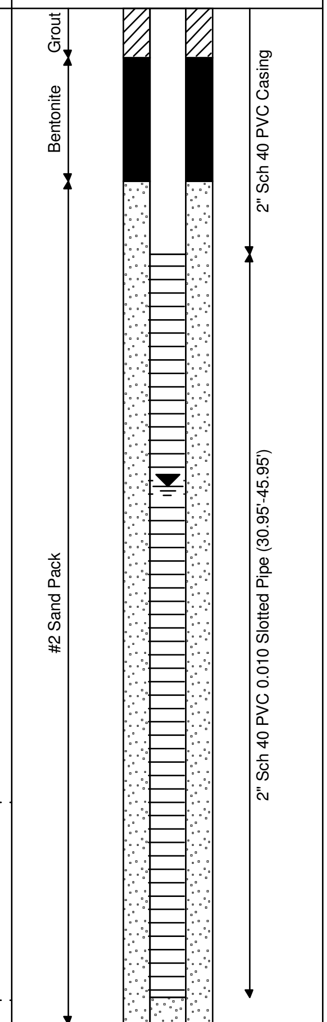
LOG OF BORING: OW4-3S

Lincoln Co. MSWSLF Ph. 4 — **Project No. G15141.6**

Drilling contractor:	Bluestone	Date started:	3/23/2015	Surface elevation:	824.05 ft (MSL)
Drill rig & method:	8.5" OD HSA NO SPT	Date ended:	3/23/2015	Top of pipe elevation:	827.05 ft (MSL)
Logged by:	J. Pfohl	Completion depth:	46.50 ft	Depth to water (TOB):	36.00 ft
		Stickup height:	3.00 ft	Depth to water (24hrs):	35.63 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
30	21		X	SAPROLITE; (SM) LB SILTY SAND, cap-graded fine & coarse grained, pronounced relict structure, white feldspar & black manganese partings, medium density, dry.
35				SAPROLITE - Undisturbed sample collected from adjacent OW4-3D (34'-36') lab tested as (SM) "Light brown SILTY SAND" (72.4% sand, 16.7% silt, 10.9% clay).
40	23		X	SAPROLITE; (SM) LB SILTY SAND, well graded, pronounced relict structure, white feldspar & black manganese partings, medium density, dry.
45	34		X	SAPROLITE; (SM) LOG SAND, cap-graded fine & medium grained, few black manganese partings, pronounced relict structure, trace white medium grained angular white quartz fragments, medium density, moist.
				No HSA refusal at OW4-3S. Tricone refusal at 62.08' or 761.54' amsl in directly adjacent OW4-3D.
50				Boring terminated at 46.5 feet

Well Diagram



PMW-38

Proposed to be converted from OW4-3S OW4-3S

WELL CONSTRUCTION RECORD

This form can be used for single or multiple wells

1. Well Contractor Information:

John Thompson

Well Contractor Name

3579-A

NC Well Contractor Certification Number

Bluestone Environmental, LLC

Company Name

2. Well Construction Permit #: ____________________

List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:

- ☐Agricultural
- ☐Municipal/Public
- ☐Geothermal (Heating/Cooling Supply)
- ☐Residential Water Supply (single)
- ☐Industrial/Commercial
- ☐Residential Water Supply (shared)
- ☐Irrigation

Non-Water Supply Well:

- ☑Monitoring
- ☐Recovery

Injection Well:

- ☐Aquifer Recharge
- ☐Groundwater Remediation
- ☐Aquifer Storage and Recovery
- ☐Salinity Barrier
- ☐Aquifer Test
- ☐Stormwater Drainage
- ☐Experimental Technology
- ☐Subsidence Control
- ☐Geothermal (Closed Loop)
- ☐Tracer
- ☐Geothermal (Heating/Cooling Return)
- ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 3/23/15 **Well ID#** OW4-3S

5a. Well Location:

Lincoln Co MSWLF, Ph 4 (future)

Facility/Owner Name | Facility ID# (if applicable)

5291 Crouse Rd Crouse NC 28033

Physical Address, City, and Zip

Lincoln | 2691874263

County | Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minntes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.418429 N 81.356210 W

6. Is (are) the well(s): ☐Permanent or ☑Temporary

7. Is this a repair to an existing well: ☐Yes or ☑No

If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1

For multiple injection or non-water supply wells ONLY with the same construction, you can submit one form.

9. Total well depth below land surface: Screen 45.95, Sand 46.50 (ft.)

For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 38.63 (24 hrs. after set) (ft.)

If water level is above casing, use "+"

11. Borehole diameter: 8.5 (in.)

12. Well construction method: auger

(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) ________ **Method of test:** ________

13b. Disinfection type: ________ **Amount:** ________

For Internal Use ONLY:

14. WATER ZONES

FROM	TO	DESCRIPTION
35.82 ft.	>46.50 ft.	Unconfined uppermost aquifer in soil
ft.	ft.	

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
+3.00 ft.	30.95 ft.	2 in.	Sch 40	PVC flush thread
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
30.95 ft.	45.95 ft.	2 in.	0.01"	Sch 40	PVC
ft.	ft.	in.	1/4" space		

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0.0 ft.	3.0 ft.	Concrete	Gravity >190 lbs. solids
3.0 ft.	27.0 ft.	Bent. Grout	Tremie 130 lbs. solids
27.0 ft.	29.50 ft.	Bent. Chips	Gravity 65 lbs. hydrated

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
29.5 ft.	46.5 ft.	#2 Silica Sand	Gravity
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0.0 ft.	42.0 ft.	SOIL; Silty Sand, residuum, mod. density
42.0 ft.	46.5 ft.	SOIL; Saprolite, more dense
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	2'X2' concrete pad with locked steel case

21. REMARKS

Observation well for hydrogeologic study for future Ph 4 LF

Shallower counterpart to adjacent nested well OW4-3D

22. Certification:

[signature] 3/30/15

Signature of Certified Well Contractor | Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:

You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

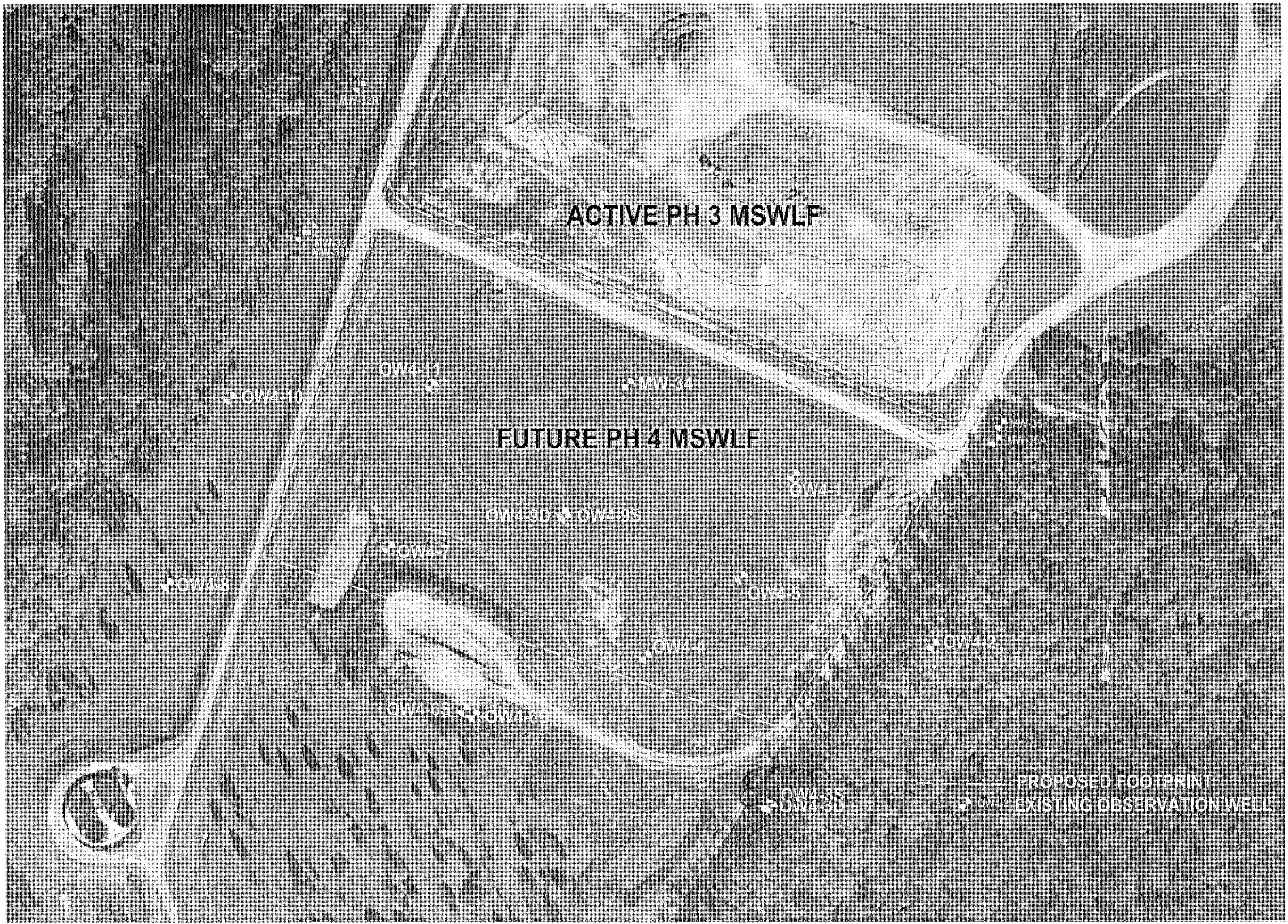
24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636

24c. For Water Supply & Injection Wells:
Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.



Lincoln Co. MSWLF
5291 Crouse Rd
Crouse NC 28033

N

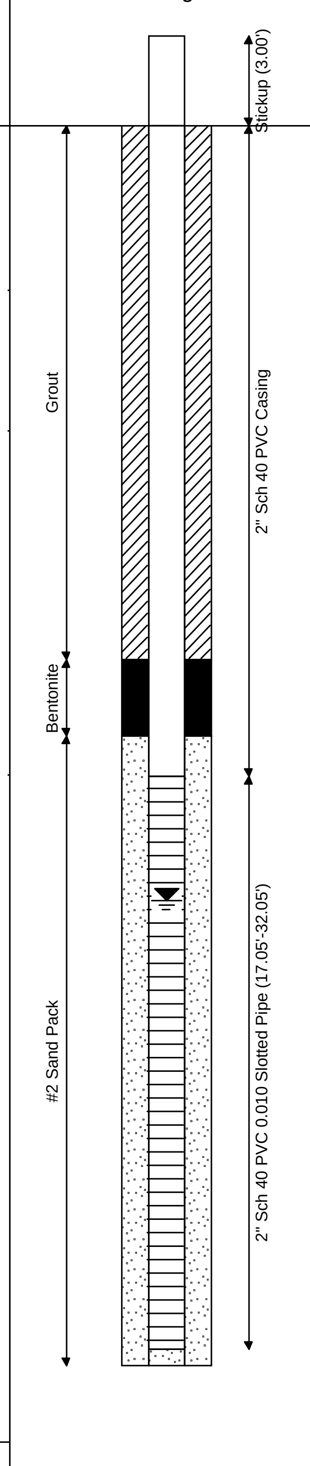
LOG OF BORING: OW4-6S

Lincoln Co. MSWSLF Ph. 4 | **Project No. G15141.6**

Drilling contractor: Bluestone	Date started: 3/23/2015	Surface elevation: 814.97 ft (MSL)
Drill rig & method: 8.5" OD HSA NO SPT	Date ended: 3/23/2015	Top of pipe elevation: 817.97 ft (MSL)
Logged by: J. Pfohl	Completion depth: 32.50 ft	Depth to water (TOB): 21.50 ft
	Stickup height: 3.00 ft	Depth to water (24hrs): 20.29 ft

Depth (ft)	SPT (bpf)	Soil Type Symbol	Sample	Description of Material & Remarks
0				NO SPT PERFORMED IN OW4-6S. HOWEVER SPT PERFORMED IN ADJACENT CLUSTER WELL OW4-6D AND DESCRIPTIONS RE-TRANSCRIBED.
	9		X	RESIDUUM; (ML), LB CLAYEY FINE SAND, stiff density, uniformly fine grained, homogenous, low plasticity, organic root debris, dry.
5	13		X	RESIDUUM; (ML), LB SILTY SAND, stiff density, uniformly fine grained, homogenous, low plasticity, dry.
10	12		X	RESIDUUM; (MH), LB SANDY ELASTIC SILT, stiff density, low-medium plasticity, dry.
				RESIDUUM- Undisturbed sample collected from adjacent OW4-6D (12'-14') - Lab Tested as (MH) "Orangish brown sandy elastic SILT" (47.1% sand, 18.4% silt, 34.5% clay).
15	11		X	RESIDUUM; (MH), LB SANDY ELASTIC SILT, stiff density, low plasticity, dry.
20	22		X	SAPROLITE; (SM) PYB SILTY SAND, well graded, medium density, no mottles, dry.
25	52		X	SAPROLITE; (SM) DYB SILTY SAND, well graded, very dense, no mottles, dry.
30	70		X	SAPROLITE; (SM) DYB SILTY SAND, well graded, very dense, pronounced relict structure, white feldspar & black manganese partings, dry.
				NO Auger Refusal - Neither PWR nor Bedrock encountered in OW4-6S. However rock encountered at adjacent cluster well OW4-6D at 81.5' bls (733.84 ft amsl).
				Boring terminated at 32.5 feet

Well Diagram



PMW-39

Proposed to be converted from OW4-6S

WELL CONSTRUCTION RECORD

This form can be used for single or multiple wells

For Internal Use ONLY:

1. Well Contractor Information:

John Thompson

Well Contractor Name

3579-A

NC Well Contractor Certification Number

Bluestone Environmental, LLC

Company Name

2. Well Construction Permit #: ______

List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:

- ☐Agricultural
- ☐Municipal/Public
- ☐Geothermal (Heating/Cooling Supply)
- ☐Residential Water Supply (single)
- ☐Industrial/Commercial
- ☐Residential Water Supply (shared)
- ☐Irrigation

Non-Water Supply Well:

- ☑Monitoring
- ☐Recovery

Injection Well:

- ☐Aquifer Recharge
- ☐Groundwater Remediation
- ☐Aquifer Storage and Recovery
- ☐Salinity Barrier
- ☐Aquifer Test
- ☐Stormwater Drainage
- ☐Experimental Technology
- ☐Subsidence Control
- ☐Geothermal (Closed Loop)
- ☐Tracer
- ☐Geothermal (Heating/Cooling Return)
- ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 3/23/15 **Well ID#** OW4-6S

5a. Well Location:

Lincoln Co MSWLF, Ph 4 (future)

Facility/Owner Name

Facility ID# (if applicable)

5291 Crouse Rd Crouse NC 28033

Physical Address, City, and Zip

Lincoln

County

Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.418803 N 81.357685 W

6. Is (are) the well(s): ☐**Permanent** or ☑**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**

If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1

For multiple injection or non-water supply wells ***ONLY*** *with the* ***same construction****, you can submit one form.*

9. Total well depth below land surface: Screen 32.05, Sand 32.50 **(ft.)**

For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 23.29 (24 hrs. after set) **(ft.)**

If water level is above casing, use "+"

11. Borehole diameter: 8.5 **(in.)**

12. Well construction method: auger

(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) ______ **Method of test:** ______

13b. Disinfection type: ______ **Amount:** ______

14. WATER ZONES

FROM	TO	DESCRIPTION
20.29 ft.	>32.50 ft.	Unconfined uppermost aquifer in soil
ft.	ft.	

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
+3.00 ft.	17.05 ft.	2 in.	Sch 40	PVC flush thread
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
17.05 ft.	32.05 ft.	2 in.	0.01"	Sch 40	PVC
ft.	ft.	in.	1/4" space		

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0 ft.	3 ft.	Concrete	Gravity >190 lbs. solids
3 ft.	14 ft.	Bent. Grout	Tremie 60 lbs. solids
14 ft.	16 ft.	Bent. Chips	Gravity 55 lbs. hydrated

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
16.0 ft.	32.5 ft.	#2 Silica Sand	Gravity
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0.0 ft.	22.0 ft.	SOIL; Silty Sand, residuum, soft
22.0 ft.	32.5 ft.	SOIL; Saprolite, increasingly dense
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	
ft.	ft.	2'X2' concrete pad with locked steel case

21. REMARKS

Observation well for hydrogeologic study for future Ph 4 LF

Shallower counterpart to adjacent nested well OW4-6D

22. Certification:

[signature] 3/30/15

Signature of Certified Well Contractor Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:

You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636

24c. For Water Supply & Injection Wells:

Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.

Lincoln Co. MSWLF
5291 Crouse Rd
Crouse NC 28033

N

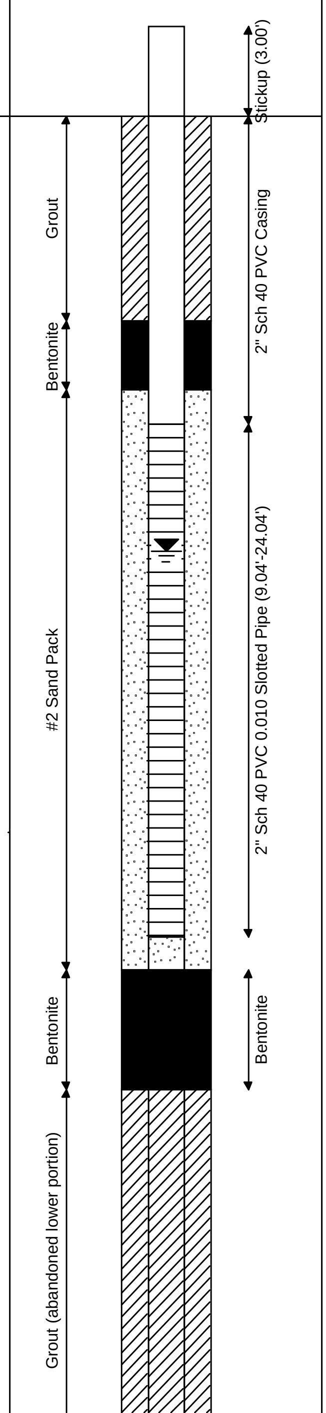
LOG OF BORING: OW4-8

Lincoln Co. MSWSLF Ph. 4 — **Project No. G15141.6**

Drilling contractor:	Bluestone	Date started:	2/25/2015	Surface elevation:	808.81 ft (MSL)
Drill rig & method:	6" OD mud rotary, NQ rock core, SPT	Date ended:	2/25/2015	Top of pipe elevation:	811.81 ft (MSL)
Logged by:	J. Pfohl	Completion depth:	75.00 ft	Depth to water (TOB):	13.00 ft
		Stickup height:	3.00 ft	Depth to water (24hrs):	12.75 ft

Depth (ft)	SPT (bpf)	Description of Material & Remarks
	5	RESIDUUM; (ML) VPO SANDY SILT; high plasticity, homogeneous, medium stiff density, moist.
5	5	RESIDUUM; (ML) VPO SANDY SILT; high plasticity, homogeneous, medium stiff density, moist.
		UNDISTURBED "Shelby tube" SAMPLE; Lab tested as "Orangish Brown SANDY SILT" (44.2% sand, 25.1% silt, 30.7% clay).
10	10	SAPROLITE; (ML) VPO SANDY SILT; medium plasticity, no mottles, stiff density, moist.
15	9	SAPROLITE; (CL) PYB SANDY SILT, medium plasticity, mottled, stiff density, moist.
		UNDISTURBED "Shelby tube" SAMPLE; Lab tested as "Gray and orange SANDY SILT" (48.7% sand, 38.2% silt, 13.1% clay).
20	11	SAPROLITE; (CL) GO SANDY SILT, low plasticity, stiff density, wet.
25	13	SAPROLITE; (SM) PYB SILTY SAND, cap-graded medium to coarse grained, medium denisty, white and blak partings, wet.
30	17	SAPROLITE; (SM) LB SILTY SAND, cap-graded medium to coarse grained, medium denisty, white and blak partings, wet.
35	14	SAPROLITE; (SM) PYB SILTY SAND, cap graded fine to med. grains, medium density, trace manganese staining, moist.

Well Diagram



Municipal Engineering Services Company, P.A.
Operation/Construction Managers Civil/Sanitary Engineers Environmental Studies
PO Box 97, Garner, North Carolina 27529 (919) 772-5393 PO Box 349, Boone, North Carolina 28607 (828) 262-1767

PMW-40

Proposed to be converted from OW4-8

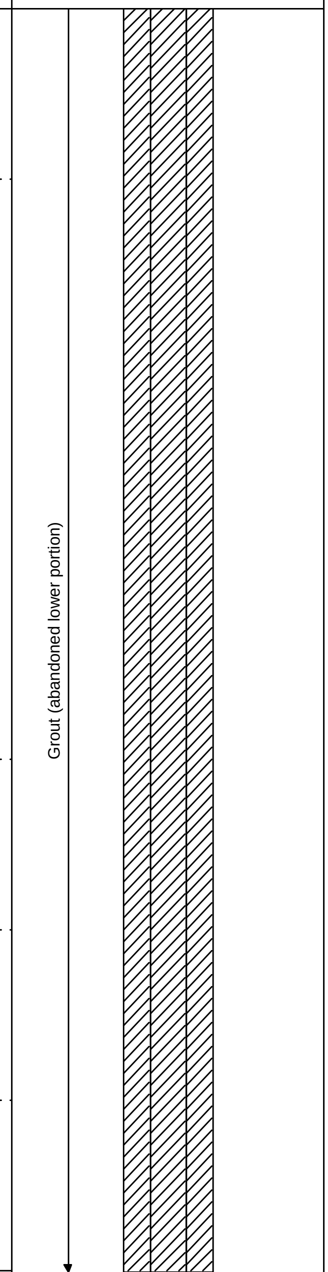
LOG OF BORING: OW4-8

Lincoln Co. MSWSLF Ph. 4 — **Project No. G15141.6**

Drilling contractor:	Bluestone	Date started:	2/25/2015	Surface elevation:	808.81 ft (MSL)
Drill rig & method:	6" OD mud rotary, NQ rock core, SPT	Date ended:	2/25/2015	Top of pipe elevation:	811.81 ft (MSL)
Logged by:	J. Pfohl	Completion depth:	75.00 ft	Depth to water (TOB):	13.00 ft
		Stickup height:	3.00 ft	Depth to water (24hrs):	12.75 ft

Depth (ft)	SPT (bpf)	Description of Material & Remarks
39–43	10	SAPROLITE; (SM) PYB SILTY SAND, cap graded fine to med. grains, medium density, trace manganese staining, moist.
43–47	50/3""	WEATHERED ROCK (HIGHLY); (SP) LOG SAND, cap-graded fine to medium grained, very dense, moist.
47–50		REFUSAL of Tricone (metal not carbide bit) at 47' bls (761.81' amsl) WEATHERED ROCK (MODERATELY) RUN #1 (47-50') REC=50%, RQD=0%; Brown, interlayered with saprolite.
50–55		WEATHERED ROCK (MODERATELY) RUN #2 (50-55') REC=46%, RQD=0%; Brown, interlayered with saprolite.
55–60		WEATHERED ROCK (MODERATELY) RUN #3 (55-60') REC=88%, RQD=0%;Brown, interlayered with saprolite.
60–65		SAPROLITE RUN #4 (60-65') REC=0%, RQD=0%; No core recovery as saprolite washed away during coring process.
65–70		WEATHERED ROCK (MODERATELY) #5 (65-70') REC=17%, RQD=0%; gray, interlayered with saprolite.
70–75		BEDROCK RUN #6 (70-75') REC=90%, RQD=0%; Sillimanite schist; White with light gray shallow dipping foliations; 70'-71' slighlty weathered, gray, iron stained, 71'-75' faintly weathered.
75		Boring terminated at 75.0 feet

Well Diagram



WELL CONSTRUCTION RECORD

This form can be used for single or multiple wells

For Internal Use ONLY:

1. Well Contractor Information:

John Thompson
Well Contractor Name

3579-A
NC Well Contractor Certification Number

Bluestone Environmental, LLC
Company Name

2. Well Construction Permit #: ____________
List all applicable well permits (i.e. County, State, Variance, Injection, etc.)

3. Well Use (check well use):

Water Supply Well:
☐Agricultural ☐Municipal/Public
☐Geothermal (Heating/Cooling Supply) ☐Residential Water Supply (single)
☐Industrial/Commercial ☐Residential Water Supply (shared)
☐Irrigation

Non-Water Supply Well:
☑Monitoring ☐Recovery

Injection Well:
☐Aquifer Recharge ☐Groundwater Remediation
☐Aquifer Storage and Recovery ☐Salinity Barrier
☐Aquifer Test ☐Stormwater Drainage
☐Experimental Technology ☐Subsidence Control
☐Geothermal (Closed Loop) ☐Tracer
☐Geothermal (Heating/Cooling Return) ☐Other (explain under #21 Remarks)

4. Date Well(s) Completed: 2/25/15 **Well ID#** OW4-8

5a. Well Location:

Lincoln Co MSWLF, Ph 4 (future)
Facility/Owner Name

Facility ID# (if applicable)

5291 Crouse Rd Crouse NC 28033
Physical Address, City, and Zip

Lincoln
County

2691874263
Parcel Identification No. (PIN)

5b. Latitude and Longitude in degrees/minutes/seconds or decimal degrees:
(if well field, one lat/long is sufficient)

35.419216 N 81.359375 W

6. Is (are) the well(s): ☐**Permanent** or ☑**Temporary**

7. Is this a repair to an existing well: ☐**Yes** or ☑**No**
If this is a repair, fill out known well construction information and explain the nature of the repair under #21 remarks section or on the back of this form.

8. Number of wells constructed: 1
For multiple injection or non-water supply wells ***ONLY*** *with the* ***same construction****, you can submit one form.*

9. Total well depth below land surface: Screen 24.04, Sand 25.00 **(ft.)**
For multiple wells list all depths if different (example- 3@200' and 2@100')

10. Static water level below top of casing: 15.75 (24 hrs. after set) **(ft.)**
If water level is above casing, use "+"

11. Borehole diameter: 6 **(in.)**

12. Well construction method: mud rotary, rock core
(i.e. auger, rotary, cable, direct push, etc.)

FOR WATER SUPPLY WELLS ONLY:

13a. Yield (gpm) ____________ **Method of test:** ____________

13b. Disinfection type: ____________ **Amount:** ____________

14. WATER ZONES

FROM	TO	DESCRIPTION
12.75 ft.	47.00 ft.	Unconfined uppermost aquifer in soil
47.00 ft.	75.00 ft.	in slightly weathered and fractured rock

15. OUTER CASING (for multi-cased wells) OR LINER (if applicable)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
ft.	ft.	in.		

16. INNER CASING OR TUBING (geothermal closed-loop)

FROM	TO	DIAMETER	THICKNESS	MATERIAL
+3.00 ft.	9.04 ft.	2 in.	Sch 40	PVC flush thread
ft.	ft.	in.		

17. SCREEN

FROM	TO	DIAMETER	SLOT SIZE	THICKNESS	MATERIAL
9.04 ft.	24.04 ft.	2 in.	0.01"	Sch 40	PVC
ft.	ft.	in.	1/4" space		

18. GROUT

FROM	TO	MATERIAL	EMPLACEMENT METHOD & AMOUNT
0 ft.	3 ft.	Concrete	Gravity >260 lbs. solids
3,25 ft.	6,47 ft.	Bent. Grout	Tremie 10,60 lbs. solids
6,47 ft.	8,75 ft.	Bent. Chips	Tremie 28, 200 lbs. hydrated

19. SAND/GRAVEL PACK (if applicable)

FROM	TO	MATERIAL	EMPLACEMENT METHOD
8.0 ft.	25.0 ft.	#2 Silica Sand	Gravity
ft.	ft.		

20. DRILLING LOG (attach additional sheets if necessary)

FROM	TO	DESCRIPTION (color, hardness, soil/rock type, grain size, etc.)
0 ft.	43 ft.	SOIL; Silt residuum, soft
43 ft.	47 ft.	Highly weathered rock; White, wet
47 ft.	75 ft.	Rock; White, Very fractured, poor RQD
ft.	ft.	
ft.	ft.	
ft.	ft.	25'-75' abandoned beneath well
ft.	ft.	2'X2' concrete pad with locked steel case

21. REMARKS

Temporary observation well for hydrogeologic study
for future MSWLF Phase 4

22. Certification:

[signature] 3/30/15
Signature of Certified Well Contractor — Date

By signing this form, I hereby certify that the well(s) was (were) constructed in accordance with 15A NCAC 02C .0100 or 15A NCAC 02C .0200 Well Construction Standards and that a copy of this record has been provided to the well owner.

23. Site diagram or additional well details:
You may use the back of this page to provide additional well site details or well construction details. You may also attach additional pages if necessary.

SUBMITTAL INSTUCTIONS

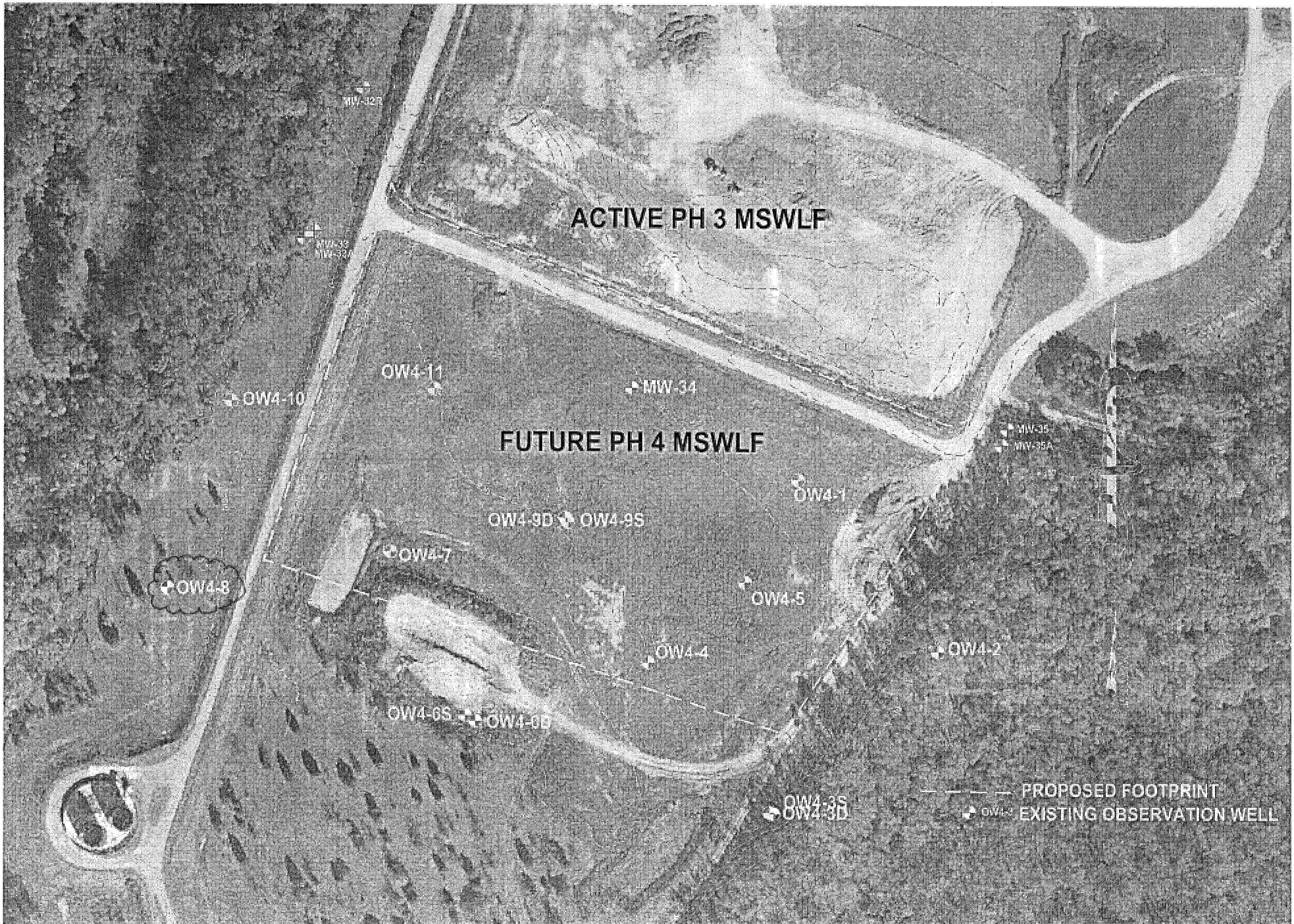
24a. For All Wells: Submit this form within 30 days of completion of well construction to the following:

Division of Water Resources, Information Processing Unit,
1617 Mail Service Center, Raleigh, NC 27699-1617

24b. For Injection Wells ONLY: In addition to sending the form to the address in 24a above, also submit a copy of this form within 30 days of completion of well construction to the following:

Division of Water Resources, Underground Injection Control Program,
1636 Mail Service Center, Raleigh, NC 27699-1636

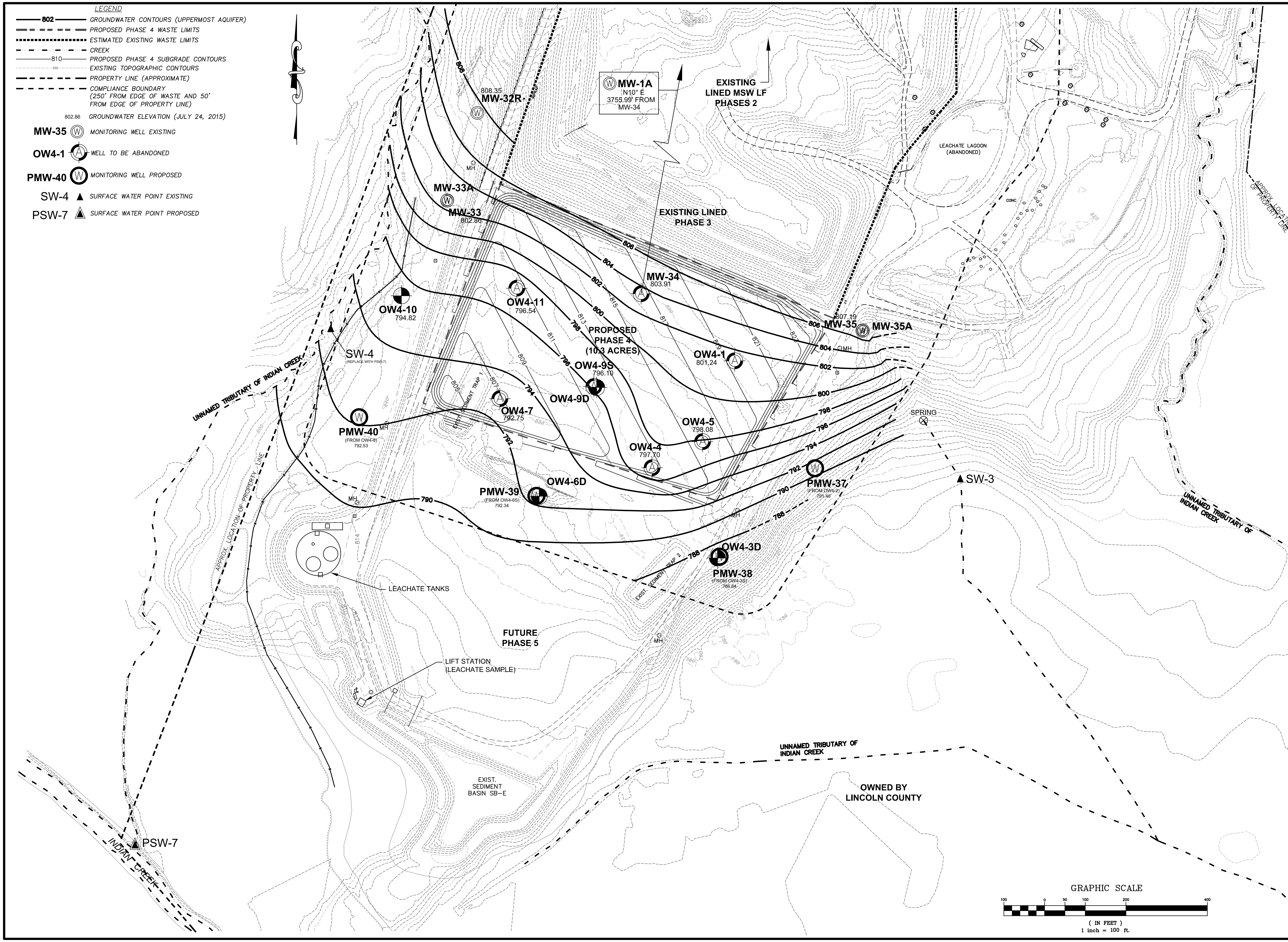
24c. For Water Supply & Injection Wells:
Also submit one copy of this form within 30 days of completion of well construction to the county health department of the county where constructed.



Lincoln Co. MSWLF
5291 Crouse Rd
Crouse NC 28033

N

Appendix B



Municipal Engineering Services Company, P.A.

P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LINCOLN COUNTY
CROUSE, NORTH CAROLINA

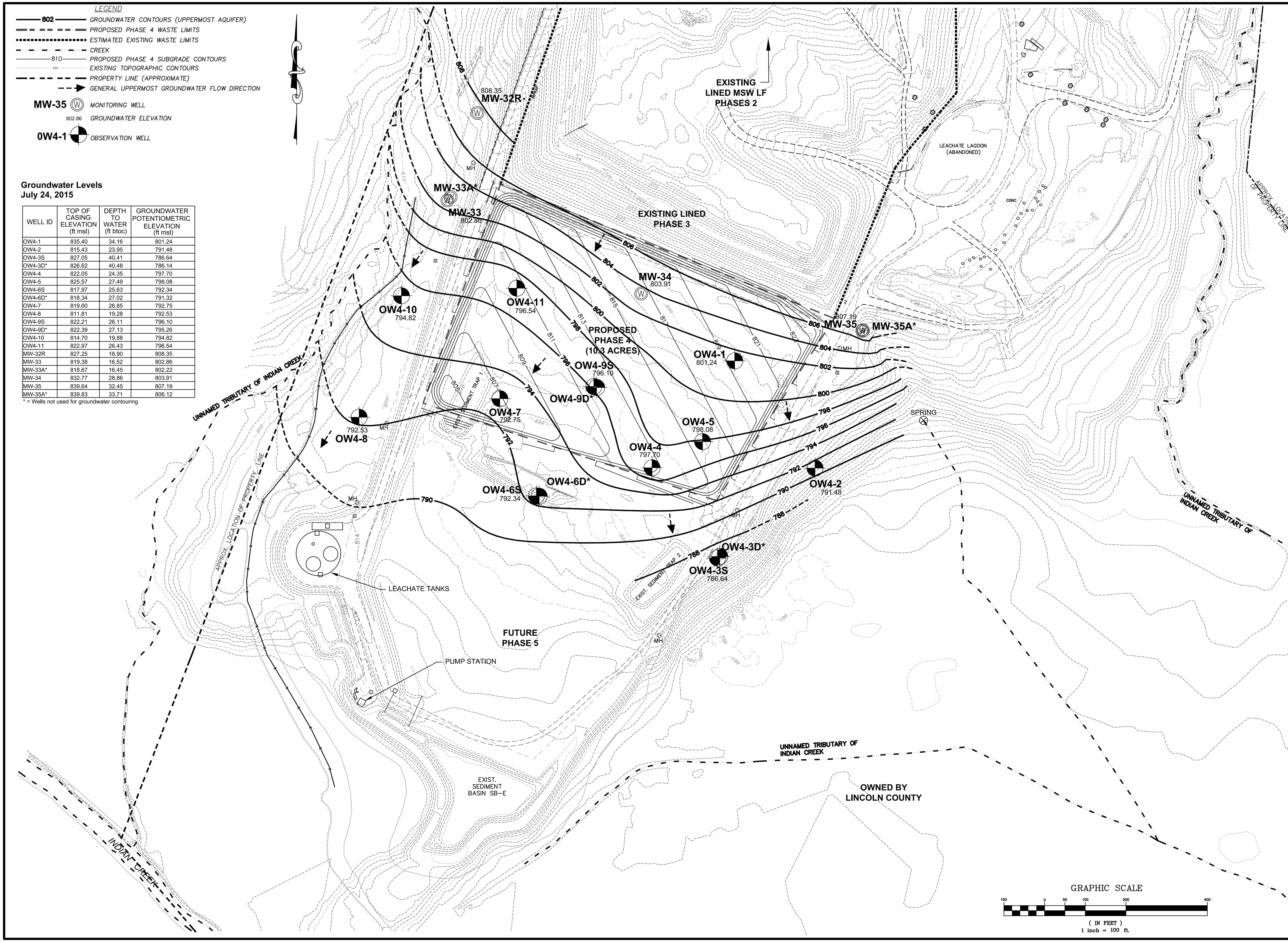
DATE	BY	REV.	DESCRIPTION
			WATER QUALITY MONITORING PLAN

SCALE: 1" = 100'
DATE: 10-13-2015
DRWN. BY: R.MOSS
CHKD. BY: S.GANDY
PROJECT NUMBER: G15041
DRAWING NO.
SHEET NO. 1

Groundwater Levels
July 24, 2015

WELL ID	TOP OF CASING ELEVATION (ft msl)	DEPTH TO WATER (ft btoc)	GROUNDWATER POTENTIOMETRIC ELEVATION (ft msl)
OW4-1	835.40	34.16	801.24
OW4-2	815.43	23.95	791.48
OW4-3S	827.05	40.41	786.64
OW4-3D*	826.62	40.48	786.14
OW4-4	822.05	24.35	797.70
OW4-5	825.57	27.49	798.08
OW4-6S	817.97	25.63	792.34
OW4-6D*	818.34	27.02	791.32
OW4-7	819.60	26.85	792.75
OW4-8	811.81	19.28	792.53
OW4-9S	822.21	26.11	796.10
OW4-9D*	822.39	27.13	795.26
OW4-10	814.70	19.88	794.82
OW4-11	822.97	26.43	796.54
MW-32R	827.25	18.90	808.35
MW-33	819.38	16.52	802.86
MW-33A*	818.67	16.45	802.22
MW-34	832.77	28.86	803.91
MW-35	839.64	32.45	807.19
MW-35A*	839.83	33.71	806.12

* = Wells not used for groundwater contouring



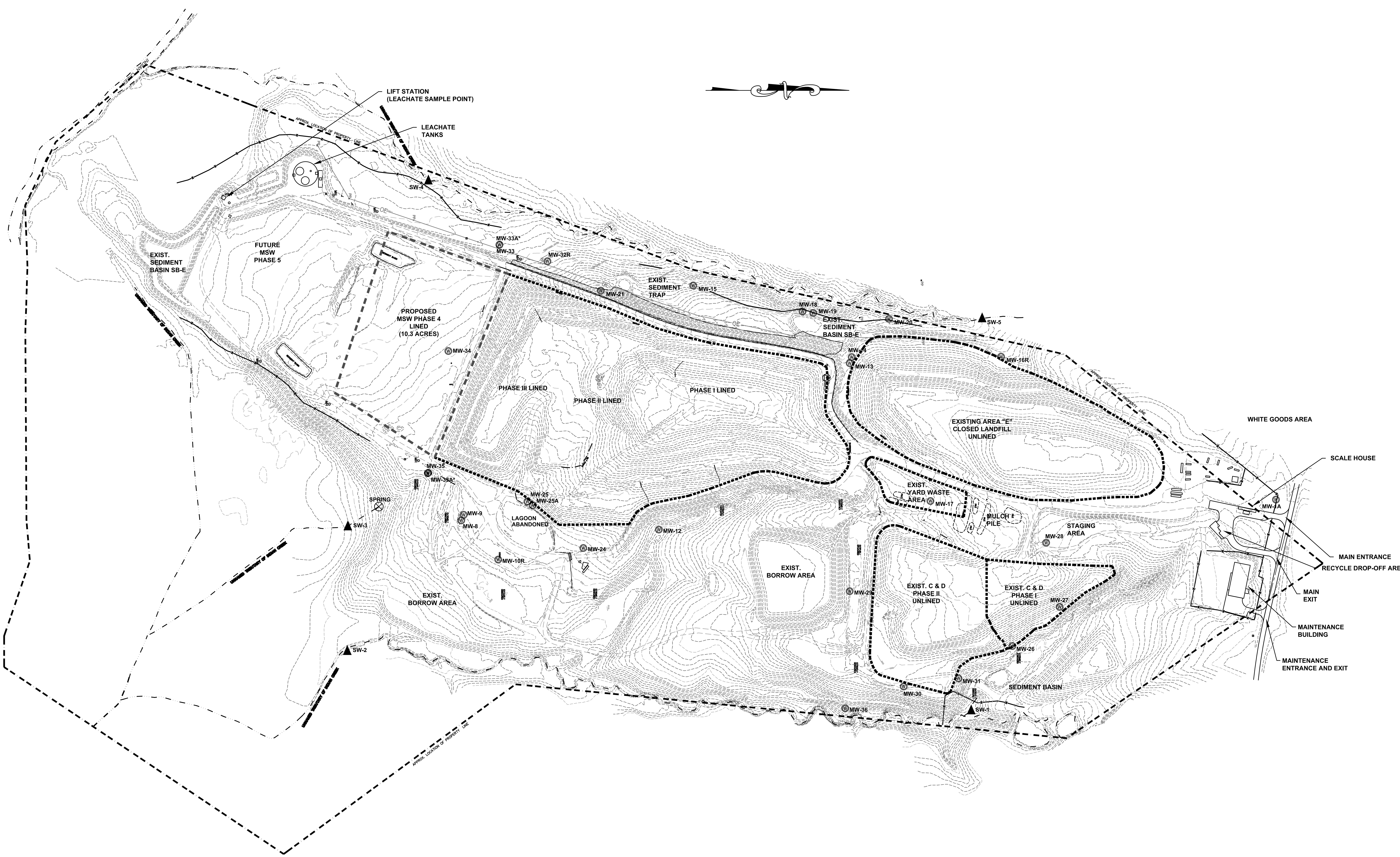
Municipal Engineering Services Company, P.A.
P.O. BOX 97 GARNER, N.C. 27529 (919) 772-5393
P.O. BOX 349 BOONE, N.C. 28607 (828) 262-1767
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LINCOLN COUNTY
CROUSE, NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

GROUNDWATER SURFACE
JULY 24, 2015

SCALE:	1" = 100'
DATE:	10-13-2015
DRWN. BY:	R.MOSS
CHKD. BY:	S.GANDY
PROJECT NUMBER	G15041
DRAWING NO.	SHEET NO. 2



TOPOGRAPHIC FEATURES DIGITIZED FROM A MAP PROVIDED BY THE COUNTY. TOPOGRAPHIC SURVEY WAS ORIGINALLY PERFORMED BY SPATIAL DATA CONSULTANTS, INC. DATED APRIL 7, 2010.

LEGEND

- PROPOSED PHASE 4 WASTE LIMITS
- ESTIMATED EXISTING WASTE LIMITS
- CREEK
- 250 EXISTING TOPOGRAPHIC CONTOURS
- PROPERTY LINE (APPROXIMATE)
- MW-35 (W) EXISTING MONITORING WELL
- SW-2 ▲ EXISTING SURFACE WATER SAMPLE POINT

Municipal Services
P.O. BOX 97 GARNER, N.C. 27529
(919) 772-5393

Engineering Company, P.A.
P.O. BOX 349 BOONE, N.C. 28607
(828) 262-1767
LICENSE NUMBER: C-0281

MUNICIPAL SOLID WASTE LANDFILL FACILITY
LINCOLN COUNTY
CROUSE, NORTH CAROLINA

DATE	BY	REV.	DESCRIPTION

EXISTING WATER QUALITY MONITORING LOCATIONS

SCALE: 1" = 200'
DATE: 10/8/2015
DRWN. BY: R.MOSS
CHKD. BY: S.GANDY
PROJECT NUMBER: G15041
DRAWING NO.
SHEET NO. 3

Appendix C

Solid Waste Section
Guidelines for Groundwater, Soil, and Surface Water Sampling

STATE OF NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
DIVISION OF WASTE MANAGEMENT
SOLID WASTE SECTION

General Sampling Procedures

The following guidance is provided to insure a consistent sampling approach so that sample collection activities at solid waste management facilities provide reliable data. Sampling must begin with an evaluation of facility information, historical environmental data and site geologic and hydrogeologic conditions. General sampling procedures are described in this document.

Planning

Begin sampling activities with planning and coordination. The party contracting with the laboratory is responsible for effectively communicating reporting requirements and evaluating data reliability as it relates to specific monitoring activities.

Sample Collection

Contamination Prevention

a.) Take special effort to prevent cross contamination or environmental contamination when collecting samples.
  1. If possible, collect samples from the least contaminated sampling location (or background sampling location, if applicable) to the most contaminated sampling location.
  2. Collect the ambient or background samples first, and store them in separate ice chests or separate shipping containers within the same ice chest (e.g. untreated plastic bags).
  3. Collect samples in flowing water at designated locations from upstream to downstream.

b.) Do not store or ship highly contaminated samples (concentrated wastes, free product, etc.) or samples suspect of containing high concentrations of contaminants in the same ice chest or shipping containers with other environmental samples.
  1. Isolate these sample containers by sealing them in separate, untreated plastic bags immediately after collecting, preserving, labeling, etc.
  2. Use a clean, untreated plastic bag to line the ice chest or shipping container.

c.) All sampling equipment should be thoroughly decontaminated and transported in a manner that does not allow it to become contaminated. Arrangements should be made ahead of time to decontaminate any sampling or measuring equipment that will be reused when taking samples from more than one well. Field decontamination of sampling equipment will be necessary before sampling each well to minimize the risk of cross contamination. Decontamination procedures should be included in reports as necessary. Certified pre-cleaned sampling equipment and containers may be used. When collecting aqueous samples, rinse the sample collection equipment with a portion of the sample water before taking the actual sample. Sample containers do not need to be rinsed. In the case of petroleum hydrocarbons, oil and grease, or containers with pre-measured preservatives, the sample containers cannot be rinsed.

d.) Place all fuel-powered equipment away from, and downwind of, any site activities (e.g., purging, sampling, decontamination).

1. If field conditions preclude such placement (i.e., the wind is from the upstream direction in a boat), place the fuel source(s) as far away as possible from the sampling activities and describe the conditions in the field notes.
2. Handle fuel (i.e., filling vehicles and equipment) prior to the sampling day. If such activities must be performed during sampling, the personnel must wear disposable gloves.
3. Dispense all fuels downwind. Dispose of gloves well away from the sampling activities.

Filling Out Sample Labels

Fill out label, adhere to vial and collect sample. Print legibly with indelible ink. At a minimum, the label or tag should identify the sample with the following information:

1. Sample location and/or well number
2. Sample identification number
3. Date and time of collection
4. Analysis required/requested
5. Sampler's initials
6. Preservative(s) used, if any [i.e., HCl, $Na_2S_2O_3$, NO_3, ice, etc.]
7. Any other pertinent information for sample identification

Sample Collection Order

Unless field conditions justify other sampling regimens, collect samples in the following order:

1. Volatile Organics and Volatile Inorganics
2. Extractable Organics, Petroleum Hydrocarbons, Aggregate Organics and Oil and Grease
3. Total Metals
4. Inorganic Nonmetallics, Physical and Aggregate Properties, and Biologicals
5. Microbiological

NOTE: *If the pump used to collect groundwater samples cannot be used to collect volatile or extractable organics then collect all other parameters and withdraw the pump and tubing. Then collect the volatile and extractable organics.*

Health and Safety

Implement all local, state, and federal requirements relating to health and safety. Follow all local, state and federal requirements pertaining to the storage and disposal of any hazardous or investigation derived wastes.

a.) The Solid Waste Section recommends wearing protective gloves when conducting all sampling activities.

1. Gloves serve to protect the sample collector from potential exposure to sample constituents, minimize accidental contamination of samples by the collector, and preserve accurate tare weights on preweighed sample containers.
2. Do not let gloves come into contact with the sample or with the interior or lip of the sample container. Use clean, new, unpowdered and disposable gloves. Various types of gloves may be used as long as the construction materials do not contaminate the sample or if internal safety protocols require greater protection.
3. Note that certain materials that may potentially be present in concentrated effluent can pass through certain glove types and be absorbed in the skin. Many vendor catalogs provide information about the permeability of different gloves and the circumstances under which the glove material might be applicable. The powder in powdered gloves can contribute significant contamination. Powdered gloves are not recommended unless it can be demonstrated that the powder does not interfere with the sample analysis.
4. Change gloves after preliminary activities, after collecting all the samples at a single sampling point, if torn or used to handle extremely dirty or highly contaminated surfaces. Properly dispose of all used gloves as investigation derived wastes.

b.) Properly manage all investigation derived waste (IDW).

5. To prevent contamination into previously uncontaminated areas, properly manage all IDW. This includes all water, soil, drilling mud, decontamination wastes, discarded personal protective equipment (PPE), etc. from site investigations, exploratory borings, piezometer and monitoring well installation, refurbishment, abandonment, and other investigative activities. Manage all IDW that is determined to be RCRA-regulated hazardous waste according to the local, state and federal requirements.
6. Properly dispose of IDW that is not a RCRA-regulated hazardous waste but is contaminated above the Department’s Soil Cleanup Target Levels or the state standards and/or minimum criteria for ground water quality. If the drill cuttings/mud orpurged well water is contaminated with hazardous waste, contact the DWM Hazardous Waste Section (919-508-8400) for disposal options. Maintain all containers holding IDW in good condition. Periodically inspect the containers for damage and ensure that all required labeling (DOT, RCRA, etc.) are clearly visible.

Sample Storage and Transport

Store samples for transport carefully. Pack samples to prevent from breaking and to maintain a temperature of approximately 4 degrees Celsius (°C), adding ice if necessary. Transport samples to a North Carolina-certified laboratory as soon as possible. Avoid unnecessary handling of sample containers. Avoid heating (room temperature or above, including exposure to sunlight) or freezing of the sample containers. Reduce the time between sample collection and delivery to a laboratory whenever possible and be sure that the analytical holding times of your samples can be met by the laboratory.

a.) A complete chain-of-custody (COC) form must be maintained to document all transfers and receipts of the samples. Be sure that the sample containers are labeled with the sample location and/or well number, sample identification, the date and time of collection, the analysis to be performed, the preservative added (if any), the sampler's initials, and any other pertinent information for sample identification. The labels should contain a unique identifier (i.e., unique well numbers) that can be traced to the COC form. The details of sample collection must be documented on the COC. The COC must include the following:
    1. Description of each sample (including QA/QC samples) and the number of containers (sample location and identification)
    2. Signature of the sampler
    3. Date and time of sample collection
    4. Analytical method to be performed
    5. Sample type (i.e., water or soil)
    6. Regulatory agency (i.e., NCDENR/DWM – SW Section)
    7. Signatures of all persons relinquishing and receiving custody of the samples
    8. Dates and times of custody transfers

b.) Pack samples so that they are segregated by site, sampling location or by sample analysis type. When COC samples are involved, segregate samples in coolers by site. If samples from multiple sites will fit in one cooler, they may be packed in the same cooler with the associated field sheets and a single COC form for all. Coolers should not exceed a maximum weight of 50 lbs. Use additional coolers as necessary. All sample containers should be placed in plastic bags (segregated by analysis and location) and completely surrounded by ice.
    1. Prepare and place trip blanks in an ice filled cooler before leaving for the field.
    2. Segregate samples by analysis and place in sealable plastic bags.
    3. Pack samples carefully in the cooler placing ice around the samples.
    4. Review the COC. The COC form must accompany the samples to the laboratory. The trip blank(s) must also be recorded on the COC form.
    5. Place completed COC form in a waterproof bag, sealed and taped under the lid of the cooler.
    6. Secure shipping containers with strapping tape to avoid accidental opening.
    7. For COC samples, a tamper-proof seal may also be placed over the cooler lid or over a bag or container containing the samples inside the shipping cooler.

8. "COC" or "EMERG" should be written in indelible ink on the cooler seal to alert sample receipt technicians to priority or special handling samples.
9. The date and sample handler's signature must also be written on the COC seal.
10. Deliver the samples to the laboratory or ship by commercial courier. **NOTE***: If transport time to the laboratory is not long enough to allow samples to be cooled to 4° C, a temperature reading of the sample source must be documented as the field temperature on the COC form. A downward trend in temperature will be adequate even if cooling to 4° C is not achieved. The field temperature should always be documented if there is any question as to whether samples will have time to cool to 4° C during shipment. Thermometers must be calibrated annually against an NIST traceable thermometer and documentation must be retained.*

Appendix A - Decontamination of Field Equipment

Decontamination of personnel, sampling equipment, and containers - before and after sampling - must be used to ensure collection of representative samples and to prevent the potential spread of contamination. Decontamination of personnel prevents ingestion and absorption of contaminants. It must be done with a soap and water wash and deionized or distilled water rinse. Certified pre-cleaned sampling equipment and containers may also be used.

All previously used sampling equipment must be properly decontaminated before sampling and between sampling locations. This prevents the introduction of contamination into uncontaminated samples and avoids cross-contamination of samples. Cross-contamination can be a significant problem when attempting to characterize extremely low concentrations of organic compounds or when working with soils that are highly contaminated.

Clean, solvent-resistant gloves and appropriate protective equipment must be worn by persons decontaminating tools and equipment.

Cleaning Reagents

Recommendations for the types and grades of various cleaning supplies are outlined below. The recommended reagent types or grades were selected to ensure that the cleaned equipment is free from any detectable contamination.

a.) Detergents: Use Liqui-Nox (or a non-phosphate equivalent) or Alconox (or equivalent). Liqui-Nox (or equivalent) is recommended by EPA, although Alconox (or equivalent) may be substituted if the sampling equipment will not be used to collect phosphorus or phosphorus containing compounds.

b.) Solvents: Use pesticide grade isopropanol as the rinse solvent in routine equipment cleaning procedures. This grade of alcohol must be purchased from a laboratory supply vendor. Rubbing alcohol or other commonly available sources of isopropanol **are not acceptable**. Other solvents, such as acetone or methanol, may be used as the final rinse solvent if they are pesticide grade. However, methanol is more toxic to the environment and acetone may be an analyte of interest for volatile organics.

1. **Do not** use acetone if volatile organics are of interest
2. Containerize all methanol wastes (including rinses) and dispose as a hazardous waste.

Pre-clean equipment that is heavily contaminated with organic analytes. Use reagent grade acetone and hexane or other suitable solvents. Use pesticide grade methylene chloride when cleaning sample containers. Store all solvents away from potential sources of contamination.

c.) Analyte-Free Water Sources: Analyte-free water is water in which all analytes of interest and all interferences are below method detection limits. Maintain documentation (such as results from equipment blanks) to demonstrate the reliability and purity of analyte-free water source(s). The source of the water must meet the requirements of the analytical method and must be free from the analytes of interest. In general, the following water types are associated with specific analyte groups:

1. *Milli-Q (or equivalent polished water)*: suitable for all analyses.

2. *Organic-free*: suitable for volatile and extractable organics.
3. *Deionized water*: may not be suitable for volatile and extractable organics.
4. *Distilled water*: not suitable for volatile and extractable organics, metals or ultratrace metals.

Use analyte-free water for blank preparation and the final decontamination water rinse. In order to minimize long-term storage and potential leaching problems, obtain or purchase analyte-free water just prior to the sampling event. If obtained from a source (such as a laboratory), fill the transport containers and use the contents for a single sampling event. Empty the transport container(s) at the end of the sampling event. Discard any analyte-free water that is transferred to a dispensing container (such as a wash bottle or pump sprayer) at the end of each sampling day.

d.) <u>Acids</u>:

1. *Reagent Grade Nitric Acid*: 10 - 15% (one volume concentrated nitric acid and five volumes deionized water). Use for the acid rinse unless nitrogen components (e.g., nitrate, nitrite, etc.) are to be sampled. If sampling for ultra-trace levels of metals, use an ultra-pure grade acid.
2. *Reagent Grade Hydrochloric Acid*: 10% hydrochloric acid (one volume concentrated hydrochloric and three volumes deionized water). Use when nitrogen components are to be sampled.
3. If samples for both metals and the nitrogen-containing components are collected with the equipment, use the hydrochloric acid rinse, or thoroughly rinse with hydrochloric acid after a nitric acid rinse. If sampling for ultra trace levels of metals, use an ultra-pure grade acid.
4. Freshly prepared acid solutions may be recycled during the sampling event or cleaning process. Dispose of any unused acids according to local ordinances.

Reagent Storage Containers

The contents of all containers must be clearly marked.

a.) <u>Detergents</u>:

1. Store in the original container or in a HDPE or PP container.

b.) <u>Solvents</u>:

1. Store solvents to be used for cleaning or decontamination in the original container until use in the field. If transferred to another container for field use, use either a glass or Teflon container.
2. Use dispensing containers constructed of glass, Teflon or stainless steel. Note: If stainless steel sprayers are used, any gaskets that contact the solvents must be constructed of inert materials.

c.) <u>Analyte-Free Water</u>:

1. Transport in containers appropriate for the type of water stored. If the water is commercially purchased (e.g., grocery store), use the original containers when transporting the water to the field. Containers made of glass, Teflon, polypropylene or HDPE are acceptable.
2. Use glass or Teflon to transport organic-free sources of water on-site. Polypropylene or HDPE may be used, but are not recommended.

3. Dispense water from containers made of glass, Teflon, HDPE or polypropylene.
4. Do not store water in transport containers for more than three days before beginning a sampling event.
5. If working on a project that has oversight from EPA Region 4, use glass containers for the transport and storage of all water.
6. Store and dispense acids using containers made of glass, Teflon or plastic.

General Requirements

a.) Prior to use, clean/decontaminate all sampling equipment (pumps, tubing, lanyards, split spoons, etc.) that will be exposed to the sample.

b.) Before installing, clean (or obtain as certified pre-cleaned) all equipment that is dedicated to a single sampling point and remains in contact with the sample medium (e.g., permanently installed groundwater pump). If you use certified pre-cleaned equipment no cleaning is necessary.
   1. Clean this equipment any time it is removed for maintenance or repair.
   2. Replace dedicated tubing if discolored or damaged.

c.) Clean all equipment in a designated area having a controlled environment (house, laboratory, or base of field operations) and transport it to the field, pre-cleaned and ready to use, unless otherwise justified.

d.) Rinse all equipment with water after use, even if it is to be field-cleaned for other sites. Rinse equipment used at contaminated sites or used to collect in-process (e.g., untreated or partially treated wastewater) samples immediately with water.

e.) Whenever possible, transport sufficient clean equipment to the field so that an entire sampling event can be conducted without the need for cleaning equipment in the field.

f.) Segregate equipment that is only used once (i.e., not cleaned in the field) from clean equipment and return to the in-house cleaning facility to be cleaned in a controlled environment.

g.) Protect decontaminated field equipment from environmental contamination by securely wrapping and sealing with one of the following:
   1. Aluminum foil (commercial grade is acceptable)
   2. Untreated butcher paper
   3. Clean, untreated, disposable plastic bags. Plastic bags may be used for all analyte groups except volatile and extractable organics. Plastic bags may be used for volatile and extractable organics, if the equipment is first wrapped in foil or butcher paper, or if the equipment is completely dry.

Cleaning Sample Collection Equipment

a.) <u>On-Site/In-Field Cleaning</u> – Cleaning equipment on-site is not recommended because environmental conditions cannot be controlled and wastes (solvents and acids) must be containerized for proper disposal.
   1. Ambient temperature water may be substituted in the hot, sudsy water bath and hot water rinses.

NOTE: Properly dispose of all solvents and acids.

2. Rinse all equipment with water after use, even if it is to be field-cleaned for other sites.
3. Immediately rinse equipment used at contaminated sites or used to collect in-process (e.g., untreated or partially treated wastewater) samples with water.

b.) Heavily Contaminated Equipment - In order to avoid contaminating other samples, isolate heavily contaminated equipment from other equipment and thoroughly decontaminate the equipment before further use. Equipment is considered heavily contaminated if it:

1. Has been used to collect samples from a source known to contain significantly higher levels than background.
2. Has been used to collect free product.
3. Has been used to collect industrial products (e.g., pesticides or solvents) or their byproducts.

NOTE: *Cleaning heavily contaminated equipment in the field is not recommended.*

c.) On-Site Procedures:

1. Protect all other equipment, personnel and samples from exposure by isolating the equipment immediately after use.
2. At a minimum, place the equipment in a tightly sealed, untreated, plastic bag.
3. Do not store or ship the contaminated equipment next to clean, decontaminated equipment, unused sample containers, or filled sample containers.
4. Transport the equipment back to the base of operations for thorough decontamination.
5. If cleaning must occur in the field, document the effectiveness of the procedure, collect and analyze blanks on the cleaned equipment.

d.) Cleaning Procedures:

1. If organic contamination cannot be readily removed with scrubbing and a detergent solution, pre-rinse equipment by thoroughly rinsing or soaking the equipment in acetone.
2. Use hexane only if preceded and followed by acetone.
3. In extreme cases, it may be necessary to steam clean the field equipment before proceeding with routine cleaning procedures.
4. After the solvent rinses (and/or steam cleaning), use the appropriate cleaning procedure. Scrub, rather than soak, all equipment with sudsy water. If high levels of metals are suspected and the equipment cannot be cleaned without acid rinsing, soak the equipment in the appropriate acid. Since stainless steel equipment should not be exposed to acid rinses, do not use stainless steel equipment when heavy metal contamination is suspected or present.
5. If the field equipment cannot be cleaned utilizing these procedures, discard unless further cleaning with stronger solvents and/or oxidizing solutions is effective as evidenced by visual observation and blanks.
6. Clearly mark or disable all discarded equipment to discourage use.

e.) General Cleaning - Follow these procedures when cleaning equipment under controlled conditions. Check manufacturer's instructions for cleaning restrictions and/or recommendations.

1. *Procedure for Teflon, stainless steel and glass sampling equipment*: This procedure must be used when sampling for ALL analyte groups. (Extractable organics, metals, nutrients, etc. or if a single decontamination protocol is desired to clean all Teflon, stainless steel and glass equipment.) Rinse equipment with hot tap water. Soak equipment in a hot, sudsy water solution (Liqui-Nox or equivalent). If necessary, use a brush to remove particulate matter or surface film. Rinse thoroughly with hot tap water. If samples for trace metals or inorganic analytes will be collected with the equipment that is not stainless steel, thoroughly rinse (wet all surfaces) with the appropriate acid solution. Rinse thoroughly with analyte-free water. Make sure that all equipment surfaces are thoroughly flushed with water. If samples for volatile or extractable organics will be collected, rinse with isopropanol. Wet equipment surfaces thoroughly with free-flowing solvent. Rinse thoroughly with analyte-free water. Allow to air dry. Wrap and seal as soon as the equipment has air-dried. If isopropanol is used, the equipment may be air-dried without the final analyte-free water rinse; however, the equipment must be completely dry before wrapping or use. Wrap clean sampling equipment according to the procedure described above.
2. *General Cleaning Procedure for Plastic Sampling Equipment*: Rinse equipment with hot tap water. Soak equipment in a hot, sudsy water solution (Liqui-Nox or equivalent). If necessary, use a brush to remove particulate matter or surface film. Rinse thoroughly with hot tap water. Thoroughly rinse (wet all surfaces) with the appropriate acid solution. Check manufacturer's instructions for cleaning restrictions and/or recommendations. Rinse thoroughly with analyte-free water. Be sure that all equipment surfaces are thoroughly flushed. Allow to air dry as long as possible. Wrap clean sampling equipment according to the procedure described above.

Appendix B - Collecting Soil Samples

Soil samples are collected for a variety of purposes. A methodical sampling approach must be used to assure that sample collection activities provide reliable data. Sampling must begin with an evaluation of background information, historical data and site conditions.

Soil Field Screening Procedures

Field screening is the use of portable devices capable of detecting petroleum contaminants on a real-time basis or by a rapid field analytical technique. Field screening should be used to help assess locations where contamination is most likely to be present.

When possible, field-screening samples should be collected directly from the excavation or from the excavation equipment's bucket. If field screening is conducted only from the equipment's bucket, then a minimum of one field screening sample should be collected from each 10 cubic yards of excavated soil. If instruments or other observations indicate contamination, soil should be separated into stockpiles based on apparent degrees of contamination. At a minimum, soil suspected of contamination must be segregated from soil observed to be free of contamination.

a.) Field screening devices – Many field screen instruments are available for detecting contaminants in the field on a rapid or real-time basis. Acceptable field screening instruments must be suitable for the contaminant being screened. The procdedure for field screening using photoionization detectors (PIDs) and flame ionization detectors (FIDs) is described below. If other instruments are used, a description of the instrument or method and its intended use must be provided to the Solid Waste Section. Whichever field screening method is chosen, its accuracy must be verified throughout the sampling process. Use appropriate standards that match the use intended for the data. Unless the Solid Waste Section indicates otherwise, wherever field screening is recommended in this document, instrumental or analytical methods of detection must be used, not olfactory or visual screening methods.

b.) Headspace analytical screening procedure for filed screening (semi-quantitative field screening) - The most commonly used field instruments for Solid Waste Section site assessments are FIDs and PIDs. When using FIDs and PIDs, use the following headspace screening procedure to obtain and analyze field-screening samples:

1. Partially fill (one-third to one-half) a clean jar or clean ziplock bag with the sample to be analyzed. The total capacity of the jar or bag may not be less than eight ounces (app. 250 ml), but the container should not be so large as to allow vapor diffusion and stratification effects to significantly affect the sample.
2. If the sample is collected from a spilt-spoon, it must be transferred to the jar or bag for headspace analysis immediately after opening the split-spoon. If the sample is collected from an excavation or soil pile, it must be collected from freshly uncovered soil.

3. If a jar is used, it must be quickly covered with clean aluminum foil or a jar lid; screw tops or thick rubber bands must be used to tightly seal the jar. If a zip lock bag is used, it must be quickly sealed shut.
4. Headspace vapors must be allowed to develop in the container for at least 10 minutes but no longer than one hour. Containers must be shaken or agitated for 15 seconds at the beginning and the end of the headspace development period to assist volatilization. Temperatures of the headspace must be warmed to at least 5° C (approximately 40° F) with instruments calibrated for the temperature used.
5. After headspace development, the instrument sampling probe must be inserted to a point about one-half the headspace depth. The container opening must be minimized and care must be taken to avoid the uptake of water droplets and soil particulates.
6. After probe insertion, the highest meter reading must be taken and recorded. This will normally occur between two and five seconds after probe insertion. If erratic meter response occurs at high organic vapor concentrations or conditions of elevated headspace moisture, a note to that effect must accompany the headspace data.
7. All field screening results must be documented in the field record or log book.

Soil Sample Collection Procedures for Laboratory Samples

The number and type of laboratory samples collected depends on the purpose of the sampling activity. Samples analyzed with field screening devices may not be substituted for required laboratory samples.

a.) General Sample Collection - When collecting samples from potentially contaminated soil, care should be taken to reduce contact with skin or other parts of the body. Disposable gloves should be worn by the sample collector and should be changed between samples to avoid cross-contamination. Soil samples should be collected in a manner that causes the least disturbance to the internal structure of the sample and reduces its exposure to heat, sunlight and open air. Likewise, care should be taken to keep the samples from being contaminated by other materials or other samples collected at the site. When sampling is to occur over an extended period of time, it is necessary to insure that the samples are collected in a comparable manner. All samples must be collected with disposable or clean tools that have been decontaminated. Disposable gloves must be worn and changed between sample collections. Sample containers must be filled quickly. Soil samples must be placed in containers in the order of volatility, for example, volatile organic aromatic samples must be taken first, organics next, then heavier range organics, and finally soil classification samples. Containers must be quickly and adequately sealed, and rims must be cleaned before tightening lids. Tape may be used only if known not to affect sample analysis. Sample containers must be clearly labeled. Containers must immediately be preserved according to procedures in this Section. Unless specified otherwise, at a minimum, the samples must be immediately cooled to 4 ± 2°C and this temperature must be maintained throughout delivery to the laboratory.

b.) Surface Soil Sampling - Surface soil is generally classified as soil between the ground surface and 6-12 inches below ground surface. Remove leaves, grass and surface debris from the area to be sampled. Select an appropriate, pre-cleaned sampling device and collect the sample. Transfer the sample to the appropriate sample container. Clean the outside of the sample container to remove excess soil. Label the sample container, place on wet ice to preserve at 4°C, and complete the field notes.

c.) Subsurface Soil Sampling – The interval begins at approximately 12 inches below ground surface. Collect samples for volatile organic analyses. For other analyses, select an appropriate, pre-cleaned sampling device and collect the sample. Transfer the sample to the appropriate sample container. Clean the outside of the sample container to remove excess soil. Label the sample container, place on wet ice to preserve at 4°C, and complete field notes.

d.) Equipment for Reaching the Appropriate Soil Sampling Depth - Samples may be collected using a hollow stem soil auger, direct push, Shelby tube, split-spoon sampler, or core barrel. These sampling devices may be used as long as an effort is made to reduce the loss of contaminants through volatilization. In these situations, obtain a sufficient volume of so the samples can be collected without volatilization and disturbance to the internal structure of the samples. Samples should be collected from cores of the soil. Non-disposable sampling equipment must be decontaminated between each sample location. **NOTE:** *If a confining layer has been breached during sampling, grout the hole to land.*

e.) Equipment to Collect Soil Samples - Equipment and materials that may be used to collect soil samples include disposable plastic syringes and other “industry-standard” equipment and materials that are contaminant-free. Non-disposable sampling equipment must be decontaminated between each sample location.

Appendix C - Collecting Groundwater Samples

Groundwater samples are collected to identify, investigate, assess and monitor the concentration of dissolved contaminant constituents. To properly assess groundwater contamination, first install sampling points (monitoring wells, etc.) to collect groundwater samples and then perform specific laboratory analyses. All monitoring wells should be constructed in accordance with 15A NCAC 2C .0100 and sampled as outlined in this section. Groundwater monitoring is conducted using one of two methods:

1. Portable Monitoring: Monitoring that is conducted using sampling equipment that is discarded between sampling locations. Equipment used to collect a groundwater sample from a well such as bailers, tubing, gloves, and etc. are disposed of after sample collection. A new set of sampling equipment is used to collect a groundwater sample at the next monitor well.

2. Dedicated Monitoring: Monitoring that utilizes permanently affixed down-well and well head components that are capped after initial set-up. Most dedicated monitoring systems are comprised of an in-well submersible bladder pump, with air supply and sample discharge tubing, and an above-ground driver/controller for regulation of flow rates and volumes. The pump and all tubing housed within the well should be composed of Teflon or stainless steel components. This includes seals inside the pump, the pump body, and fittings used to connect tubing to the pump. Because ground water will not be in contact with incompatible constituents and because the well is sealed from the surface, virtually no contamination is possible from intrinsic sources during sampling and between sampling intervals. All dedicated monitoring systems must be approved by the Solid Waste Section before installation.

Groundwater samples may be collected from a number of different configurations. Each configuration is associated with a unique set of sampling equipment requirements and techniques:

1. Wells without Plumbing: These wells require equipment to be brought to the well to purge and sample unless dedicated equipment is placed in the well.

2. Wells with In-Place Plumbing: Wells with in-place plumbing do not require equipment to be brought to the well to purge and sample. In-place plumbing is generally considered permanent equipment routinely used for purposes other than purging and sampling, such as for water supply.

3. Air Strippers or Remedial Systems: These types of systems are installed as remediation devices.

Groundwater Sample Preparation

The type of sample containers used depends on the type of analysis performed. First, determine the type(s) of contaminants expected and the proper analytical method(s). Be sure to consult your selected laboratory for its specific needs and requirements prior to sampling.

Next, prepare the storage and transport containers (ice chest, etc.) before taking any samples so that each sample can be placed in a chilled environment immediately after collection.

Use groundwater purging and sampling equipment constructed of only non-reactive, non-leachable materials that are compatible with the environment and the selected analytes. In selecting groundwater purging and sampling equipment, give consideration to the depth of the well, the depth to groundwater, the volume of water to be evacuated, the sampling and purging technique, and the analytes of interest. Additional supplies, such as reagents and preservatives, may be necessary.

All sampling equipment (bailers, tubing, containers, etc.) must be selected based on its chemical compatibility with the source being sampled (e.g., water supply well, monitoring well) and the contaminants potentially present.

a.) Pumps - All pumps or pump tubing must be lowered and retrieved from the well slowly and carefully to minimize disturbance to the formation water. This is especially critical at the air/water interface.

1. *Above-Ground Pumps*
    - Variable Speed Peristaltic Pump: Use a variable speed peristaltic pump to purge groundwater from wells when the static water level in the well is no greater than 20- 25 feet below land surface (BLS). If the water levels are deeper than 18-20 feet BLS, the pumping velocity will decrease. A variable speed peristaltic pump can be used for normal purging and sampling, and sampling low permeability aquifers or formations. Most analyte groups can be sampled with a peristaltic pump if the tubing and pump configurations are appropriate.
    - Variable Speed Centrifugal Pump: A variable speed centrifugal pump can be used to purge groundwater from 2-inch and larger internal diameter wells. **Do not use** this type of pump to collect groundwater samples. When purging is complete, do not allow the water that remains in the tubing to fall back into the well. Install a check valve at the end of the purge tubing.
2. *Submersible Pumps*
    - Variable Speed Electric Submersible Pump: A variable speed submersible pump can be used to purge and sample groundwater from 2-inch and larger internal diameter wells. A variable speed submersible pump can be used for normal purging and sampling, and sampling low permeability aquifers or formations. The pump housing, fittings, check valves and associated hardware must be constructed of stainless steel. All other materials must be

compatible with the analytes of interest. Install a check valve at the output side of the pump to prevent backflow. If purging **and** sampling for organics, the entire length of the delivery tube must be Teflon, polyethylene or polypropylene (PP) tubing; the electrical cord must be sealed in Teflon, polyethylene or PP and any cabling must be sealed in Teflon, polyethylene or PP, or be constructed of stainless steel; and all interior components that contact the sample water (impeller, seals, gaskets, etc.) must be constructed of stainless steel or Teflon.

3. *Variable Speed Bladder Pump*: A variable speed, positive displacement, bladder pump can be used to purge and sample groundwater from 3/4-inch and larger internal diameter wells.
    - A variable speed bladder pump can be used for normal purging and sampling, and sampling low permeability aquifers or formations.
    - The bladder pump system is composed of the pump, the compressed air tubing, the water discharge tubing, the controller and a compressor, or a compressed gas supply.
    - The pump consists of a bladder and an exterior casing or pump body that surrounds the bladder and two (2) check valves. These parts can be composed of various materials, usually combinations of polyvinyl chloride (PVC), Teflon, polyethylene, PP and stainless steel. Other materials must be compatible with the analytes of interest.
    - If purging and sampling for organics, the pump body must be constructed of stainless steel. The valves and bladder must be Teflon, polyethylene or PP; the entire length of the delivery tube must be Teflon, polyethylene or PP; and any cabling must be sealed in Teflon, polyethylene or PP, or be constructed of stainless steel.
    - Permanently installed pumps may have a PVC pump body as long as the pump remains in contact with the water in the well.

b.) <u>Bailers</u>

1. *Purging*: Bailers must be used with caution because improper bailing can cause changes in the chemistry of the water due to aeration and loosening particulate matter in the space around the well screen. Use a bailer if there is non-aqueous phase liquid (free product) in the well or if non-aqueous phase liquid is suspected to be in the well.
2. *Sampling*: Bailers must be used with caution.
3. *Construction and Type*: Bailers must be constructed of materials compatible with the analytes of interest. Stainless steel, Teflon, rigid medical grade PVC, polyethylene and PP bailers may be used to sample all analytes. Use disposable bailers when sampling grossly contaminated sample sources. NCDENR recommends using dual check valve bailers when collecting samples. Use bailers with a controlled flow bottom to collect volatile organic samples.

4. *Contamination Prevention*: Keep the bailer wrapped (foil, butcher paper, etc.) until just before use. Use protective gloves to handle the bailer once it is removed from its wrapping. Handle the bailer by the lanyard to minimize contact with the bailer surface.

c.) Lanyards

1. Lanyards must be made of non-reactive, non-leachable material. They may be cotton twine, nylon, stainless steel, or may be coated with Teflon, polyethylene or PP.
2. Discard cotton twine, nylon, and non-stainless steel braided lanyards after sampling each monitoring well.
3. Decontaminate stainless steel, coated Teflon, polyethylene and PP lanyards between monitoring wells. They do not need to be decontaminated between purging and sampling operations.

Water Level and Purge Volume Determination

The amount of water that must be purged from a well is determined by the volume of water and/or field parameter stabilization.

a.) General Equipment Considerations - Selection of appropriate purging equipment depends on the analytes of interest, the well diameter, transmissivity of the aquifer, the depth to groundwater, and other site conditions.

1. Use of a pump to purge the well is recommended unless no other equipment can be used or there is non-aqueous phase liquid in the well, or non-aqueous phase liquid is suspected to be in the well.
2. Bailers must be used with caution because improper bailing:
    - Introduces atmospheric oxygen, which may precipitate metals (i.e., iron) or cause other changes in the chemistry of the water in the sample (i.e., pH).
    - Agitates groundwater, which may bias volatile and semi-volatile organic analyses due to volatilization.
    - Agitates the water in the aquifer and resuspends fine particulate matter.
    - Surges the well, loosening particulate matter in the annular space around the well screen.
    - May introduce dirt into the water column if the sides of the casing wall are scraped.

NOTE: *It is critical for bailers to be slowly and gently immersed into the top of the water column, particularly during the final stages of purging. This minimizes turbidity and disturbance of volatile organic constituents.*

b.) Initial Inspection

1. Remove the well cover and remove all standing water around the top of the well casing (manhole) before opening the well.
2. Inspect the exterior protective casing of the monitoring well for damage. Document the results of the inspection if there is a problem.
3. It is recommended that you place a protective covering around the well head. Replace the covering if it becomes soiled or ripped.

4. Inspect the well lock and determine whether the cap fits tightly. Replace the cap if necessary.

c.) Water Level Measurements - Use an electronic probe or chalked tape to determine the water level. Decontaminate all equipment before use. Measure the depth to groundwater from the top of the well casing to the nearest 0.01 foot. Always measure from the same reference point or survey mark on the well casing. Record the measurement.

1. *Electronic Probe*: Decontaminate all equipment before use. Follow the manufacturer's instructions for use. Record the measurement.
2. *Chalked Line Method*: Decontaminate all equipment before use. Lower chalked tape into the well until the lower end is in the water. This is usually determined by the sound of the weight hitting the water. Record the length of the tape relative to the reference point. Remove the tape and note the length of the wetted portion. Record the length. Determine the depth to water by subtracting the length of the wetted portion from the total length. Record the result.

d.) Water Column Determination - To determine the length of the water column, subtract the depth to the top of the water column from the total well depth (or gauged well depth if silting has occurred). The total well depth depends on the well construction. If gauged well depth is used due to silting, report total well depth also. Some wells may be drilled in areas of sinkhole, karst formations or rock leaving an open borehole. Attempt to find the total borehole depth in cases where there is an open borehole below the cased portion.

e.) Well Water Volume - Calculate the total volume of water, in gallons, in the well using the following equation:

$$V = (0.041)d \times d \times h$$

Where:

V = volume in gallons
d = well diameter in inches
h = height of the water column in feet

The total volume of water in the well may also be determined with the following equation by using a casing volume per foot factor (Gallons per Foot of Water) for the appropriate diameter well:

$$V = [\text{Gallons per Foot of Water}] \times h$$

Where:

V = volume in gallons
h = height of the water column in feet

Record all measurements and calculations in the field records.

f.) Purging Equipment Volume - Calculate the total volume of the pump, associated tubing and flow cell (if used), using the following equation:

$$V = p + ((0.041)d \times d \times l) + fc$$

Where:

V = volume in gallons
p = volume of pump in gallons
d = tubing diameter in inches
l = length of tubing in feet

fc = volume of flow cell in gallons

g.) If the groundwater elevation data are to be used to construct groundwater elevation contour maps, all water level measurements must be taken within the same 24 hour time interval when collecting samples from multiple wells on a site, unless a shorter time period is required. If the site is tidally influenced, complete the water level measurements within the time frame of an incoming or outgoing tide.

Well Purging Techniques

The selection of the purging technique and equipment is dependent on the hydrogeologic properties of the aquifer, especially depth to groundwater and hydraulic conductivity.

a.) Measuring the Purge Volume - The volume of water that is removed during purging must be recorded. Therefore, you must measure the volume during the purging operation.

1. Collect the water in a graduated container and multiply the number of times the container was emptied by the volume of the container, OR
2. Estimate the volume based on pumping rate. This technique may be used only if the pumping rate is constant. Determine the pumping rate by measuring the amount of water that is pumped for a fixed period of time, or use a flow meter.
    - Calculate the amount of water that is discharged per minute: D = Measured Amount/Total Time In Minutes
    - Calculate the time needed to purge one (1) well volume or one (1) purging equipment volume: Time = V/D
      Where: V = well volume or purging equipment volume
      D = discharge rate
    - Make new measurements each time the pumping rate is changed.
3. Use a totalizing flow meter.
    - Record the reading on the totalizer prior to purging.
    - Record the reading on the totalizer at the end of purging.
    - To obtain the volume purged, subtract the reading on the totalizer prior to purging from the reading on the totalizer at the end of purging.
    - Record the times that purging begins and ends in the field records.

b.) Purging Measurement Frequency - When purging a well that has the well screen fully submerged and the pump or intake tubing is placed within the well casing above the well screen or open hole, purge a minimum of one (1) well volume prior to collecting measurements of the field parameters. Allow at least one quarter (1/4) well volume to purge between subsequent measurements. When purging a well that has the pump or intake tubing placed within a fully submerged well screen or open hole, purge until the water level has stabilized (well recovery rate equals the purge rate), then purge a minimum of one (1) volume of the pump, associated tubing and flow cell (if used) prior to collecting measurements of the field parameters. Take measurements of the field parameters no sooner than two (2) to three (3) minutes apart. Purge at least three (3) volumes of the pump, associated tubing and flow cell, if used, prior to collecting a sample. When purging a well that has a partially submerged well screen, purge a minimum of one (1) well volume prior to collecting measurements of the field parameters. Take measurements of the field parameters no sooner than two (2) to three (3) minutes apart.

c.) Purging Completion - Wells must be adequately purged prior to sample collection to ensure representation of the aquifer formation water, rather than stagnant well water. This may be achieved by purging three volumes from the well or by satisfying any one of the following three purge completion criteria:

1.) Three (3) consecutive measurements in which the three (3) parameters listed below are within the stated limits, dissolved oxygen is no greater than 20 percent of saturation at the field measured temperature, and turbidity is no greater than 20 Nephelometric Turbidity Units (NTUs).

- Temperature: + 0.2° C
- pH: + 0.2 Standard Units
- Specific Conductance: + 5.0% of reading

Document and report the following, as applicable. The last four items only need to be submitted once:

- Purging rate.
- Drawdown in the well, if any.
- A description of the process and the data used to design the well.
- The equipment and procedure used to install the well.
- The well development procedure.
- Pertinent lithologic or hydrogeologic information.

2.) If it is impossible to get dissolved oxygen at or below 20 percent of saturation at the field measured temperature or turbidity at or below 20 NTUs, then three (3) consecutive measurements of temperature, pH, specific conductance and the parameter(s) dissolved oxygen and/or turbidity that do not meet the requirements above must be within the limits below. The measurements are:

- Temperature: + 0.2° C
- pH: + 0.2 Standard Units
- Specific Conductance: + 5.0% of reading
- Dissolved Oxygen: + 0.2 mg/L or 10%, whichever is greater
- Turbidity: + 5 NTUs or 10%, whichever is greater

Additionally, document and report the following, as applicable, except that the last four(4) items only need to be submitted once:

- Purging rate.
- Drawdown in the well, if any.
- A description of conditions at the site that may cause the dissolved oxygen to be high and/or dissolved oxygen measurements made within the screened or open hole portion of the well with a downhole dissolved oxygen probe.

- A description of conditions at the site that may cause the turbidity to be high and any procedures that will be used to minimize turbidity in the future.
- A description of the process and the data used to design the well.
- The equipment and procedure used to install the well.
- The well development procedure.
- Pertinent lithologic or hydrogeologic information.

3.) If after five (5) well volumes, three (3) consecutive measurements of the field parameters temperature, pH, specific conductance, dissolved oxygen, and turbidity are not within the limits stated above, check the instrument condition and calibration, purging flow rate and all tubing connections to determine if they might be affecting the ability to achieve stable measurements. It is at the discretion of the consultant/contractor whether or not to collect a sample or to continue purging. Further, the report in which the data are submitted must include the following, as applicable. The last four (4) items only need to be submitted once.

- Purging rate.
- Drawdown in the well, if any.
- A description of conditions at the site that may cause the Dissolved Oxygen to be high and/or Dissolved Oxygen measurements made within the screened or open hole portion of the well with a downhole dissolved oxygen probe.
- A description of conditions at the site that may cause the turbidity to be high and any procedures that will be used to minimize turbidity in the future.
- A description of the process and the data used to design the well.
- The equipment and procedure used to install the well.
- The well development procedure.
- Pertinent lithologic or hydrogeologic information.

If wells have previously and consistently purged dry, and the current depth to groundwater indicates that the well will purge dry during the current sampling event, minimize the amount of water removed from the well by using the same pump to purge and collect the sample:

- Place the pump or tubing intake within the well screened interval.
- Use very small diameter Teflon, polyethylene or PP tubing and the smallest possible pump chamber volume. This will minimize the total volume of water pumped from the well and reduce drawdown.
- Select tubing that is thick enough to minimize oxygen transfer through the tubing walls while pumping.

- Pump at the lowest possible rate (100 mL/minute or less) to reduce drawdown to a minimum.
- Purge at least two (2) volumes of the pumping system (pump, tubing and flow cell, if used).
- Measure pH, specific conductance, temperature, dissolved oxygen and turbidity, then begin to collect the samples.

Collect samples immediately after purging is complete. The time period between completing the purge and sampling cannot exceed six hours. If sample collection does not occur within one hour of purging completion, re-measure the five field parameters: temperature, pH, specific conductance, dissolved oxygen and turbidity, just prior to collecting the sample. If the measured values are not within 10 percent of the previous measurements, re-purge the well. The exception is "dry" wells.

d.) <u>Lanyards</u>

1. Securely fasten lanyards, if used, to any downhole equipment (bailers, pumps, etc.).
2. Use bailer lanyards in such a way that they do not touch the ground surface.

Wells Without Plumbing

a.) <u>Tubing/Pump Placement</u>

1. If attempting to minimize the volume of purge water, position the intake hose or pump at the midpoint of the screened or open hole interval.
2. If monitoring well conditions do not allow minimizing of the purge water volume, position the pump or intake hose near the top of the water column. This will ensure that all stagnant water in the casing is removed.
3. If the well screen or borehole is partially submerged, and the pump will be used for both purging and sampling, position the pump midway between the measured water level and the bottom of the screen. Otherwise, position the pump or intake hose near the top of the water column.

b.) <u>Non-dedicated (portable) pumps</u>

1. *Variable Speed Peristaltic Pump*
    - Wear sampling gloves to position the decontaminated pump and tubing.
    - Attach a short section of tubing to the discharge side of the pump and into a graduated container.
    - Attach one end of a length of new or precleaned tubing to the pump head flexible hose.
    - Place the tubing as described in one of the options listed above.
    - Change gloves before beginning to purge.
    - Measure the depth to groundwater at frequent intervals.
    - Record these measurements.
    - Adjust the purging rate so that it is equivalent to the well recovery rate to minimize drawdown.

- If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
- If the water table continues to drop during pumping, lower the tubing at the approximate rate of drawdown so that water is removed from the top of the water column.
- Record the purging rate each time the rate changes.
- Measure the purge volume.
- Record this measurement.
- Decontaminate the pump and tubing between wells (see Appendix C) or if precleaned tubing is used for each well, only the pump.

2. *Variable Speed Centrifugal Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves to position the decontaminated pump and tubing.
    - Place the decontaminated suction hose so that water is always pumped from the top of the water column.
    - Change gloves before beginning to purge.
    - Equip the suction hose with a foot valve to prevent purge water from re-entering the well.
    - Measure the depth to groundwater at frequent intervals.
    - Record these measurements.
    - To minimize drawdown, adjust the purging rate so that it is equivalent to the well recovery rate.
    - If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
    - If the water table continues to drop during pumping, lower the tubing at the approximate rate of drawdown so that the water is removed from the top of the water column.
    - Record the purging rate each time the rate changes.
    - Measure the purge volume.
    - Record this measurement.
    - Decontaminate the pump and tubing between wells or if precleaned tubing is used for each well, only the pump.
3. *Variable Speed Electric Submersible Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves to position the decontaminated pump and tubing.
    - Carefully position the decontaminated pump.

- Change gloves before beginning to purge.
- Measure the depth to groundwater at frequent intervals.
- Record these measurements.
- To minimize drawdown, adjust the purging rate so that it is equivalent to the well recovery rate.
- If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
- If the water table continues to drop during pumping, lower the tubing or pump at the approximate rate of drawdown so that water is removed from the top of the water column.
- Record the purging rate each time the rate changes.
- Measure the purge volume.
- Record this measurement.
- Decontaminate the pump and tubing between wells or only the pump if precleaned tubing is used for each well.

4. *Variable Speed Bladder Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves to position the decontaminated pump and tubing.
    - Attach the tubing and carefully position the pump.
    - Change gloves before beginning purging.
    - Measure the depth to groundwater at frequent intervals.
    - Record these measurements.
    - To minimize drawdown, adjust the purging rate so that it is equivalent to the well recovery rate.
    - If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdrawal rate with the recharge rate.
    - If the water table continues to drop during pumping, lower the tubing or pump at the approximate rate of drawdown so that water is removed from the top of the water column.
    - Record the purging rate each time the rate changes.
    - Measure the purge volume.
    - Record this measurement.
    - Decontaminate the pump and tubing between wells or if precleaned tubing is used for each well, only the pump.

c.) <u>Dedicated Portable Pumps</u>

1. *Variable Speed Electric Submersible Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves.

- Measure the depth to groundwater at frequent intervals.
- Record these measurements.
- Adjust the purging rate so that it is equivalent to the well recovery rate to minimize drawdown.
- If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdraw with the recharge rate.
- Record the purging rate each time the rate changes.
- Measure the purge volume.
- Record this measurement.

2. *Variable Speed Bladder Pump*
    - Position fuel powered equipment downwind and at least 10 feet from the well head. Make sure that the exhaust faces downwind.
    - Wear sampling gloves.
    - Measure the depth to groundwater at frequent intervals.
    - Record these measurements.
    - Adjust the purging rate so that it is equivalent to the well recovery rate to minimize drawdown.
    - If the purging rate exceeds the well recovery rate, reduce the pumping rate to balance the withdraw with the recharge rate.
    - Record the purging rate each time the rate changes.
    - Measure the purge volume.
    - Record this measurement.
3. *Bailers* - Using bailers for purging is not recommended unless care is taken to use proper bailing technique, or if free product is present in the well or suspected to be in the well.
    - Minimize handling the bailer as much as possible.
    - Wear sampling gloves.
    - Remove the bailer from its protective wrapping just before use.
    - Attach a lanyard of appropriate material.
    - Use the lanyard to move and position the bailer.
    - Lower and retrieve the bailer slowly and smoothly.
    - Lower the bailer carefully into the well to a depth approximately a foot above the water column.
    - When the bailer is in position, lower the bailer into the water column at a rate of 2 cm/sec until the desired depth is reached.
    - Do not lower the top of the bailer more than one (1) foot below the top of the water table so that water is removed from the top of the water column.
    - Allow time for the bailer to fill with aquifer water as it descends into the water column.

- Carefully raise the bailer. Retrieve the bailer at the same rate of 2 cm/sec until the bottom of the bailer has cleared to top of the water column.
- Measure the purge volume.
- Record the volume of the bailer.
- Continue to carefully lower and retrieve the bailer as described above until the purging is considered complete, based on either the removal of 3 well volumes.
- Remove at least one (1) well volume before collecting measurements of the field parameters. Take each subsequent set of measurements after removing at least one quarter (1/4) well volume between measurements.

Groundwater Sampling Techniques

a.) Purge wells.

b.) Replace protective covering around the well if it is soiled or torn after completing purging operations.

c.) Equipment Considerations

1. The following pumps are approved to collect volatile organic samples:
    - Stainless steel and Teflon variable speed submersible pumps
    - Stainless steel and Teflon or polyethylene variable speed bladder pumps
    - Permanently installed PVC bodied pumps (As long as the pump remains in contact with the water in the well at all times)
2. Collect sample from the sampling device and store in sample container. Do not use intermediate containers.
3. To avoid contamination or loss of analytes from the sample, handle sampling equipment as little as possible and minimize equipment exposure to the sample.
4. To reduce chances of cross-contamination, use dedicated equipment whenever possible. "Dedicated" is defined as equipment that is to be used solely for one location for the life of that equipment (e.g., permanently mounted pump). Purchase dedicated equipment with the most sensitive analyte of interest in mind.
    - Clean or make sure dedicated pumps are clean before installation. They do not need to be cleaned prior to each use, but must be cleaned if they are withdrawn for repair or servicing.
    - Clean or make sure any permanently mounted tubing is clean before installation.
    - Change or clean tubing when the pump is withdrawn for servicing.
    - Clean any replaceable or temporary parts.

- Collect equipment blanks on dedicated pumping systems when the tubing is cleaned or replaced.
- Clean or make sure dedicated bailers are clean before placing them into the well.
- Collect an equipment blank on dedicated bailers before introducing them into the water column.
- Suspend dedicated bailers above the water column if they are stored in the well.

Sampling Wells Without Plumbing

a.) Sampling with Pumps – The following pumps may be used to sample for organics:

- Peristaltic pumps
- Stainless steel, Teflon or polyethylene bladder pumps
- Variable speed stainless steel and Teflon submersible pumps

1. *Peristaltic Pump*
   - Volatile Organics: One of three methods may be used.
     - Remove the drop tubing from the inlet side of the pump; submerge the drop tubing into the water column; prevent the water in the tubing from flowing back into the well; remove the drop tubing from the well; carefully allow the groundwater to drain into the sample vials; avoid turbulence; do not aerate the sample; repeat steps until enough vials are filled. OR
     - Use the pump to fill the drop tubing; quickly remove the tubing from the pump; prevent the water in the tubing from flowing back into the well; remove the drop tubing from the well; carefully allow the groundwater to drain into the sample vials; avoid turbulence; do not aerate the sample; repeat steps until enough vials are filled. OR
     - Use the pump to fill the drop tubing; withdraw the tubing from the well; reverse the flow on the peristaltic pumps to deliver the sample into the vials at a slow, steady rate; repeat steps until enough vials are filled.
   - Extractable Organics: If delivery tubing is not polyethylene or PP, or is not Teflon lined, use pump and vacuum trap method. Connect the outflow tubing from the container to the influent side of the peristaltic pump. Turn pump on and reduce flow until smooth and even. Discard a

small portion of the sample to allow for air space. Preserve (if required), label, and complete field notes.

- Inorganic samples: These samples may be collected from the effluent tubing. If samples are collected from the pump, decontaminate all tubing (including the tubing in the head) or change it between wells. Preserve (if required), label, and complete field notes.

2. *Variable Speed Bladder Pump*
    - If sampling for organics, the pump body must be constructed of stainless steel and the valves and bladder must be Teflon. All tubing must be Teflon, polyethylene, or PP and any cabling must be sealed in Teflon, polyethylene or PP, or made of stainless steel.
    - After purging to a smooth even flow, reduce the flow rate.
    - When sampling for volatile organic compounds, reduce the flow rate to 100-200mL/minute, if possible.
3. *Variable Speed Submersible Pump*
    - The housing must be stainless steel.
    - If sampling for organics, the internal impellers, seals and gaskets must be constructed of stainless steel, Teflon, polyethylene or PP. The delivery tubing must be Teflon, polyethylene or PP; the electrical cord must be sealed in Teflon; any cabling must be sealed in Teflon or constructed of stainless steel.
    - After purging to a smooth even flow, reduce the flow rate.
    - When sampling for volatile organic compounds, reduce the flow rate to 100-200mL/minute, if possible.

b.) Sampling with Bailers - A high degree of skill and coordination are necessary to collect representative samples with a bailer.

1. *General Considerations*
    - Minimize handling of bailer as much as possible.
    - Wear sampling gloves.
    - Remove bailer from protective wrapping just before use.
    - Attach a lanyard of appropriate material.
    - Use the lanyard to move and position the bailers.
    - Do not allow bailer or lanyard to touch the ground.
    - If bailer is certified precleaned, no rinsing is necessary.
    - If both a pump and a bailer are to be used to collect samples, rinse the exterior and interior of the bailer with sample water from the pump before removing the pump.
    - If the purge pump is not appropriate for collecting samples (e.g., non-inert components), rinse the bailer by collecting a single bailer of the groundwater to be sampled.
    - Discard the water appropriately.

- Do not rinse the bailer if Oil and Grease samples are to be collected.

2. *Bailing Technique*
   - Collect all samples that are required to be collected with a pump before collecting samples with the bailer.
   - Raise and lower the bailer gently to minimize stirring up particulate matter in the well and the water column, which can increase sample turbidity.
   - Lower the bailer carefully into the well to a depth approximately a foot above the water column. When the bailer is in position, lower the bailer into the water column at a rate of 2 cm/sec until the desired depth is reached.
   - Do not lower the top of the bailer more than one foot below the top of the water table, so that water is removed from the top of the water column.
   - Allow time for the bailer to fill with aquifer water as it descends into the water column.
   - Do not allow the bailer to touch the bottom of the well or particulate matter will be incorporated into the sample. Carefully raise the bailer. Retrieve the bailer at the same rate of 2 cm/sec until the bottom of the bailer has cleared to top of the water column.
   - Lower the bailer to approximately the same depth each time.
   - Collect the sample. Install a device to control the flow from the bottom of the bailer and discard the first few inches of water. Fill the appropriate sample containers by allowing the sample to slowly flow down the side of the container. Discard the last few inches of water in the bailer.
   - Repeat steps for additional samples.
   - As a final step measure the DO, pH, temperature, turbidity and specific conductance after the final sample has been collected. Record all measurements and note the time that sampling was completed.

c.) <u>Sampling Low Permeability Aquifers or Wells that have Purged Dry</u>

1. Collect the sample(s) after the well has been purged. Minimize the amount of water removed from the well by using the same pump to purge and collect the sample. If the well has purged dry, collect samples as soon as sufficient sample water is available.
2. Measure the five field parameters temperature, pH, specific conductance, dissolved oxygen and turbidity at the time of sample collection.
3. Advise the analytical laboratory and the client that the usual amount of sample for analysis may not be available.

Appendix D - Collecting Samples from Wells with Plumbing in Place

In-place plumbing is generally considered permanent equipment routinely used for purposes other than purging and sampling, such as for water supply.

a.) Air Strippers or Remedial Systems - These types of systems are installed as remediation devices. Collect influent and effluent samples from air stripping units as described below.

1. Remove any tubing from the sampling port and flush for one to two minutes.
2. Remove all hoses, aerators and filters (if possible).
3. Open the spigot and purge sufficient volume to flush the spigot and lines and until the purging completion criteria have been met.
4. Reduce the flow rate to approximately 500 mL/minute (a 1/8" stream) or approximately 0.1 gal/minute before collecting samples.
5. Follow procedures for collecting samples from water supply wells as outlined below.

b.) Water Supply Wells – Water supply wells with in-place plumbing do not require equipment to be brought to the well to purge and sample. Water supply wells at UST facilities must be sampled for volatile organic compounds (VOCs) and semivolatile compounds (SVOCs).

1. *Procedures for Sampling Water Supply Wells*
    - Label sample containers prior to sample collection.
    - Prepare the storage and transport containers (ice chest, etc.) before taking any samples so each collected sample can be placed in a chilled environment immediately after collection.
    - You must choose the tap closest to the well, preferably at the wellhead. The tap must be before any holding or pressurization tank, water softener, ion exchange, disinfection process or before the water line enters the residence, office or building. If no tap fits the above conditions, a new tap that does must be installed.
    - The well pump must not be lubricated with oil, as that may contaminate the samples.
    - The sampling tap must be protected from exterior contamination associated with being too close to a sink bottom or to the ground. If the tap is too close to the ground for direct collection into the appropriate container, it is acceptable to use a smaller (clean) container to transfer the sample to a larger container.
    - Leaking taps that allow water to discharge from around the valve stem handle and down the outside of the faucet, or taps in which water tends to run up on the outside of the lip, are to be avoided as sampling locations.

- Disconnect any hoses, filters, or aerators attached to the tap before sampling.
- Do not sample from a tap close to a gas pump. The gas fumes could contaminate the sample.

2. *Collecting Volatile Organic Samples*
    - Equipment Needed: VOC sample vials [40 milliliters, glass, may contain 3 to 4 drops of hydrochloric acid (HCl) as preservative]; Disposable gloves and protective goggles; Ice chest/cooler; Ice; Packing materials (sealable plastic bags, bubble wrap, etc.); and Lab forms.
    - Sampling Procedure: Run water from the well for at least 15 minutes. If the well is deep, run water longer (purging three well volumes is best). If tap or spigot is located directly before a holding tank, open a tap after the holding tank to prevent any backflow into the tap where you will take your sample. This will ensure that the water you collect is "fresh" from the well and not from the holding tank. After running the water for at least 15 minutes, reduce the flow of water. The flow should be reduced to a trickle but not so slow that it begins to drip. A smooth flow of water will make collection easier and more accurate. Remove the cap of a VOC vial and hold the vial under the stream of water to fill it. Be careful not to spill any acid that is in the vial. For best results use a low flow of water and angle the vial slightly so that the water runs down the inside of the vial. This will help keep the sample from being agitated, aerated or splashed out of the vial. It will also increase the accuracy of the sample. As the vial fills and is almost full, turn the vial until it is straight up and down so the water won't spill out. Fill the vial until the water is just about to spill over the lip of the vial. The surface of the water sample should become mounded. It is a good idea not to overfill the vial, especially if an acid preservative is present in the vial. Carefully replace and screw the cap onto the vial. Some water may overflow as the cap is put on. After the cap is secure, turn the vial upside down and gently tap the vial to see if any bubbles are present. If bubbles are present in the vial, remove the cap, add more water and check again to see if bubbles are present. Repeat as necessary. After two samples without bubbles have been collected, the samples should be labeled and prepared for shipment. Store samples at 4° C.

3. *Collecting Extractable Organic and/or Metals Samples*

- Equipment Needed: SVOC sample bottle [1 liter, amber glass] and/or Metals sample bottle [0.5 liter, polyethylene or glass, 5 milliliters of nitric acid (HNO3) preservative]; Disposable gloves and protective goggles; Ice Chest/Cooler; Ice; Packing materials (sealable plastic bags, bubble wrap, etc.); and Lab forms.
- Sampling Procedure: Run water from the well for at least 15 minutes. If the well is deep, run the water longer (purging three well volumes is best). If tap or spigot is located directly before a holding tank, open a tap after the holding tank to prevent any backflow into the tap where you will take your sample. This will ensure that the water you collect is "fresh" from the well and not from the holding tank. After running the water for at least 15 minutes, reduce the flow. Low water flow makes collection easier and more accurate. Remove the cap of a SVOC or metals bottle and hold it under the stream of water to fill it. The bottle does not have to be completely filled (i.e., you can leave an inch or so of headspace in the bottle). After filling, screw on the cap, label the bottle and prepare for shipment. Store samples at 4° C.

Appendix E - Collecting Surface Water Samples

The following topics include 1.) acceptable equipment selection and equipment construction materials and 2.) standard grab, depth-specific and depth-composited surface water sampling techniques.

Facilities which contain or border small rivers, streams or branches should include surface water sampling as part of the monitoring program for each sampling event. A simple procedure for selecting surface water monitoring sites is to locate a point on a stream where drainage leaves the site. This provides detection of contamination through, and possibly downstream of, site via discharge of surface waters. The sampling points selected should be downstream from any waste areas. An upstream sample should be obtained in order to determine water quality upstream of the influence of the site.

a.) General Cautions
   1. When using watercraft take samples near the bow away and upwind from any gasoline outboard engine. Orient watercraft so that bow is positioned in the upstream direction.
   2. When wading, collect samples upstream from the body. Avoid disturbing sediments in the immediate area of sample collection.
   3. Collect water samples prior to taking sediment samples when obtaining both from the same area (site).
   4. Unless dictated by permit, program or order, sampling at or near man-made structures (e.g., dams, weirs or bridges) may not provide representative data because of unnatural flow patterns.
   5. Collect surface water samples from downstream towards upstream.

b.) Equipment and Supplies - Select equipment based on the analytes of interest, specific use, and availability.

c.) Surface Water Sampling Techniques - Adhere to all general protocols applicable to aqueous sampling when following the surface water sampling procedures addressed below.
   1. *Manual Sampling*: Use manual sampling for collecting grab samples for immediate in-situ field analyses. Use manual sampling in lieu of automatic equipment over extended periods of time for composite sampling, especially when it is necessary to observe and/or note unusual conditions.
      - Surface Grab Samples - Do not use sample containers containing premeasured amounts of preservatives to collect grab samples. If the sample matrix is homogeneous, then the grab method is a simple and effective technique for collection purposes. If homogeneity is not apparent, based on flow or vertical variations (and should never be assumed), then use other collection protocols. Where practical, use the actual sample container submitted to the laboratory for collecting samples to be analyzed for oil and grease, volatile organic compounds (VOCs), and microbiological samples. This procedure eliminates the possibility of contaminating the sample with an intermediate collection container. The use of

unpreserved sample containers as direct grab samplers is encouraged since the same container can be submitted for laboratory analysis after appropriate preservation. This procedure reduces sample handling and eliminates potential contamination from other sources (e.g., additional sampling equipment, environment, etc.).

1. Grab directly into sample container.
2. Slowly submerge the container, opening neck first, into the water.
3. Invert the bottle so the neck is upright and pointing towards the direction of water flow (if applicable). Allow water to run slowly into the container until filled.
4. Return the filled container quickly to the surface.
5. Pour out a few mL of sample away from and downstream of the sampling location. This procedure allows for the addition of preservatives and sample expansion. Do not use this step for volatile organics or other analytes where headspace is not allowed in the sample container.
6. Add preservatives, securely cap container, label, and complete field notes. If sample containers are attached to a pole via a clamp, submerge the container and follow steps 3 – 5 but omit steps 1 and 2.

- Sampling with an Intermediate Vessel or Container: If the sample cannot be collected directly into the sample container to be submitted to the laboratory, or if the laboratory provides prepreserved sample containers, use an unpreserved sample container or an intermediate vessel (e.g., beakers, buckets or dippers) to obtain the sample. These vessels must be constructed appropriately, including any poles or extension arms used to access the sample location.
    1. Rinse the intermediate vessel with ample amounts of site water prior to collecting the first sample.
    2. Collect the sample as outlined above using the intermediate vessel.
    3. Use pole mounted containers of appropriate construction to sample at distances away from shore, boat, etc. Follow the protocols above to collect samples.
- Peristaltic Pump and Tubing: The most portable pump for this technique is a 12 volt peristaltic pump. Use appropriately precleaned, silastic tubing in the pump head and attach polyethylene, Tygon, etc. tubing to the pump. This technique is not acceptable for Oil and Grease, EPH, VPH or VOCs. Extractable organics can be collected through the pump if flexible interior-wall Teflon, polyethylene or PP tubing is used in the pump head or if used with the organic trap setup.

1. Lower appropriately precleaned tubing to a depth of 6 – 12 inches below water surface, where possible.
2. Pump 3 – 5 tube volumes through the system to acclimate the tubing before collecting the first sample.
3. Fill individual sample bottles via the discharge tubing. Be careful not to remove the inlet tubing from the water.
4. Add preservatives, securely cap container, label, and complete field notes.

- Mid-Depth Grab Samples: Mid-depth samples or samples taken at a specific depth can approximate the conditions throughout the entire water column. The equipment that may be used for this type of sampling consists of the following depth-specific sampling devices: Kemmerer, Niskin, Van Dorn type, etc. You may also use pumps with tubing or double check-valve bailers. Certain construction material details may preclude its use for certain analytes. Many Kemmerer samplers are constructed of plastic and rubber that preclude their use for all volatile and extractable organic sampling. Some newer devices are constructed of stainless steel or are all Teflon or Teflon-coated. These are acceptable for all analyte groups without restriction.
    1. Measure the water column to determine maximum depth and sampling depth prior to lowering the sampling device.
    2. Mark the line attached to the sampler with depth increments so that the sampling depth can be accurately recorded.
    3. Lower the sampler slowly to the appropriate sampling depth, taking care not to disturb the sediments.
    4. At the desired depth, send the messenger weight down to trip the closure mechanism.
    5. Retrieve the sampler slowly.
    6. Rinse the sampling device with ample amounts of site water prior to collecting the first sample. Discard rinsate away from and downstream of the sampling location.
    7. Fill the individual sample bottles via the discharge tube.
- Double Check-Valve Bailers: Collect samples using double check-valve bailers if the data requirements do not necessitate a sample from a strictly discrete interval of the water column. Bailers with an upper and lower check-valve can be lowered through the water column. Water will continually be displaced through the bailer until the desired depth is reached, at which point the bailer is retrieved. Sampling with this type of bailer must follow the same protocols outlined above, except that a messenger weight is not applicable. Although not designed specifically for this kind of sampling, a bailer is acceptable when a mid-depth sample is required

1. As the bailer is dropped through the water column, water is displaced through the body of the bailer. The degree of displacement depends upon the check-valve ball movement to allow water to flow freely through the bailer body.
2. Slowly lower the bailer to the appropriate depth. Upon retrieval, the two check valves seat, preventing water from escaping or entering the bailer.
3. Rinse the sampling device with ample amounts of site water prior to collecting the first sample.
4. Fill the individual sample bottles via the discharge tube. Sample bottles must be handled as described above.

- Peristaltic Pump and Tubing: The most portable pump for this technique is a 12 volt peristaltic pump. Use appropriately precleaned, silastic tubing in the pump head and attach HDPE, Tygon, etc. tubing to the pump. This technique is not acceptable for Oil and Grease, EPH, VPH or VOCs. Extractable organics can be collected through the pump if flexible interior-wall Teflon, polyethylene or PP tubing is used in the pump head, or if used with an organic trap setup.
    1. Measure the water column to determine the maximum depth and the sampling depth.
    2. Tubing will need to be tied to a stiff pole or be weighted down so the tubing placement will be secure. Do not use a lead weight. Any dense, non-contaminating, non-interfering material will work (brick, stainless steel weight, etc.). Tie the weight with a lanyard (braided or monofilament nylon, etc.) so that it is located below the inlet of the tubing.
    3. Turn the pump on and allow several tubing volumes of water to be discharged before collecting the first sample.
    4. Fill the individual sample bottles via the discharge tube. Sample bottles must be handled as described above.