Groundwater Sampling and Analysis Plan

for Compliance with the Coal Combustion Residuals (CCR) Rule and Consent Agreement No. RCRA-08-2022-0008

Public Service Company of Colorado

Comanche Station

July 19, 2022

Revised May 15, 2023

Table of Contents

List of Tables

List of Figures

List of Appendices and Attachments

Certification

Groundwater Sampling and Analysis Plan

Public Service Company of Colorado, an Xcel Energy Company

Comanche Station, Pueblo County, Colorado

I hereby certify that the groundwater sampling and analysis plan at Comanche Station is designed to meet the Federal Coal Combustion Residuals Rule and Consent Agreement No. RCRA-08-2022-0008.

15-MAY-2023

Matthew M Rohr
Colorado PE License 0053467
License Renewal Date October 31, 2023

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Quinn V. Kilty

Digitally signed by Quinn V. Kilty
Date: 2023.05.15 15:26:10 -06'00'

Quinn V. Kilty
Manager, Environmental Services

1.0 Introduction

This Groundwater Sampling and Analysis (GSA) Plan (Plan) was prepared for the Comanche Station (Comanche or site) to support compliance with the U.S. Environmental Protection Agency's (EPA) final Coal Combustion Residuals (CCR) Rule 40 CFR § 257 and Consent Agreement No. RCRA-08-2022-0008 (Consent Agreement) Paragraphs 79 and 95. Comanche is an electrical power generation facility owned and operated by Public Service Company of Colorado (PSCo) an Xcel Energy Company (Xcel) (Figure 1).

This Plan sets forth the requirements, procedures, and compliance reporting for collecting, analyzing, and managing groundwater samples and data from the Comanche Station.

2.0 Facility Description

Comanche Station is a coal-fired plant consisting of three units (Units 1, 2, 3) that burn Powder River Basin coal. Unit 1 was built in 1973, Unit 2 was built in 1975, and Unit 3 was built in 2010 (Tetra Tech, 2012). All three units are currently planned to cease operating by the end of 2034. Comanche Station currently has two CCR units subject to the CCR Rule: a landfill and an impoundment (Figure 2). The sections that follow provide a brief description of the CCR units.

2.1 CCR Landfill

The CCR landfill, also known as the CCR Ash Disposal Facility (Figure 2), was originally permitted as an approximately 280-acre engineered ash monofill consisting of eight disposal cells. With the currently planned early retirement dates of all three units, the updated landfill configuration will consist of only three disposal cells encompassing 94 acres. Currently, disposal is occurring in two cells in the southeast corner of the permitted landfill. Cell 1 was constructed with a compacted clay liner (Xcel Energy, 2005), and Cell 2E was constructed with CCR Rule compliant liner and leachate collection systems. Fly ash from all three units is collected in silos for either beneficial use or disposal in the landfill. Bottom ash is also permitted to be disposed in the on-site landfill, if needed. Water treatment sludge (lime from the on-site raw water treatment system), process water pond sediment, coal impurities, and excavation soils are also permitted for disposal at the landfill (Tetra Tech, 2015).

2.2 CCR Impoundment

Bottom ash generated from Units 1 and 2 was sluiced to the Bottom Ash Pond for dewatering and temporary storage until June 2021. Bottom ash solids were routinely excavated from the impoundment and either beneficially used off-site or transported to the landfill for disposal. Bottom ash is removed from Unit 3 dry via a submerged flight conveyor (SFC) and does not go into the Bottom Ash Pond; it is transported dry either to off-site beneficial use or to the landfill for disposal. According to historic documents, the impoundment was constructed in 1972 with a three-foot thick clay liner. The impoundment is approximately 513 feet long by 138 feet wide and 26 feet deep with a surface area of 1.6 acres. The primary influent to the CCR impoundment was sluiced bottom ash. Additional influent sources included continuous deionization softeners waste, brine and rinse, and activated carbon filter backwash and brine (Tetra Tech, 2013).

During operations, the CCR impoundment effluent discharged to the polishing pond immediately east of the Bottom Ash Pond (Figure 2). The Bottom Ash Pond ceased receiving non-CCR waste in January 2021 when non-CCR waste streams were re-routed to the Wastewater Ponds and CCR wastes by June 2021 when construction of a new treatment system for bottom ash sluice water was completed. The treatment system collects bottom ash solids for beneficial use or disposal and discharges treated effluent to the existing polishing pond.

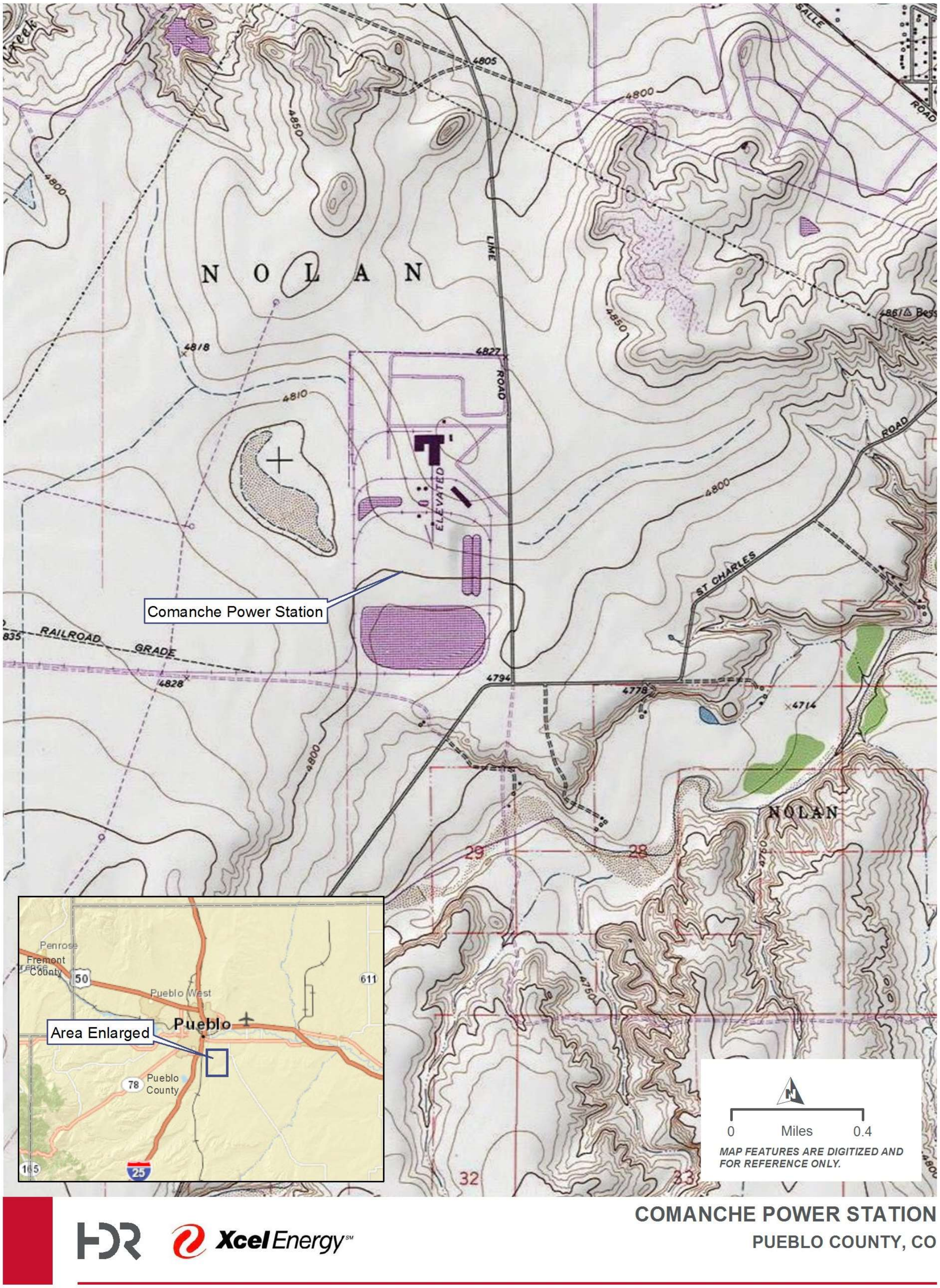

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Figure 1.Vicinity Map for Comanche Power Station

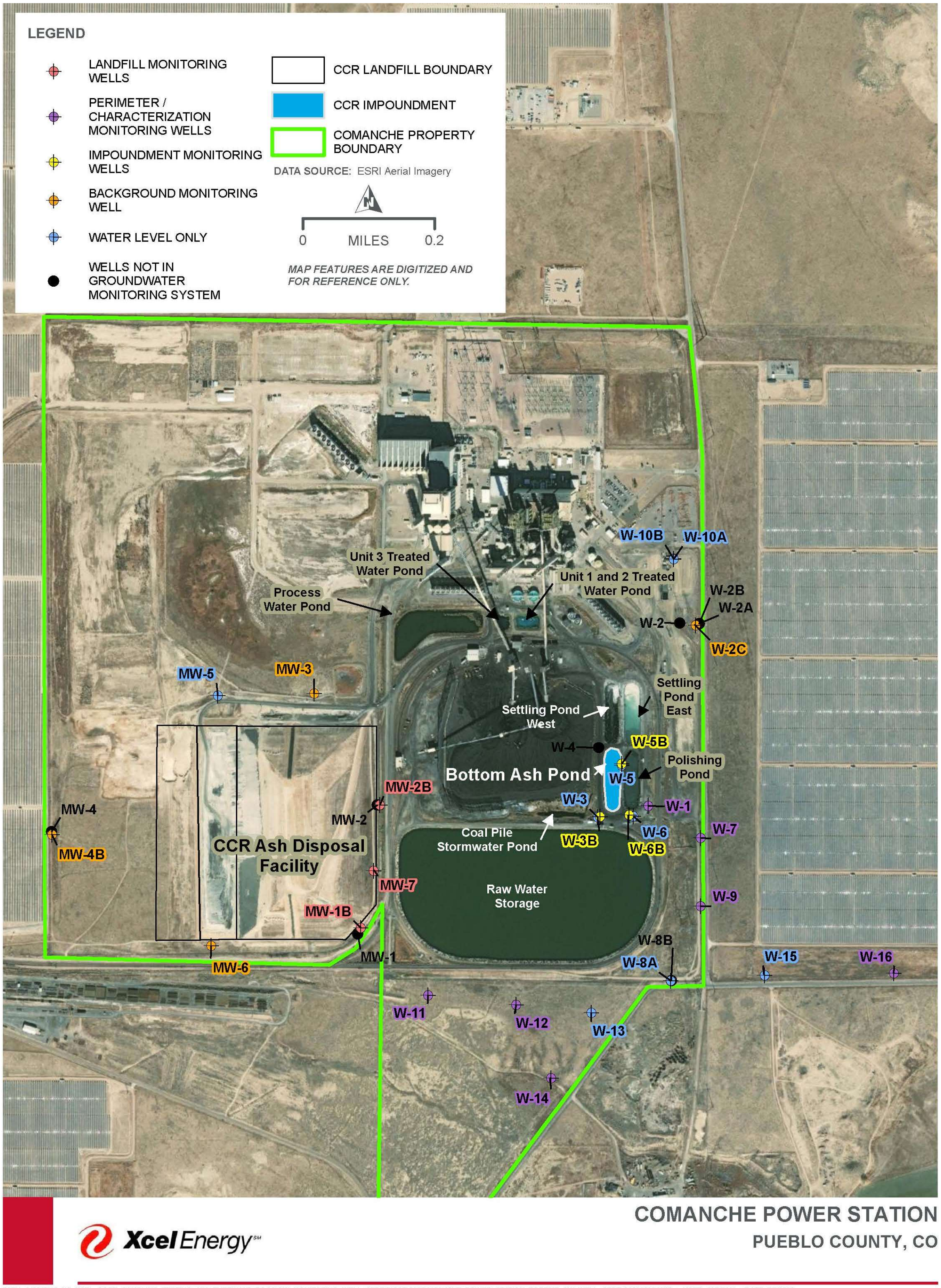

Figure 2. Monitoring Well Location and CCR Facilities Map

3.0 Design of the Groundwater Monitoring System

The placement and depth of monitoring wells that comprise the certified monitoring well network are described in the Groundwater Monitoring System Certification (HDR, 2022). The full description of well construction details for the landfill, Bottom Ash Pond, and perimeter/ characterization wells are contained within the Monitoring Well Installation Report (HDR, 2022a). A summary of monitoring well construction details, as of the date of this Plan, are contained in Table 1. Monitoring wells included in the system in Table 1 are current as of the date of this Plan. The sample locations are described and updated in the Groundwater Monitoring System Certification (HDR, 2022). The well locations are shown on Figure 2. Monitoring wells included in the system and well categories shown on Figure 2 are current as of the date of this Plan. However, the Well Installation Report (not this Plan) is the official document to track any new well installations at the Site over time, and the Groundwater Monitoring System Certification (not this Plan) is the official document to track the wells to be sampled for the CCR Rule compliance program.

Table 1. Monitoring Well Construction Details

Well I.D.	Northing	Easting	Elevation TOC (ft)	Well Total Depth (ft bgs)	Screen Interval (ft bgs)	Depth of Dedicated Pump Intake (ft btoc)	Well Stickup (ft)	Well Material Type	Depth to Water (ft btoc)	Groundwater Elevation (ft asml) 3/28/2022
Landfill										
MW-1B	4228051.34	536729.52	4807.72	40	25-40	40.18	2.18	4.5-inch PVC	31.07	4776.65
MW-2B	4228351.21	536776.74	4801.72	30	20-30	30.39	2.39	2-inch PVC	18.12	4783.6
MW-3	4228624.19	536615.92	4798.45	11 (2 ft sump)	4-9	8.67	1.67	4.5-inch PVC	8.76	4789.69
MW-4B	4228278.78	535974.97	4826.41	58	38-58	58.31	2.31	2-inch PVC	37.8	4788.61
MW-6	4228008.03	536363.95	4823.08	42 (5 ft sump)	27-37	43.73	2.23	2-inch PVC	31.16	4791.92
MW-7	4228190.62	536761.19	4803.2	36	26-36	37.20	2.2	2-inch PVC	20.3	4782.9
Bottom Ash Pond										
W-2A	4228795.47	537556.62	4827.86	34	24-34	34.21	2.21	2-inch PVC	26.72	4801.14
W-2C	4228790.88	537548.96	4827.78	34	24-34	34.16	2.16	2-inch PVC	28.08	4799.7
W-3B	4228322.89	537314.64	4810.29	45	35-45	45.08	2.08	2-inch PVC	16.29	4794.00
W-5B	4228325.00	536380.00	4810.62	36	30.5-35.5	36.33	2.5	2-inch PVC	10.38	4800.24
W-6B	4228327.33	537385.76	4807.47	42	32-42	41.80	1.88	2-inch PVC	14.7	4792.77
Perimeter/ Characterization										
W-1	4228349.09	537432.61	4799.5	13	3-13	14.37	1.87	2-inch PVC	10.41	4790.955
W-7	4228271.43	537560.80	4797.8	21	6-21	21.33	2.33	2-inch PVC	8.03	4789.51
W-9	4228088.00	537562.00	4801.78	40	27.35-37.35	41.81	2.31	2-inch PVC	35.89	4765.89
W-11	4227888.00	536898.00	4795.99	34	23-33	34.38	2.38	2-inch PVC	23.36	4772.63
W-12	4227869.00	537107.00	4791.65	25	14-24	26.72	2.22	2-inch PVC	21.83	4769.82
W-14	4227684.91	537195.11	4773.86	43	38-43	44.63	2.13	2-inch PVC	38.14	4737.85
W-16	4227940.75	538033.53	4788.9	46.5	36-46	46.33	2.33	2-inch PVC	37.13	4751.77
Water Level Only										
W-3	4228322.28	537309.21	4807.41	29	14-29	28.04	1.04	2-inch PVC	13.63	4793.78
MW-5	4228619.73	536379.93	4806.97	36 (10ft sump)	16-26	30.43	2.43	2-inch PVC	26.9	4780.07
W-5	4228447.93	537367.35	4811.89	23.5 (10 ft sump)	3.5-13.5	15.33	3.83	2-inch PVC	12.35	4799.54
W-6	4228323.54	537396.39	4807.46	25 (10ft sump)	5-15	18.90	3.9	2-inch PVC	9.96	4797.5
W-8A	4227922.80	537487.53	4804.26	30	15-30	N/A	2.16	2-inch PVC	DRY	DRY
W-10A	4228951.00	537490.00	4835.21	18	7-17	N/A	2.22	2-inch PVC	DRY	DRY
W-10B	4228953.00	539470.00	4835.22	31	20-30	N/A	2.21	2-inch PVC	27.85	4807.37
W-13	537292.00	4227853.00	4801.96	29	24-29	N/A	2.3	2-inch PVC	29.42	4772.54
W-15	4227935.68	537717.07	4791.27	31	26-31	N/A	2.09	2-inch PVC	DRY	DRY

Notes: TOC = top of casing, BTOC = below top of casing, BGS = below ground surface, amsl = above mean sea level
N/A = no dedicated pump is installed
Easting/Northing coordinates provided in UTM NAD 83 Zone 13 meters

4.0 Groundwater Monitoring Program

4.1 Background Monitoring

To comply with CCR Part § 257.94, eight rounds of upgradient and downgradient monitoring well sampling will be completed at each of the CCR units at Comanche. These samples will represent background water quality. Each time a new well is installed, a series of eight sample events will be completed on a 5-week frequency and referred to as "background monitoring", even for wells that are compliance wells. The 5-week sampling frequency is considered representative, provided the evaluation of the data for autocorrelation is acceptable.

Background monitoring samples will be analyzed for the parameters in Appendices III and IV of Part § 257, plus Total Suspended Solids (TSS) (Table 2). The eight rounds of background water quality data for the background wells from each CCR unit will be used to develop background threshold values (BTVs) for each constituent of interest (COI). The Groundwater Monitoring System Certification will be updated to maintain which wells at each CCR unit are considered background wells, compliance wells, and characterization wells (HDR, 2022). The statistical methods for development of the BTV are described in the Data Management and Statistical Procedures Plan (HDR 2022b) (Attachment 1).

After a minimum of eight rounds of sampling to establish background water quality, detection monitoring is initiated.

Table 2. Groundwater Quality Parameters to be Analyzed
Appendix III Constituents for Background and Detection Monitoring*
Boron
Calcium
Chloride
Fluoride
pH
Sulfate
Total Dissolved Solids (TDS)
Appendix IV Constituents for Background and Assessment Monitoring*
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Fluoride
Lead
Lithium
Mercury
Molybdenum
Selenium
Thallium
Radium 226 and 228 combined
Additional Constituents
Total Suspended Solids

*All metals are to be analyzed as total metals.

4.2 Detection Monitoring Program

Per the CCR Rule 257.94(c), after eight background groundwater sampling events were completed, detection monitoring was initiated at each of the CCR units. Detection monitoring occurs semiannually and wells in the certified monitoring system are sampled and analyzed for the Appendix III COI listed in Table 2. Detection monitoring events will continue as appropriate for the active life of the CCR unit and post-closure period.

As described in the Data Management and Statistical Procedures Plan (Attachment 1), after background monitoring is completed and periodically thereafter, BTVs are developed for each CCR unit for each COI. The BTVs and statistics used to develop the current BTVs are documented in the Background Water Quality Statistical Certification (HDR, 2021). The HDR (2021) Background Certification includes the BTVs as of the time this Plan was developed;

however, BTVs will be updated on a periodic basis and new Background Certification documents developed over time using the statistical procedures in Attachment 1. The upper prediction limit (UPL) BTVs are used during detection monitoring of the CCR Rule's implementation. After each semiannual detection monitoring event, compliance well Appendix III concentrations are compared against the UPL BTVs for that specific CCR unit. Note that for field pH, both the UPL and the lower prediction limit (LPL) are compared.

During detection monitoring, if one or more Appendix III COIs are detected at a statistically significant increase (SSI) above UPLs established in the most up to date Background Groundwater Certification, PSCo will:

- notify EPA by email as quickly as practicable about the SSI and provide all pertinent sampling and validated analytical results regarding such detection with the next Monthly Progress Report to EPA;
- if validated analytical results are not received within 9 weeks of the sampling event notify EPA as quickly as practicable, and submit the unvalidated analytical results with the Monthly Progress Report, unless requested to be delivered more quickly by EPA;
- within 14 days of detecting the SSI inform EPA by email whether it intends to prepare an Alternative Source Demonstration (ASD) pursuant to 40 C.F.R. § 257.93(e)(2); and
- initiate assessment monitoring within 90 days of detecting the SSI if no ASD is sought.

If PSCo prepares an ASD, it will be submitted to EPA within 90 Days of detecting the SSI. Once submitted, the initiation of assessment monitoring may be delayed until EPA makes a determination on the ASD, unless EPA requires initiation of assessment monitoring.

4.2.1 Landfill

Eight rounds of background sampling were collected from August through December 2020 at the landfill. Background threshold values (BTVs) were developed in 2021 using the background water quality data, as described in the Background Water Quality Statistical Certification (HDR, 2021). In the May 26, 2021 PSCo memorandum, Determination of Statistically Significant Increases over Background per 257.93(h)(2), concentrations of Appendix III COIs from compliance monitoring wells at the landfill were compared against the BTVs and shown to have one SSI over background. PSCo completed an Alternative Source Determination for the Landfill (HDR, 2021a), which EPA approved on June 29, 2022. Therefore, the current monitoring status of the Landfill at the time of this Plan preparation is detection monitoring. Detection monitoring continues semiannually, currently in May and November each year, for the active life of the landfill and post-closure period of the landfill or until assessment monitoring is triggered.

4.2.2 Bottom Ash Pond

Background monitoring at the Bottom Ash Pond was conducted between August 2020 and December 2020. The first detection monitoring sample event at the Bottom Ash Pond occurred in January 2021. As described in the May 26, 2021 PSCo memorandum, Determination of Statistically Significant Increases over Background per 257.93(h)(2), concentrations of Appendix III COIs from each compliance monitoring well at the bottom ash impoundment were compared against the BTVs and several COIs were found to have an SSI over background. The SSIs triggered the assessment monitoring program for the impoundment. The status of the Bottom Ash Pond as of this Plan preparation is assessment monitoring, which is described in Section 4.3.

4.3 Assessment Monitoring Program

The following section applies when PSCo establishes an assessment monitoring program for a CCR unit in accordance with 40 CFR § 257.95 in response to SSIs identified during detection monitoring. Within 90 days of triggering an assessment monitoring program and annually thereafter, PSCo will sample and analyze the groundwater for all COIs in Appendix IV of Part § 257, plus TSS for the purposes of determining detected COIs. Within 90 days of obtaining results from the initial assessment monitoring sample event, and on a semiannual basis thereafter, PSCo will sample all wells for all COIs in Appendix III of Part § 257 and for detected COIs in Appendix IV of Part § 257.

In accordance with 40 CFR § 257.95(e), Appendix III and IV assessment monitoring results would be compared to the UPL BTVs. According to 40 CFR § 257.95(e), the CCR unit may return from assessment monitoring to detection monitoring when all Appendix III and Appendix IV constituents are "shown to be at or below background values, using the statistical procedures in paragraph 40 CFR § 257.93(g) for two consecutive sampling events." PSCo may submit a proposal to EPA to return to detection monitoring for the CCR unit. The unit will not return to detection monitoring until the proposal is approved by EPA and notification has been placed in the facility's operating record as required by § 257.105(h)(7).

In accordance with 40 CFR § 257.95(f), if assessment monitoring concentrations of Appendix III and Appendix IV constituents are above BTVs but Appendix IV constituents are below the groundwater protection standard (GPS), then assessment monitoring will continue. The Statistical Procedures Plan describes the statistical methods that would be used to develop the assessment monitoring BTVs and GPS.

If one or more Appendix IV COIs are detected above the GPS, PSCo will:

- notify EPA by email as quickly as practicable after validated analytical results are received and provide sampling results to EPA with the Monthly Progress Report, unless requested to be delivered more quickly by EPA;
- if validated analytical results are not received within 9 weeks of the sampling event notify EPA as quickly as practicable, and submit the unvalidated analytical results with the Monthly Progress Report, unless requested to be delivered more quickly by EPA; and
- sample all perimeter monitoring wells located hydraulically downgradient of the monitoring well(s) where Appendix IV concentrations exceeding the groundwater protection standard occurred and complete laboratory analysis for the presence of Appendix III and IV COIs.

If Appendix III and detected Appendix IV COIs exceed BTVs according to § 257.95(e), and detected Appendix IV COIs exceed GPS per § 257.95(f), then detected Appendix IV constituents will be statistically compared to the GPS to identify SSLs above the GPS per § 257.95(g), following the statistical procedures as described in the Data Management and

Statistical Procedures Plan (Attachment 1). As described in the Statistical Procedures Plan, lower confidence limits (LCLs) will be calculated for each compliance and characterization well for each Appendix IV COI for statistical comparison against the GPS. If an LCL is calculated above the GPS, this is considered a statistically significant level (SSL) over GPS. If any SSL over GPS is detected at a waste boundary well, PSCo will:

- within 14 days inform EPA by email whether it intends to prepare an ASD for the exceedance pursuant to 40 C.F.R. § 257.95(g)(3)(ii);
- place a notification in the operating record identifying the GPS exceedances;
- within 90 days initiate assessment of corrective measures in accordance with 40 CFR § 257.96;
- characterize the nature and extent of the release and any relevant site conditions that may affect the remedy ultimately selected in accordance with 40 CFR § 257.97; and
- notify all persons who own the land or reside on the land that directly overlies any part of the plume of contamination.

PSCo may delay initiation of an assessment of corrective measures until EPA makes a determination pursuant to 40 C.F.R. § 257.95(g)(3)(ii) on Respondent's demonstration. Should PSCo initiate an Assessment of Corrective Measures, assessment monitoring sampling will continue.

If waste boundary well SSLs are identified, nature and extent wells will be installed as needed to define the contaminant plume(s) including at least one well at the facility boundary in the direction of contaminant migration pursuant to 40 C.F.R. § 257.95(g)(1). These nature and extent wells will be sampled at an increased frequency (5-week frequency) immediately after installation in effort to have sufficient samples (minimum 8) from each new well (as soon as possible) to complete the statistical comparison against the GPS. Once a nature and extent well has 8 or more sample events, the entire available data set from that well is used to calculate the LCLs, and if the LCL is below the GPS then the well will not be considered part of the plume and if the LCL is above the GPS then the well will be considered part of the plume. Between the time a new nature and extent well has been installed and 8 samples have been collected (approximately a 10-month window), concentrations from each sample event will be compared to the GPS on a single event basis and the exceedance will be described in any reporting documents as single event exceedances. Determination for whether additional nature and extent wells are warranted to define the plume will not require a statistical comparison (8 sample events), nor should be made after a single sample event, but may be completed with approximately two sample events comparisons to the GPS. For example, if two sample events have GPS exceedances, that will be an indication that additional nature and extent wells are warranted to define the plume, and conversely if two sample events do not have GPS exceedances, that will be an indication that additional nature and extent wells are not warranted at that time.

4.3.1 Bottom Ash Pond

In the May 26, 2021 PSCo memorandum, *Determination of Statistically Significant Increases over Background* per 257.93(h)(2), concentrations of Appendix III COIs from downgradient monitoring wells at the Bottom Ash Impoundment were compared against the BTVs and shown to have SSIs over background. The SSIs triggered the assessment monitoring program for the Bottom Ash Pond. The Groundwater Protection Standards and Determination of SSL per 257.95(g) memorandum identified concentrations at compliance wells at an SSL over GPS and initiated Assessment of Corrective Measures for the Bottom Ash Pond (HDR 2021b). PSCo will submit the ACM to EPA by November 16, 2022. Therefore, the current monitoring status of the Bottom Ash Pond at the time of this Plan preparation is assessment monitoring and assessment of corrective measures. Assessment monitoring will continue semiannually in May and November each year at the Bottom Ash Pond for the active life and post-closure period of the impoundment.

If and when a corrective action program is implemented, these plans will be revised to include monitoring and statistical procedures appropriate for corrective actions monitoring.

5.0 Sampling Procedures

Groundwater sampling events conducted at Comanche Station adhere to the steps in the following sections. Groundwater sampling will be directed by a Field Team Leader (FTL), a mid- or senior-level environmental professional (engineer, geologist, or scientist) with appropriate experience. Field staff will be junior to mid-level environmental professionals or environmental technicians overseen by the FTL.

5.1 Sampling Start-Up Activities

5.1.1 EPA Oversight

PSCo will provide EPA email notification of sampling at least 7 days prior to the collection date via email to Linda Jacobson, Jacobson.Linda@epa.gov. PSCo will allow oversight of each sampling event by EPA or a representative of EPA, including contractors, as identified by EPA. Upon request from EPA, PSCo shall provide split samples to the EPA.

5.1.2 Office Preparations

The Project Manager (PM) will assign an FTL to direct field activities and coordinate with project personnel. Task specific responsibilities of the FTL include:

- Coordinate sampling activities with the PM and analytical laboratory.
- Confirm that laboratory-supplied sample containers and equipment arrive prior to the start of sampling.
- The FTL will confirm the list of wells to be sampled and include the most recent water level measurement to confirm planned sample depths.
- Inventory field supplies and check condition of rental equipment.

- Confirm availability of equipment and order additional equipment/supplies for rental prior to the start of sampling event, including laboratory sample bottles.
- Ensure that the field equipment is properly calibrated per manufacturer's instruction.
- Obtain well location maps and well construction logs.
- Prepare field forms and other documentation for the planned event.
- Schedule time and location for the initial meeting with field staff to review project information and begin work. Verify site specific safety training has been completed by all samplers.
- Load vehicle with equipment and supplies.
- Complete equipment and supply checklists and verify that required documentation and equipment for field activities are on site.

5.1.3 Field Preparations

After arrival on site, but prior to commencement of operations, the following activities will be performed:

- Complete equipment and supply checklists and verify that required documentation and equipment for field activities are on site.
- View well locations and confirm the wells are accessible and well IDs are clearly marked.
- Review locations for planned field activities to evaluate for hazards. Select location for storage and disposal of decontamination and purge waters (either treatment system bunker or active lime settling pond).
- Confirm the location and length of the screened interval and the total depth of the well to be sampled.
- Review sampling activities and assignments with field staff.
- Prior to sampling, the monitoring instruments must be calibrated and the calibration documented. The instruments shall be checked for calibration at the beginning of each day. The instruments are rented from Geotech Environmental and are calibrated by the supplier prior to rental. The rental calibration documentation in the instrument case shall be checked prior to the use the first day of sampling. On subsequent sample days, the instrument calibration should be checked and if the field measurement falls outside the calibration range, the instrument must be re-calibrated so that all measurements fall within the calibration range. At the end of each day, a calibration check is performed to verify that instruments remained in calibration throughout the day. This check is performed while the instrument is in measurement mode, not calibration mode. Note: during the day if the instrument reads zero or a negative number for dissolved oxygen, pH, specific conductance, or turbidity (negative value only), this indicates that the instrument drifted out of calibration or the instrument is malfunctioning. If this situation occurs the data from this instrument will need to be re-

calibrated. Recalibration will follow the manufacturer's instructions located inside the instrument case.

5.2 Water Level Gauging

The following steps will be taken before collecting groundwater samples in the field.

- Locate the well to be sampled, confirm well ID and record the condition of the well.
- Measure the water level from the measuring point marked at the top of the PVC casing to the nearest 0.01 foot and record the measurement on the Sample Collection Data sheet (Appendix A). Every measurement should be taken from the same measuring point.
- Decontaminate the water-level indicator and tape that contacted groundwater prior to each use (Section 5.3.3).
- Well depth can be obtained from well construction logs. Measuring total depth of wells is not possible without removal of dedicated pumps.

5.3 Well Purging and Sample Collection

5.3.1 Dedicated Bladder Pumps

Due to the low yield and high suspended solids in many wells completed in the weathered shale, installation and use of dedicated low-flow pumps for sampling is required in all groundwater monitoring wells, except those wells used for monitoring water level only. Geotech Bladder Pumps with polyethylene bladder and tubing are installed in all background, compliance, and characterization wells. Pump tubing was specifically designed for each specific well screen and groundwater level, and pump intake depths within each well are in Table 1. The following section outlines the procedures for purging and collection of groundwater samples using dedicated low-flow bladder pumps. Dedicated bladder pumps should never be removed from the assigned well unless repairs are needed to avoid possible contamination. Decontamination of tubing, safety cable, and the pump is required in the event of pump removal from the well.

1.0 Upon arrival at the monitoring well, inspect the slipcover and note any corrosion or damage that impede proper connection of air and water lines. Remove freeze kit tubing and place in an unused plastic bag to prevent contamination. Connect flexible silicone tubing to the water outlet line.

2.0 Connect the compressed air line from the pump control box to the air-in line on the slipcover, then connect the power supply to the pump control box.

3.0 Connect the flow-through cell at the end of the flexible tubing and prepare the bucket for the purge water. Be prepared with a watch/timer to calculate flow rate and time the purge water quality measurements.

4.0 Check the drawdown information from previous sampling event(s) for each well. Duplicate, to the extent practicable, the extraction rate (use final pump dial setting information) from previous event(s). If changes are made in the extraction rate(s) used during previous sampling event(s) record new values, and explain reasons for the changes in the field logbook.

5.0 Begin purging the well at a rate of approximately 200 to 500 milliliters per minute (mL/min). Follow the manufacturer guidelines on the inside of the pump control box to identify the appropriate air pressure, discharge, and recharge timers. Note the pump control settings for future use and reference. The goal is to induce a steady flow rate while minimizing drawdown. The discharge should flow with minimal turbulence or agitation.

6.0 All purge water will be collected in buckets or barrels for ultimate discharge into the treatment system bunker or active lime settling pond. Purge water will not be discharged directly into the polishing pond unless approved by PSCo.

7.0 Record depth to groundwater level frequently during purge. If drawdown is greater than 4 inches, decrease the discharge rate of the pump and repeat discharge and water level measurements. Repeat until the depth to water stabilizes. Record pumping rates and depths to water on the Sample Collection Data sheet (Appendix A).

8.0 An in-line multi-probe flow-through cell will be used to monitor the stabilization parameters so as not to expose the water to the atmosphere prior to measurement. During purging, water quality indicator parameters (pH, ORP, turbidity, specific conductivity, and DO) will be measured approximately every 5 minutes until the parameters have stabilized. Measurement will be recorded on the field data sheet (Appendix A).

9.0 Sampling may begin once the well has stabilized from purging and a minimum of one equipment volume is purged (Table 3). Stabilization is achieved after three successive readings are within ± 0.1 for pH, ± 10 mV for ORP, ± 3% for specific conductance, ± 3% for temperature, ± 10% for values greater than 0.5 mg/L, if three dissolved oxygen values are less than 0.5 mg/L, consider the values as stabilized, and ± 10% for turbidity for values greater than 10 NTU; if three turbidity values are less than 10 NTU, consider the values as stabilized. If <10 NTU cannot be achieved after 2 hours of purging and the turbidity does not appear to be improving, sample may be collected but an additional sample bottle will be collected for dissolved metals analysis at the laboratory for later comparison against total metal concentrations to evaluate the impact of sediment. The Chain of Custody will be modified to reflect the added request for analysis.

Specific conductance and DO usually take the longest to stabilize. Up to 2 hours of purging may be required to reach stabilization. Stabilized purge indicator trends are generally obvious and follow either an exponential or asymptotic change to stable parameter values during purging.

The flow-through-cell must be designed in a way that prevents gas bubble entrapment in the cell. Placing the flow-through-cell at a 45-degree angle with the port facing upward can help remove bubbles from the flow-through-cell. Throughout the measurement process, the flow-through-cell must remain free of any gas bubbles.

Otherwise, the monitoring probes may act erratically. When the pump is cycling on/off, water in the cell must not drain out. Monitoring probes must remain submerged in water at all times.

The pump will not be powered off between purging and sample collection.

Table 3. Equipment Volume for Dedicated Well Pumps

Well I.D.	Equipment Volume (pump and tubing) (ml)	Well I.D.	Equipment Volume (pump and tubing) (ml)
MW-1B	658	W-7	496
MW-2B	574	W-1	436
MW-3	387	W-9	672
MW-4B	815	W-11	608
MW-6	689	W-12	542
MW-7	633	W-14	697
W-1	436	W-16	711
W-2A	607	W-3	554
W-2C	606	MW-5	574
W-3B	701	W-5	444
W-5B	627	W-6	475
W-6B	673		

10.0 There are a few wells at Comanche with consistently low recharge that typically purge dry prior to meeting stabilization even at lowest possible purge rates. At these wells, purge the well at the lowest possible rate and sample the well after one equipment volume is purged. In the case where there is very low recharge and insufficient volume in the well to collect analytical sample volume without purging the well dry, allowing time for recovery may be necessary as a last resort.

11.0 Groundwater samples will be collected by gently filling the sample bottles with minimum turbulence once stabilization is established. Lower the flow rate to 100 mL/min and fill sample containers (see Section 5.3.2).

5.3.2 Sample Collection, Preservation, and Handling, and Chain of Custody

Sample bottles will be labeled prior to collecting water in the bottles. Bottle labels will be completed for each sample container collected for analysis, using ink or permanent marker. Each label will include the following:

- Site Location (Comanche)
- Well identification number (MW-#);
- Sample collection date: month, day, year;

- Sample collection time;
- Sample preservation method (e.g. nitric acid); and
- Initials of personnel collecting the sample.

It is critical that both the sample bottle monitoring well identification and sample times match exactly the sample name and collection time written on both the field data sheet and the chain of custody. Groundwater samples will be collected by gently filling the sample bottles with minimum turbulence. In the event the field sampler is required to add preservative to the sample bottle, leave a small amount of head space for addition of the preservative with no overflow. No field filtering will be required. While not anticipated, should the laboratory require addition of preservative, it will be added to the sample bottle immediately after filling the bottle.

Samples will be stored in a cooler with ice. The Chain of Custody form should be completed in the field as the sampling progresses and signed upon transfer of custody at the laboratory. Chain of custody procedures comprise the following elements: (1) maintaining custody of samples, and (2) documentation of the requested analysis. To document chain of custody, an accurate record must be maintained to trace the possession of each sample from the moment of collection through analysis and reporting. The field chain of custody record is used to record the custody of all samples collected and maintained by Field Staff. All sample sets will be accompanied by a chain of custody record. It also serves as a sample logging mechanism for the laboratory sample custodian. The following rules apply to chain of custody records:

- All information must be supplied in the indicated spaces to complete the field chain of custody record. It is critical that the proper contact information is provided to the laboratory. This should always be the sampler.
- Each person who maintained custody of the samples must sign in the designated signature block.
- The sample ID, date, and time on the chain of custody must match the sample bottle exactly.
- The total number of sample containers for each sample must be listed in the appropriate column. Total sample bottles need to be counted and double checked. Required analyses should be circled or entered in the appropriate location on the form and double checked.
- If expedited turnaround is requested, this needs to be noted clearly.
- Electronic results are required as EDDs and PDF files of the laboratory report.
- The last person receiving the samples should be the laboratory sample custodian or their designee(s).
- The chain of custody record is an accountability document and should be filled out thoughtfully.

5.3.3 Decontamination

The purpose of decontamination is: (1) to eliminate the transfer of contaminants from one groundwater monitor well to another, and (2) to protect the health and safety of personnel who may come in contact with contaminated equipment. Decontamination procedures described in this section will be performed at the beginning of each day of field work and between each monitor point, and whenever the equipment is suspected of having been contaminated.

Wells utilizing dedicated bladder pumps will also have dedicated tubing, reducing the need for decontamination unless contact is made with a surface or object that is potentially contaminated. Dedicated tubing is to be handwashed using Alconox or Liquinox / tap water solution and rinsed with clean tap water.

Decontamination of the water level meter is to be completed on sections that contact the groundwater. The meter will be handwashed using a Alconox or Liquinox with tap water solution and rinsed with deionized water after each well measurement.

6.0 Quality Control

The quality assurance and quality control procedures control the measurement process and ensure the usability and reliability of sampling and analysis data. This SOP is the first step to ensuring high-quality environmental data. Following standard procedures for decontaminating field equipment; maintaining, calibrating, and operating field equipment and instrumentation in accordance with manufacturer's instructions; using skilled personnel for sampling; and adhering to this Sampling and Analysis Plan constitute the quality assurance procedures for the project. Errors that affect environmental measurements can be introduced in the field during sample collection, processing, shipment, in the laboratory, and during database entry.

The precision of field sampling procedures will be evaluated by collection and analysis of field duplicate samples. Duplicate samples are two or more samples collected or processed so that the samples are essentially identical in composition. Duplicate samples will be used to evaluate the reproducibility (precision) of analyte concentration values reported by the laboratory. Although two replicates are not adequate to assess precision, they can be used to show whether variability of results for the samples is within the range of expected precision.

The number of duplicate samples to be collected must be one for every sample event. Sample identification for duplicates will be to add the letter "T" after the well prefix (e.g. MW-3 and MWT-3). The precision will be measured through the evaluation of relative percentage differences (RPDs) between sample and duplicate sample and between matrix spike and matrix spike duplicates and calculated as follows:

$$\text{Relative Percentage Difference (\%)} = \frac{\text{concentration SA} - \text{concentration SB}}{\text{average concentration of SA+SB}} \times 100$$

Where SA denotes Sample A; SB denotes the duplicate, sample B.

This measurement will be completed during data validation process (Attachment 1). Duplicate field samples with RPDs less than 20 percent are considered acceptable. When greater than 20 percent difference is observed, the Project Manager and filed sample team must meet to discuss procedures and a highly experienced sampler will accompany a sample event to quality check the sample procedures.

Accuracy is measured by the difference between the measured or observed value and the true or assigned value. Accuracy in the field is assessed through the adherence to all sample handling, preservation, and holding times. Laboratory accuracy is assessed through the analysis of matrix spike/matrix spike duplicate (MS/MSD) samples. The number of MS/MSD analyses is based on laboratory quality control standards. MS/MSD analysis results reflect the ability of the laboratory and method to accurately determine the quantity of an analyte in a particular sample. The measurement of “standards”, or materials of accepted reference values, provides an assessment of the accuracy of laboratory instruments and analytical methods. Accuracy will be evaluated through the use of EPA Quality Control Samples or Standard Reference Materials. Accuracy at the laboratory is expressed as percent recovery of the control sample. Laboratory MS recovery requirement is 75 to 125 percent, and MSD maximum difference is 20 percent.

Equipment blanks are used to determine if decontamination procedures for non-dedicated equipment are performed properly and there is no “carryover” from one aqueous sample to another. One equipment blank will be collected for each sample event that non-dedicated sampling equipment is used. After the dedicated pump installation, no equipment blanks are anticipated to be collected; however, the procedure is provided in case pump or air supply malfunction occurs and rental equipment is utilized for sampling. Deionized water will be provided by the laboratory. The deionized water will be run through a decontaminated pump and tubing and collected in a sample bottle. Sample identification for equipment blanks will be to add the letter “K” after the well prefix (e.g. MW-3 and MWK-3). Detection of any of the analyzed constituents in an equipment blank will require a review of decontamination methods and analysis.

Laboratory data will be reviewed, validated, and qualified, if necessary, prior to use. The laboratory data validation procedure is described in the Data Management and Statistical Procedures Plan (HDR, 2022b) (Attachment 1).

6.1 Sample Analysis

Parameters to be analyzed are shown on Table 4. These parameters include all of the constituents required for groundwater sampling by the CCR Rule (Appendices III and IV of CCR Part § 257), plus TSS. Analytical testing of water samples will be performed by Eurofins TestAmerica Laboratory.

Table 4 is the list of parameters for analysis and the constituent maximum contaminant limit (MCL), laboratory reporting limit (RL), laboratory method detection limit (MDL) (at the time this Plan was prepared), sample bottle volume, preservation method, analysis method, and hold time. These parameters include all of the constituents required for groundwater sampling by the CCR Rule (Appendices III and IV of CCR Part § 257), plus TSS. Analytical testing of water samples will be performed by Eurofins – TestAmerica an approved contract laboratory and are submitted through the Denver location. This list of parameters is applicable to the wells within the certified groundwater monitoring system on the Comanche property boundary.

Table 4. Parameters to be Analyzed

Constituents	Units	MCL	RL	MDL[1]	Sample Bottle	Preservation	Method	Holding Time
Appendix III Constituents								
Boron	mg/L	-	0.10	0.00145	250 mL plastic	Nitric Acid	6010C	6 mos
Calcium	mg/L	-	0.20	0.0378	250 mL plastic	Nitric Acid	3005A	6 mos
Chloride	mg/L	-	3.00	1.02	250 mL plastic	Chill	9056A_28D	28 d
Fluoride	mg/L	-	0.50	0.165	250 mL plastic	None	9056A_28D	28 d
pH	SU	-	0.10	-	-	-	-	-
Sulfate	mg/L	-	5.00	1.03	250 mL plastic	Chill	9056A_28D	28 d
Total Dissolved Solids (TDS)	mg/L	-	10.00	4.7	500 mL plastic	None	2540C_ Calcd	NA
Appendix IV Constituents								
Constituents	**Units**	**MCL**	**RL**	**MDL[1]**	**Sample Bottle**	**Preservation**	**Method**	**Holding Time**
Antimony	mg/L	0.006	0.0020	0.000400	250 mL plastic	Nitric Acid	6020B	6 mos
Arsenic	mg/L	0.01	0.0050	0.000330	250 mL plastic	Nitric Acid	6020B	6 mos
Barium	mg/L	2	0.0010	0.000290	250 mL plastic	Nitric Acid	6020B	6 mos
Beryllium	mg/L	0.004	0.0010	0.000080	250 mL plastic	Nitric Acid	6020B	6 mos
Cadmium	mg/L	0.005	0.0010	0.000265	250 mL plastic	Nitric Acid	6020B	6 mos
Chromium	mg/L	0.1	0.0020	0.000500	250 mL plastic	Nitric Acid	6020C	6 mos
Cobalt	mg/L	0.006[2]	0.0010	0.000092	250 mL plastic	Nitric Acid	6020B	6 mos
Fluoride	mg/L	4	0.5000	0.165000	250 mL plastic	None	9056A_28D	28 d
Lead	mg/L	0.015	0.0010	0.000180	250 mL plastic	Nitric Acid	6020B	6 mos
Lithium	mg/L	0.040[2]	0.0200	0.009100	250 mL plastic	Nitric Acid	6010C	6 mos
Mercury	mg/L	0.002	0.0002	0.000061	500 mL plastic	HNO_3	7470A	28 d
Molybdenum	mg/L	0.1[2]	0.0020	0.000140	250 mL plastic	Nitric Acid	6020B	6 mos
Selenium	mg/L	0.05	0.0050	0.000373	250 mL plastic	Nitric Acid	6020B	6 mos
Thallium	mg/L	0.002	0.0010	0.000089	250 mL plastic	Nitric Acid	6020B	6 mos
Radium 226 and 228 combined	pCi/L	5[3]	1.0000	-	1 gal plastic	Lab acidify in <5 days HNO_3	9315_Ra266 9320_Ra228	6 mos
Additional Parameters								
Total Suspended Solids (TSS)	mg/L	-	4	1.1	500 mL plastic	None	2540D	NA

[1]MDL values are updated periodically by the laboratory, values are up to date as of the date of this Plan
[2]EPA adopted health-based value in place of MCL
[3]Colorado Water Quality Regulation

For wells located on property outside of the PSCo Comanche Property boundary, specific lists of analytical parameters are written into the agreements between the landowner and PSCo. Any such list would include the same parameters as above, but potentially a shortened list, and would follow the same methods as Table 4. As of the time of this Plan, this only applied to well

W-16. The access agreement with the landowner for well W-16 includes that only the following parameters will be analyzed, under separate Chain of Custody: cobalt, pH, TSS, magnesium, calcium, sodium, potassium, chloride, sulfate, carbonate, and bicarbonate. If new wells are installed over time outside of the PSCo property, those land agreements will need to be reviewed for any limitations to the list of analytes. Prior to sampling, the Field Staff and the Project Manager go over the list of wells and constituents.

7.0 Equipment Maintenance

The Installation and Operation Manual (Manual) for the Geotech Bladder Pumps dedicated in wells is in Attachment 2. The manufacturer does not prescribe a scheduled maintenance for the pump or specific bladder life; however, Section 5 of the Manual provides a series of troubleshooting problems and descriptions. Bladder and O-Ring replacement are the most common maintenance, and Section 4 of the Manual provides the instructions for quick field replacement. Bladders that are torn, ripped, or excessively worn will be replaced. The most common symptom of a bladder needing replacement is air bubbles in the line. Field staff will be closely monitoring for this condition, and will carry replacement bladders and ground tarps with them during sampling in case a replacement is needed. Replacement bladders, as well as other key components, can be found in Section 7 of the Manual.

8.0 Data Management

For procedures regarding data management, data verification and validation, and statistical analysis, see the attached Data Management and Statistical Procedures Plan (Attachment 1).

9.0 Statistical Analysis

The Data Management and Statistical Procedures Plan (Attachment 1) provides the methodology to statistically evaluate the groundwater data, select appropriate statistical method(s), and develop the appropriate BTVs.

10.0 Reporting

Annual reporting documents will be developed no later than January 31 each year. The annual reports will be placed in the Facility's operating record and posted to the public website. The full year report must address the entire prior calendar year. Semiannual reports will be completed for submittal to the EPA no later than July 31 each year per the Consent Agreement. Semiannual reports must address the first 6 months of that year. The semiannual report may be submitted as an appendix or attachment to the full year report.

Annual reports will summarize key monitoring actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year. At a minimum, the annual and semiannual groundwater monitoring reports must contain the following information, to the extent available:

- A map, aerial image, or diagram showing the CCR unit and all background (or upgradient) and downgradient monitoring wells, to include the well identification numbers, that are part of the groundwater monitoring program for the CCR unit
- Identification of any monitoring wells that were installed or decommissioned during the preceding year, along with a narrative description of why those actions were taken
- In addition to all the monitoring data, a summary including the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs
- A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from detection monitoring to assessment monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels)
- Identify all tolerance or prediction intervals or limits and how they were determined, and present this information in table or chart format for the reporting period
- Statistical reports identifying the statistical methods and parameters used to calculate the tolerance or prediction intervals or limits, and a table of the data used to calculate the tolerance or prediction intervals or limits value for each Constituent for the reporting period
- Graphical representation demonstrating the trend(s), if any, of the concentrations of Appendix III COIs for each well from the commencement of monitoring through the date for which the report was prepared
- All lab reports for all analyses, including all chain of custody documentation for the reporting period
- All statistical data generated during the reporting period, including tests for normality, outliers, trends, spatial variability, autocorrelation, and any statistical limits or comparisons
- Copies of all boring logs, well completion logs, and field sampling logs from any boring or well installation, well development, water level testing, hydraulic testing, or testing of groundwater or other environmental media from any sampling, testing or installation conducted during the reporting period
- Updated potentiometric surface maps with groundwater flow direction(s) indicated for each sampling event for the reporting period

11.0 References

Tetra Tech, 2012. Inventory and Preliminary Classification Report, Waste Impoundments, Comanche Station, Pueblo, Colorado. November 1, 2012.

Tetra Tech, 2013. Closure Plan, Type A Waste Impoundments, Comanche Station, Pueblo, Colorado. June 28, 2013.

Tetra Tech, 2015. Engineering Design and Operations Plan, Ash Disposal Facility, Comanche Station, Pueblo, Colorado. January 13, 2015.e

HDR, 2021. Background Water Quality Statistical Certification. June 10, 2021.

HDR, 2021a. Comanche Station Landfill and Bottom Ash Pond CCR Units Alternative Source Determination of Statistically Significant Increases over Background per CCR Rule 257.93(h)(2), August 24, 2021.

HDR, 2021b. Comanche Station CCR Impoundment Groundwater Protection Standards and Determination of DDLs per 257.95(g), November 19, 2021.

HDR, 2022. Groundwater Monitoring System Certification - Compliance with the Coal Combustion Residuals Rule Comanche Station. July 5, 2022.

HDR, 2022a. Monitoring Well Installation Report. July 2022.

HDR, 2022b. Data Management and Statistical Procedures Plan, Comanche Station. July 2022.

Xcel Energy, 2005. Comanche Station Coal Ash Disposal Facility Design and Operations Plan. August 24, 2005.

Appendix A

Field Data Sheets for Groundwater Sample Collection

Water Sample Collection Field Data Sheet

Site Name:________________________________ Well ID.:____________________

Sample I.D.(match bottle and COC form exactly):_________________________________

Personnel:__________________

Date: ______________________ Static Depth to Water (ft, btoc) ________________

Date/Time Sample Collected (match bottle and COC form exactly):_____________________

Sample Method: ___________________

Water level meter, pump, and tubing decontaminated prior: Yes No

Sample QC: Duplicate Yes No Duplicate Sample ID: ____________

Sample QC: Equipment Blank Yes No Equip Blank Sample ID: ____________

Well Purging Data (Fill In All Blanks)

Depth of Sample Collection (pump depth) (ft, btoc) __________________

Time Completed: ______________________ Total Purge __________ Units______

Field Measurements:

Time (24 hour)	Amount purged (ml)	pH	COND (mS/m)	TURB (NTU)	DO (mg/L)	TEMP (Cº)	ORP (mV)	Water Depth (ft, btoc)

Flow Rate______________
Pump controller setting______________
General Comments:

____

____

____

Water Level Measurement

Site: ___________________________

Sample Event: ___________________________

Sample Personnel:________________________

Date:

Well I.D	*Prior Date* Measurement Depth to Water (ft, btoc)	Current Depth to Water (ft, btoc)	Date	Well Assessment or Notes

Attachment 1

Data Management and Statistical Procedures Plan

Data Management and Statistical Procedures Plan

for Compliance with the Coal Combustion Residuals (CCR) Rule and Consent Agreement No. RCRA-08-2022-0008

Public Service Company of Colorado
Comanche Station

May 15, 2023

Table of Contents

List of Tables

List of Figures

Abbreviations and Acronyms

Abbreviation	Definition
ANOVA	analysis of variance
BTV	background threshold value
CCR	Coal Combustion Residual
COC	Chain of Custody
COI	constituent of interest
EDD	electronic data deliverable
ICB	internal calibration blank
ICP	inductively coupled plasma
ICP-MS	ICP–mass spectrophotometry
ID	identifier
LCS	laboratory control sample
MDL	method detection limit
MS	matrix spike
MSD	matrix spike duplicate
ND	non-detect
ORP	oxidation/reduction potential
PC	Project Chemist
percentR	percent recovery
PL	prediction limit
PSCo	Public Service Company of Colorado
QC	quality control
R	rejected
RL	reporting limit
ROS	regression on order statistics
RPD	relative percent difference
SOP	Standard Operating Procedure
SSI	statistically significant increase
SSL	Statistically significant level
UPL95	95 percent upper prediction limits
USEPA	U.S. Environmental Protection Agency

Certification

Data Management and Statistical Procedures Plan for Compliance with the Coal Combustion Residuals Rule

I hereby certify that this Data Management and Statistical Procedures Plan is designed to meet the performance standard in 40 CFR Part 257 of the Federal Coal Combustion Residuals (CCR) Rule.

I am duly licensed Professional Engineer under the laws of the State of Colorado.

15-MAY-2023

Matthew Rohr, PE
Colorado PE License 0053467
License renewal date October 31, 2023

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Quinn V. Kilty Digitally signed by Quinn V. Kilty
Date: 2023.05.15 15:26:56 -06'00'

Quinn V. Kilty
Manager, Environmental Services

1.0 Project Management

This Statistical Procedures Plan provides the procedures for data management, validation, and analysis for the data generated during groundwater monitoring at the Public Service Company of Colorado's (PSCo), an Xcel Energy Company, Comanche Station. Each of PSCo's coal power–generating stations must comply with the U.S. Environmental Protection Agency's (USEPA) final Coal Combustion Residuals Rule. Groundwater monitoring of active CCR units is an integral part of compliance with the CCR Rule.

Data collection procedures for groundwater monitoring and laboratory analyses are described in the Groundwater Sampling and Analysis (GSA) Plan. The CCR Rule requires that eight samples are collected from each upgradient and downgradient well before October 17, 2017. In addition, the Rule requires that a groundwater monitoring report is placed in each facility's operating record no later than January 31, 2018, and annually thereafter. Subsequent to establishment of baseline groundwater conditions through 2017, the Rule requires continued monitoring during the active life of the CCR unit and the post-closure period. This document addresses the data management, data validation, and statistical procedures for evaluating data to select statistical method(s) required for evaluating groundwater monitoring data, as required by the CCR Rule and Consent Agreement No. RCRA-08-2022-0008.

2.0 Data Management

All project data and information must be documented in a format that is usable by project personnel. This section describes how project data and information will be documented, tracked, and managed, from generation in the field to final use and storage, in a manner that ensures data integrity and retrieval.

2.1 Data Package Deliverables

Data package deliverables for off-site analyses are listed below.

Sample Collection and Field Measurements Data Package Deliverables

Sample collection documentation will include field notebook and field form entries, field measurements, and Chain of Custody (COC) forms.

Field measurements will be taken by the sampling team for groundwater samples collected by low-flow sampling. The measurements are specific conductance, temperature, dissolved oxygen, pH, turbidity, and oxidation/reduction potential (ORP). All field and quality control (QC) sample results, calibrations, and calibration verifications will be recorded by the sampling team in a field logbook or on field forms. The logbook pages and forms will be scanned by the sampling team members and stored with other project data. The hard-copy versions of the field data will be filed by the sampling team members with other project data. The COCs will be scanned by the sampling team members, and the scanned file will be sent by the sampling team members to the Project Chemist (PC), who will save it with other project files.

Off-Site Laboratory Data Package Deliverables

The laboratory, TestAmerica, will perform data analysis as described in the GSA Plan. TestAmerica will provide laboratory data packages for each set of samples analyzed. Data and summary sufficient for the data validator to perform verification and data usability assessment are to be sent by email to the HDR PC within 6 weeks of receiving the sample. Delivery of a hard-copy data package will not be required.

TestAmerica will email the PC an analytical report and an electronic data deliverable (EDD) in the format requested by HDR for PSCo Comanche Station CCR compliance.

The information provided by the laboratory will be sufficient to review the data with respect to:

- Holding times and sample conditions
- Calibrations and instrument performance
- Detection/quantitation limits
- Spike and surrogate recoveries
- Duplicate analyses (laboratory duplicates and matrix spike [MS]/MS duplicates [MSD])
- Laboratory control sample (LCS)
- Blank contamination
- Target compound identification and quantitation

A laboratory report will be provided that includes the following hard-copy information for each analytical data package:

- Cover sheet listing the name and number of samples included in the report.
- Narrative comments describing problems encountered in analysis; identification of any analyses not meeting QC criteria, including holding times; and cautions regarding unusable data due to QC results that are outside the control limit.
- COC forms.
- Documentation of extraction, clean-up, and analytical methods used.
- Tabulated results of inorganic compounds identified and quantified, with analyte-specific detection limits. All analytes will be reported for each sample as a detected concentration or as not detected above the specific limits of quantitation, which must be stated. The laboratory will also report dilution factors, date of analysis, surrogate percent recoveries, batch run logs, and analytical batch number for each sample, with corresponding sample results.
- Analytical results for QC sample spikes, laboratory duplicates, initial and continuing calibration, verifications of standards and laboratory blanks, standard procedural blanks, LCSs, laboratory reference materials, inductively coupled plasma (ICP) interference check samples, and detection limit check samples.
- Documentation of rationale for the use of method of standard addition, if required.

Data reduction and QC review steps will be documented, signed, and dated by an authorized laboratory representative. Corresponding to each individual laboratory report, an EDD will be prepared and submitted along with the laboratory data package.

2.2 Data Handling and Management

This section describes computerized and manual procedures that trace the paths of all data from generation to final use and storage, as well as the associated quality checks for error detection that are performed to ensure data integrity.

Data Review

The laboratory will perform data review on each data package. The data review performed by the laboratory's Project Manager will make note of deficiencies and discrepancies and will be used to develop the case narrative that will be included in each data package. The laboratory will perform in-house analytical data reduction per the laboratory quality assurance manual. The data reduction steps will be documented, signed, and dated by the analyst.

Data verification and data validation will be performed by the PC, who will assign qualifiers as described in **Section 3.0**.

2.3 Data Tracking and Control

The project quality records will be maintained by HDR. These records, either electronic or hard copy in form, will include the following:

- Project work plans with any approved modifications, updates, and/or addendums
- Project Sampling SOP and Statistical Method Certification, with any approved modifications, updates, and/or addendums
- Field documentation
- COC records
- Laboratory documentation (results received from the laboratory will be documented both in hard-copy form and in an electronic format)
- Data validation and verification reports
- Final project reports and deliverables

Hard-copy field and laboratory records will be maintained in the project's central data file, where original field and laboratory documents are filed chronologically for future reference. These records are also scanned to produce electronic copies in portable document format (PDF). The electronic versions of these records will be maintained on an HDR server that has a routine backup schedule. All project records listed above will be maintained on file by HDR for a minimum of 5 years after completion of the work. Manages or similar database will be used to store and manage analytical data. Besides acting as a central data repository, the database will further facilitate data analysis and reporting. The information stored in the database will consist of sampling information (for example, sample identification, location, and sampling date and time), geotechnical data (for example, site lithology, well construction information, and groundwater elevation), and analytical chemistry data specified in different fields of the EDD format selected for the project.

Field data previously transferred from hard-copy documents into electronic files and laboratory EDDs will be reviewed for completeness and accuracy and qualified appropriately by the PC as part of the data-validation process. Data may be exported to other software as needed to facilitate review or statistical analysis.

2.3.1 Recordkeeping

The CCR Rule includes specific recordkeeping requirements at CCR 257.105(h). PSCo must place the following groundwater monitoring information, as it becomes available, in the facility's operating record:

- Annual groundwater monitoring and corrective action report
- Documentation of the design, installation, development, and decommissioning of any monitoring wells
- Groundwater monitoring system certification
- Selection of a statistical method certification
- Notification of establishing an assessment monitoring program

Additional recordkeeping requirements will apply should assessment monitoring and corrective action or closure be initiated.

2.3.2 Notification

The CCR Rule includes specific notification requirements at CCR 257.106(h). PSCo will notify the State Director and/or appropriate Tribal authority when the following groundwater monitoring information has been placed in the operating record and on the publicly accessible internet site:

- Annual groundwater monitoring and corrective action report
- Availability of the groundwater monitoring system certification
- Availability of the selection of a statistical method certification
- Notification that an assessment monitoring program has been established

Per the Consent Agreement, PSCo notifications to the State Director will also simultaneously be submitted to EPA. Additional notification requirements will apply should assessment monitoring and corrective action or closure be initiated.

3.0 Data Verification and Validation Inputs

This section describes the processes for data review and validation.

3.1 Field Data Review

The field data review will include verification that QC checks and calibrations are recorded properly in the field logbooks and/or data sheets and that any necessary and appropriate corrective actions were implemented and recorded. Such data will be written into field logbooks and/or data sheets immediately after measurements are taken. If errors are made, results will be legibly crossed out and corrected in a space adjacent to the original (erroneous) entry. Later, the appropriate Field Supervisor will review the field logbooks and/or data sheets to determine whether any transcription errors have been made by the sampling team. If transcription errors have been made, the appropriate Field Supervisor and sampling team will address the errors to provide resolution.

Field measurement data will be entered by field team members into electronic files for import to the project's database. Data entries will be made from the reviewed field data sheets or logbooks, and all data entries will be reviewed by a separate party before the electronic file is provided to the Database Manager. Electronic files of field measurement data will be maintained as part of the project's quality records.

Table 1 lists the field records that will be validated and verified and who is responsible.

3.2 Laboratory Data Review

Internal laboratory data-reduction procedures will be performed according to the laboratory's Quality Assurance Manual. Paper and electronic data files will be maintained by the laboratory for each sample for a minimum of 5 years to document the sample identification number and the sample tag number with sample results and other details, such as analytical method used, name of analyst, date of analysis, matrix sampled, reagent concentrations, instrument settings, and raw data.

The laboratory review process will include a review by the analyst, a second-level review by a supervisor or designee, and a completeness review by the laboratory's Project Manager prior to final data reporting. QC data (for example, laboratory duplicates, LCSs, MSs, and MSDs) will be compared to the acceptance criteria. The laboratory will appropriately flag unacceptable data in the data package.

Table 1 lists the analytical data package records that will be validated and verified and who is responsible.

Table 1. Data Verification and Validation Inputs

Item	Description	Verification (Completeness)	Who Will Verify	Validation (Conformance to Specifications)	Who Will Validate
Field Records					
1	Field logbooks	X	HDR Field Team Leader	X	HDR Project Chemist
1	Field equipment calibration records	X	HDR Field Team Leader	X	HDR Project Chemist
2	Chain-of-Custody forms	X	HDR Field Team Leader	X	HDR Project Chemist

Table 1. Data Verification and Validation Inputs					
Item	**Description**	**Verification (Completeness)**	**Who Will Verify**	**Validation (Conformance to Specifications)**	**Who Will Validate**
3	Field decontamination documentation	X	HDR Field Team Leader	X	HDR Project Chemist
4	Sample collection field forms	X	HDR Field Team Leader	X	HDR Project Chemist
5	Drilling logs	X	HDR Field Team Leader		
6	Well construction logs	X	HDR Field Team Leader		
7	Well development field forms	X	HDR Field Team Leader		
Analytical Data Package					
9	Cover sheet (laboratory identifying information)	X	HDR Project Chemist		
10	Case narrative	X	HDR Project Chemist	X	HDR Project Chemist
11	Internal laboratory Chain-of-Custody forms	X	HDR Project Chemist	X	HDR Project Chemist
12	Sample chronology and consistency (that is, dates and times of receipt, preparation, and analysis)	X	HDR Project Chemist	X	HDR Project Chemist
13	Communication records with laboratory	X	HDR Project Chemist		
14	EDD format consistency	X	HDR Project Chemist		HDR Project Chemist
15	Sample identification, results nomenclature, and data qualifier consistency	X	HDR Project Chemist		HDR Project Chemist
16	Method detection limit consistency	X	HDR Project Chemist	X	HDR Project Chemist
17	Instrument calibration records	X	HDR Project Chemist	X	HDR Project Chemist
18	Laboratory Report	X	HDR Project Chemist	X	HDR Project Chemist
19	Field QC sample results and calculation of accuracy and precision	X	HDR Project Chemist	X	HDR Project Chemist

3.3 Verification

Verification is a completeness check that is performed before the data review process continues in order to determine whether the required information was collected and is available. Verification is not designed for use in qualitative review but ensures the availability of sufficient information for subsequent steps of the data review process. Example inputs for conducting the completeness check are listed in **Table 1** above.

The following procedures will be completed by the PC for data verification:

- COC forms and shipping documents will be reviewed and verified for completeness and accuracy against the actual contents of the laboratory report and EDD.

- Field notes will be reviewed for completeness and accuracy by the PC prior to being placed in the site file and scanned into electronic files.

3.4 Data Validation

The purposes of data validation are to minimize suspect analytical data, designate a data qualifier for any data quality limitation discovered, and eliminate analytical data that do not pass validation acceptance criteria. A formal data validation will be performed by the PC and will include a review of field QC sample analyses and laboratory data. The PC will determine whether the measurement performance criteria have been met and will calculate the data completeness for the project.

3.4.1 Evaluating Field Data

The results of field QC sample analyses associated with each laboratory data package will be reviewed by the PC to evaluate equipment blanks and other field QC samples and further indications of the data quality. If a problem is identified through reviewing field QC data, all related field samples will be identified by the PC, and, if possible, corrective actions will be instituted and documented. If data are compromised because of a problem identified via field QC sample review, appropriate data qualifications will be used by the PC to identify the data for future data users.

The handling, preservation, and storage of samples collected during the sampling program will be monitored by the PC on an ongoing basis. The project laboratories will document sample receipt including proper containers and preservation at the time samples are logged into their individual laboratory. The sample receipt records (a required data package deliverable) as well as the COC documentation will also be assessed by the PC during data validation. Sample handling, storage, or preservation problems identified during data validation will result in appropriate qualification of data.

3.4.2 Evaluating Laboratory Data

Data verification will be performed by the PC on 100 percent of the data to ensure completeness of the data packages. The purpose of chemistry data validation is to verify that the data are of known quality, are technically valid, are defensible, and are usable for their intended purpose. The objectives of the data validation process are to:

- Verify completeness of data packages and corresponding EDDs.
- Assess compliance with project-specific procedures and programs.
- Evaluate system process control to ensure that no systematic errors exist within the data sets.
- Assess field QC samples to determine whether sampling has adversely affected the reported results and, therefore, usability.
- Assess both method and laboratory performance through tabulation of QC outliers.
- Provide measures of data quality in terms of precision, accuracy, and completeness so that overall usability can be determined.

Data validation will be performed by HDR using the general protocols and processes described in the following documents, as applicable:

- Guidance on Environmental Data Verification and Data Validation QA/G-8 (USEPA, 2002)

- Contract Laboratory Program National Functional Guidelines for Inorganic Data Review (USEPA, 2010) (as a general guidance and using professional judgment for the validation in support of or in the absence of method-specific direction)
- Guidance for Labeling Externally Validated Laboratory Analytical Data (USEPA, 2009a)
- EPA SOP HW-3b (USEPA, 2015)

The following specific QC elements will be reviewed during the validation:

- Presence and completeness of COC and sample receipt documentation
- Sample index (correlation of field sample identifier [ID] to laboratory sample ID)
- Laboratory case narrative (method deviations and QC anomalies)
- Analytical holding times
- Method blank
- MS and/or MSD recoveries
- MS/MSD relative percent difference (RPD) values
- Field duplicate RPD values
- Laboratory duplicate RPD values
- Summaries of initial and continuing calibration
- Summaries of instrument blanks (for example, internal calibration blank [ICB] and continuous calibration blank, if specified in the method)
- Interference check samples (ICP and ICP–mass spectrophotometry [ICP-MS])
- Review of LCSs
- Serial dilutions (ICP and ICP-MS)
- Post-digestion spikes
- Summaries of internal standards

Each data package will be accompanied by an EDD prepared by the laboratory. The content and format of laboratory EDDs have been specified in the Task Order between HDR and TestAmerica. Additional laboratory QC data can be included in the EDD as long as the data fields specified in the EDD are also maintained. EDDs will be cross checked by the PC against corresponding data reports to confirm consistency in the results reported in these two separate formats. The following data qualifiers will be applied during data validation by the PC:

U	The analyte was analyzed for, but was not detected at, a level greater than or equal to the level of the adjusted reporting limit (RL) for the sample and method.
J	The analyte was positively identified, and the associated numerical value is the approximate concentration of the analyte in the sample (due either to the quality of the data generated because certain QC criteria were not met, or to the concentration of the analyte being below the RL).
J+	Same as J, and the reported concentration is potentially biased high.
J–	Same as J, and the reported concentration is potentially biased low.
UJ	The analyte was not detected at a level greater than or equal to the adjusted method detection limit (MDL). However, the reported adjusted MDL is approximate and might be inaccurate or imprecise.
R	The sample results are unusable due to the quality of the data generated because certain criteria were not met. The analyte might or might not be present in the sample.

The above definitions are consistent with those described in the EPA SOP HW-2b (USEPA, 2015).

After the fieldwork and the final analytical data have been completed and reviewed by the PC, a Data Validation and Usability Report will be prepared by the PC for each sampling event. The report will summarize quality assurance and audit information, including the results of the data review; will evaluate field QC sample data, such as field duplicates; and will describe any corrective actions taken.

4.0 Data Usability Assessment

All data collected from the field activities will be evaluated against the following data quality parameters.

Precision

Precision refers to the degree to which repeated measurements are similar to one another when obtained under prescribed conditions. Precision will be assessed by evaluating the results of field duplicates to determine RPD and MS/MSDs. QC procedures and acceptance criteria are summarized in **Table 2**.

For precision:

RPD for MSD, and field duplicates percent RPD = $\left[\frac{|Amount\ in\ sample\ 1 - Amount\ in\ Sample\ 2|}{\underline{Amount\ in\ Sample\ 1 + Amount\ in\ samp \quad 2}}\right]\ x\ 100$

Accuracy

Accuracy is defined as the measure of the closeness of an individual measurement or the average of a number of measurements to the actual or “true” value. Laboratory accuracy will be assessed by evaluating LCSs and MSs and calculating the percent recovery (percentR). QC procedures and acceptance criteria are summarized in **Table 2**.

For accuracy:

Percent recovery for MS percentR = $\left(\frac{Spike\ conc. - Sample\ conc.}{Amount\ of\ spike\ added}\right)\ x\ 100$

Percent recovery for LCS percentR = $\left(\frac{Spike\ conc.}{Amount\ of\ spike\ added}\right)\ x\ 100$

<u>Representativeness</u>

Representativeness is defined as a measure of the degree to which data accurately and precisely represent the characteristics and conditions of the sample from which the measurement was taken. Field representativeness is evaluated through equipment blanks and review of sampling/ decontamination techniques. Target analytes should not be present in any blanks. Data may be qualified accordingly if target analytes are detected in blank samples.

<u>Completeness</u>

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount of data that was expected or planned for. A qualified datum will be considered unless it has been rejected (R), in which case it is unusable. The goal for completeness is 100 percent; however, a rejected (unusable) datum will be evaluated to determine whether data gaps exist or whether the project objectives were met without it.

For completeness:

Percent completeness = $\left(\frac{Number\ of\ usable\ measurements}{Number\ of\ planned\ measurements}\right)\ x\ 100$

A Data Validation and Usability Report will document the results of the data verification and validation for each sample event. This report will describe the conclusions made during the data assessment regarding data usability. Any limitations on the usability of the data will be explained, including the reasons for data qualifiers, the definitions of the qualifiers, and a summary of the specific acceptance criteria that were assessed and found to be outside control limits.

Table 2. Minimum QC Procedures for Project Parameters

Quality Check	Minimum Frequency	Acceptance Criteria	Corrective Action(s)
Metals by ICP-MS			
Laboratory control sample (percent recovery)*	One per analytical batch	75–125	Correct the problem, then reanalyze. If still out, reprep and reanalyze the LCS and all samples in the affected batch.
Laboratory matrix spike/matrix spike duplicate (percent recovery)*	One per analytical batch	75–125	Assess data to determine whether there is a matrix effect or analytical error. Analyze LCS for failed target analytes. Communicate matrix effects to the prime contractor so an evaluation can be made by the PC with respect to the project quality objectives.
Field duplicate relative percent difference	One per ten samples	20	Upon repeated nonconformance, field sampling personnel will be contacted to investigate proper sampling procedure.

Table 2. Minimum QC Procedures for Project Parameters			
Quality Check	**Minimum Frequency**	**Acceptance Criteria**	**Corrective Action(s)**
Field equipment blank	One per sampling event	No analytes detected >RL	Equipment rinsate blanks that contain analytes above RL require inspection of sampling and decontamination techniques to determine the source of residual contamination. Project action is required when excessive contamination is observed in equipment rinsate blanks.
Total Suspended Solids and Total Dissolved Solids			
Laboratory control sample (percent recovery)*	One per analytical batch	75–125	Correct the problem, then reanalyze. If still out, reprep and reanalyze the LCS and all samples in the affected batch.
Laboratory matrix spike/matrix spike duplicate (percent recovery)*	One per analytical batch	Not applicable	Not applicable.
Field duplicate relative percent difference	One per ten samples	20	Upon repeated nonconformance, field sampling personnel will be contacted to investigate proper sampling procedure.
Field equipment blank	One per sampling event	Not applicable	Not applicable.
Anions			
Laboratory control sample (percent recovery)*	One per analytical batch	75–125	Correct the problem, then reanalyze. If still out, reprep and reanalyze the LCS and all samples in the affected batch.
Laboratory matrix spike/matrix spike duplicate (percent recovery)*	One per analytical batch	75–125	Assess data to determine whether there is a matrix effect or analytical error. Analyze LCS for failed target analytes. Communicate matrix effects to the prime contractor so an evaluation can be made by the PC with respect to the project quality objectives.
Field duplicate relative percent difference	One per ten samples	20	Upon repeated nonconformance, field sampling personnel will be contacted to investigate proper sampling procedure.
Field equipment blank	One per sampling event	No analytes detected >RL	Equipment rinsate blanks that contain analytes above RL require inspection of sampling and decontamination techniques to determine the source of residual contamination. Project action is required when excessive contamination is observed in equipment rinsate blanks.
Radium 226/228			
Laboratory control sample (percent recovery)*	One per analytical batch	75–125	Correct the problem, then reanalyze If still out, reprep and reanalyze the LCS and all samples in the affected batch.
Laboratory matrix spike/matrix spike duplicate (percent recovery)*	One per analytical batch	75–125	Assess data to determine whether there is a matrix effect or analytical error. Analyze LCS for failed target analytes. Communicate matrix effects to the prime contractor so an evaluation can be made by the PC with respect to the project quality objectives.
Field duplicate relative percent difference	One per ten samples	20	Upon repeated nonconformance, field sampling personnel will be contacted to investigate proper sampling procedure.
Field equipment blank	One per sampling event	No analytes detected >RL	Equipment rinsate blanks that contain analytes above RL require inspection of sampling and decontamination techniques to determine the source of residual contamination. Project action is required when excessive contamination is observed in equipment rinsate blanks.

***** Other laboratory quality controls (for example, method blanks) will be completed following the laboratory quality assurance plan. The laboratory will be responsible for reporting the data verification codes on reports.

Table 3 contains the reporting limits and method detection limits for all Appendix III, Appendix IV, and total suspended solids constituents. Data validation includes confirming that the RLs and MDLs used in each sampling event match those listed in **Table 3**.

Table 3. Reporting and Method Limits for Appendix III, Appendix IV, and TSS

	RL	MDL	Units
Appendix III Constituents			
Boron	0.10	0.00145	mg/L
Calcium	0.20	0.0378	mg/L
Chloride	3.00	1.02	mg/L
Fluoride	0.50	0.165	mg/L
pH	0.10	-	SU
Sulfate	5.00	1.03	mg/L
Total Dissolved Solids (TDS)	10.00	4.7	mg/L
Appendix IV Constituents			
Antimony	0.0020	0.000400	mg/L
Arsenic	0.0050	0.000330	mg/L
Barium	0.0010	0.000290	mg/L
Beryllium	0.0010	0.000080	mg/L
Cadmium	0.0010	0.000265	mg/L
Chromium	0.0020	0.000500	mg/L
Cobalt	0.0010	0.000092	mg/L
Fluoride	0.5000	0.165000	mg/L
Lead	0.0010	0.000180	mg/L
Lithium (mg/l)	0.0200	0.009100	mg/L
Mercury	0.0002	0.000061	mg/L
Molybdenum	0.0020	0.000140	mg/L
Selenium	0.0050	0.000373	mg/L
Thallium	0.0010	0.000089	mg/L
Radium 226 and 228 combined	1.0000	-	pCi/L
Additional Parameters			
Total Suspended Solids (TSS)	4	1.1	mg/L

Laboratory Measurement Limits

In addition to the above data quality measures related to laboratory procedures, a step is taken to assess if the laboratory attained the lowest concentration level that could be reliably achieved for each constituent of interest. After this assessment, if some of the measurements do not meet quality standards as noted in 40 CFR 257.93(g), they will be sequestered from the current data set whether from background or downgradient well(s) and saved for future updates should data quality and quantity permit. The steps in the following Section 5 are statistical in nature and there is still potential to remove initially non-sequestered observations if deemed non-representative or not arising from field conditions.

According to 40 CFR 257.93 (g)(5), the CCR rule expects that “Any practical quantitation limit that is used in the statistical method shall be the lowest concentration level that can be reliability achieved within specified limits of precision and accuracy during routine laboratory operation conditions that are available to the facility”. With respect to the practical quantitation limit (PQL), Xcel conducts its statistical analysis of non-detect data referencing the method detection limit (MDL) and not the PQL or the reporting limit (RL).[1] To produce RLs, laboratories commonly multiply the MDL by a factor of 2 or more.[2] Since the MDL is based on documented statistical protocols, Xcel believes the MDL is a better representation of a censored value below which the laboratory cannot discern a reliable concentration. Measurements between the MDL and the RL are treated as J estimates and for statistical purposes, are treated as detects. Research by Helsel (2012) has demonstrated that use of the RL as the censored value below which all measurements are non-detects, introduces bias in the estimation of upper limits.[3]

To assess data quality and useability, the laboratory MDLs are compared in relation to available maximum contaminant levels (MCL) and whether samples were diluted prior to measurement. Laboratories adjust the MDL and RL values measured under no dilution by the dilution factor to reflect the change in measurement protocols. This adjustment can lead to MDL values and subsequently RL values being larger than MCLs where available.

Other factors that may impact data useability is the turbidity of the groundwater measured at the time of sampling. Turbidity values over a value of 10 NTU may confound total concentrations and increase total concentrations than what would be observed with lower groundwater turbidity.

Table 4 describes the potential conditions sample concentrations can exhibit when evaluating factors related to turbidity and high laboratory limits. Depending on the existence of these factors that may limit the useability of a concentration for establishing sample statistics, the observed value may progress through the statistical analysis or be sequestered until such time it can be shown to be representative of field conditions. The last column in Table 4 indicates whether an assessment as to an observation’s useability is required.

If the value is true, and depending on what key factors were true, investigations are made in relation to other measurements from the same well or near-by wells from the same gradient but measured under conditions where none or some of the factors are exhibited. If the sample in question is in the same range of these other measurements, there is evidence to potentially not sequester it. In addition to the data comparative analysis, if turbidity is greater than 10 NTU, the filtered version of the sample concentration is compared to the total concentration. If the concentrations are comparable, there is evidence that the sample in question can remain in the analysis.

To demonstrate the table’s logic, consider Condition 14 where a constituent was sampled under low turbidity conditions, yet the constituent was measured after dilution. Since no MCL is available for that constituent, no comparison of the MDL to the MCL can be made. For this condition, an initial assessment as to the sample’s useability is done. This includes evaluating if that constituent’s other

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[1] MDL is defined as the minimum concentration of a substance that can be measured and reported with 99% confidence that the analyte concentration is greater than zero. https://www.epa.gov/cwa-methods/method-detection-limit-frequent-questions

[2] Dennis R. Helsel, Statistics for Censored Environmental Data Using Minitab® and R (Hoboken, New Jersey: John Wiley & Sons, Inc., 2012), p. 28.

[3] Ibid., p. 29-33.

J estimates measured without dilution or confirmed detects (e.g., blank qualifier) are in the same numerical range. If it is, then the sample progresses through the statistical plan. If not, it will be sequestered.

For Condition 19, where the only factor that is exhibited is turbidity over 10 NTU, the initial assessment will consist of comparing the filtered concentration of a sample to that of its total concentration. If the filtered concentration is comparable to the total concentration, then the sample could remain in the dataset. In addition, if the well's other concentrations (or concentrations measured from near-by wells in the same gradient) are taken during lower turbidity conditions and are comparable to the assessed concentration, the sample can remain in the dataset.

Where conditions exist that initiate an assessment yet the concentration in question based on available evidence (e.g., filtered concentrations, other comparable concentrations collected from same well or other wells in same gradient, published literature, etc.), and professional judgement can remain in the dataset, notes as to the reasons why the value is useable will be documented. If in the future, factors that can impact data useability other than those included in Table 4 are identified, these factors will be included in the assessment's notes.

Whether the initial assessment for sample removal occurs at this stage or not, it is still possible that the sample can be removed during the subsequent statistical analysis as described in Section 5.

Table 4: Data Useability Decision Logic

Condition	Non-detect	**Turbidity > 10 NTU**	**MCL Available**	**Qualifier[1,2]**	**MDL > MCL**	**Dilution Factor > 1**	**Initial Assessment for Sample Removal**
1	FALSE	FALSE	FALSE	BLANK	NA[3]	FALSE	FALSE
2	FALSE	FALSE	FALSE	BLANK	NA	TRUE	FALSE
3	FALSE	FALSE	TRUE	BLANK	FALSE	FALSE	FALSE
4	FALSE	FALSE	TRUE	BLANK	FALSE	TRUE	FALSE
5	FALSE	FALSE	TRUE	BLANK	TRUE	FALSE	TRUE
6	FALSE	FALSE	TRUE	BLANK	TRUE	TRUE	TRUE
7	FALSE	TRUE	FALSE	BLANK	NA	FALSE	TRUE
8	FALSE	TRUE	FALSE	BLANK	NA	TRUE	TRUE
9	FALSE	TRUE	TRUE	BLANK	FALSE	FALSE	TRUE
10	FALSE	TRUE	TRUE	BLANK	FALSE	TRUE	TRUE
11	FALSE	TRUE	TRUE	BLANK	TRUE	FALSE	TRUE
12	FALSE	TRUE	TRUE	BLANK	TRUE	TRUE	TRUE
13	FALSE	FALSE	FALSE	J, J^-,J^+	NA	FALSE	FALSE
14	FALSE	FALSE	FALSE	J, J^-,J^+	NA	TRUE	TRUE
15	FALSE	FALSE	TRUE	J, J^-,J^+	FALSE	FALSE	FALSE
16	FALSE	FALSE	TRUE	J, J^-,J^+	FALSE	TRUE	FALSE
17	FALSE	FALSE	TRUE	J, J^-,J^+	TRUE	FALSE	TRUE
18	FALSE	FALSE	TRUE	J, J^-,J^+	TRUE	TRUE	TRUE
19	FALSE	TRUE	FALSE	J, J^-,J^+	NA	FALSE	TRUE

Table 4: Data Useability Decision Logic

Condition	Non-detect	**Turbidity > 10 NTU**	**MCL Available**	**Qualifier[1,2]**	**MDL > MCL**	**Dilution Factor > 1**	**Initial Assessment for Sample Removal**
20	FALSE	TRUE	FALSE	J, J^-,J^+	NA	TRUE	TRUE
21	FALSE	TRUE	TRUE	J, J^-,J^+	FALSE	FALSE	TRUE
22	FALSE	TRUE	TRUE	J, J^-,J^+	FALSE	TRUE	TRUE
23	FALSE	TRUE	TRUE	J, J^-,J^+	TRUE	FALSE	TRUE
24	FALSE	TRUE	TRUE	J, J^-,J^+	TRUE	TRUE	TRUE
25	TRUE	FALSE	FALSE	U	NA	FALSE	FALSE
26	TRUE	FALSE	FALSE	U	NA	TRUE	TRUE
27	TRUE	FALSE	TRUE	U	FALSE	FALSE	FALSE
28	TRUE	FALSE	TRUE	U	FALSE	TRUE	FALSE
29	TRUE	FALSE	TRUE	U	TRUE	FALSE	TRUE
30	TRUE	FALSE	TRUE	U	TRUE	TRUE	TRUE
31	TRUE	TRUE	FALSE	U	NA	FALSE	TRUE
32	TRUE	TRUE	FALSE	U	NA	TRUE	TRUE
33	TRUE	TRUE	TRUE	U	FALSE	FALSE	TRUE
34	TRUE	TRUE	TRUE	U	FALSE	TRUE	TRUE
35	TRUE	TRUE	TRUE	U	TRUE	FALSE	TRUE
36	TRUE	TRUE	TRUE	U	TRUE	TRUE	TRUE

[1]A qualifier with values of J, J-,J+ is a detect for statistical purposes.
[2]If sample has at least one U qualifier, sample is a non-detect.
[3]No available MCL

5.0 Statistical Analysis

Monitoring will include analyzing groundwater data and groundwater levels from wells upgradient and downgradient of the CCR facilities at Comanche Station. The Groundwater Monitoring System Plan (GMS) describes the hydrogeologic characterization and rationale for the upgradient and downgradient sample locations.

This section provides the methodology to statistically evaluate the groundwater data, select appropriate statistical method(s), and develop the appropriate background threshold values (BTVs)[4] for Appendix III and Appendix IV constituents of interest (COIs) identified in the United States Environmental Protection Agency's Disposal of Coal Combustion Residuals From Electric Utilities Final Rule (CCR Rule). The CCR Rule is formally promulgated in the U.S. Code of Federal

[4] The CCR Rule does not include the term "background threshold value" or any specific term to represent the upper prediction limit, the upper tolerance limit or the control limit other than references to the "background value", "background constituent concentration levels" or "background concentration". The EPA's ProUCL documentation uses the term "background threshold value" with explicit reference to upper prediction and upper tolerance limits throughout the documentation. For ease of reference in our planning document, we chose to use the EPA's terminology. Note that a BTV is not a fixed value. It is a statistical test for determining if there is an SSI from a groundwater sample taken at a downgradient well. Its value may change as background sample sizes change over time or if changes are made to the number of downgradient wells.

Regulations (CFR), Title 40, Parts 257 and 261 (USEPA, 2015). The 40 CFR 257.93(f) includes a list of statistical methods from which to choose for evaluating the groundwater monitoring data from CCR management areas. The options include:

- A parametric analysis of variance followed by multiple comparison.
- An analysis of variance based on ranks followed by multiple comparison procedures.
- A tolerance or prediction interval procedure, in which an interval for each constituent is established from the distribution of the background data and the level of each constituent in each compliance well is compared to the upper tolerance or prediction limit.
- A control chart approach that gives control limits for each constituent.
- Another statistical test method that meets the performance of 40 CFR 257.93(g).

The goal of statistical analysis is to provide a quantified means to evaluate whether a CCR management unit has released contaminants into the groundwater. Following the collection of groundwater monitoring data, detected constituents will be statistically evaluated to identify if a statistically significant increase (SSI) over background has occurred. The software application R[5], including use of its Envstats[6] R package and SPSS[7] will be used to conduct statistical analysis of groundwater analytical data. However, if during the period of the groundwater monitoring program an updated or more comprehensive statistical software program is available or may become available, a different software program may be used.

The steps for this process are summarized in **Error! Reference source not found.** and are described in sections 5.1 and 5.2. As groundwater monitoring progresses, the use of the selected statistical method will be subject to ongoing review. Other statistical tests may be used in place of, or in addition to, the methods specified in this Statistical Procedures Plan if such methods are better suited for analysis of future results. If test methods are changed, this Statistical Procedures Plan will be revised, as appropriate, and its certification updated.

When developing the BTVs for the Appendix III and IV constituents at sites with multiple background wells, the data from the background wells will be evaluated to determine if it is appropriate to conduct an *interwell* analysis and pool the background groundwater data from multiple wells to develop a single BTV for each constituent. The assumption for pooling groundwater data is that the constituent concentrations sampled at multiple background wells, when pooled, serve as an estimate of overall well field conditions for Appendix III and IV constituents at a given site.

Section 5.1 describes the statistical analyses used to assess and transform the groundwater data from the background monitoring wells where necessary such that the data can be used to produce appropriate BTVs and conduct statistical tests. This stage is referred to as the preliminary data analysis. Consideration is given to issues related to outliers, serial correlation, seasonality, spatial variability, and trends. It may be necessary to test for differences in group means across sub-groups of samples to verify assumptions or to add new groundwater samples to existing samples. For

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[5] R: A Language and Environment for Statistical Computing, R Core Team, R Foundation for Statistical Computing, Vienna, Austria, 2022, R version 4.2.1 (2022-06-23 ucrt), https://www.R-project.org .

[6] Millard, S. (2013). EnvStats: An R Package for Environmental Statistics. Springer, New York. ISBN 978-1-4614-8455-4

[7] IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 27.0. Armonk, NY: IBM Corp.

example, sub-group testing can be used to determine if background groundwater concentrations are changing over time or background groundwater concentrations are different by season. These differences are important since they determine if new background data can be pooled with historical data or if deseasonalization of the data is required.

Section 5.2 contains the steps to estimate statistically significant increases (SSIs) over background or statistically significant levels (SSLs) over a groundwater protection standard (GPS) where relevant for each of the detection, assessment and closure phases of the CCR Rule. A suite of prediction limits, tolerance limits, and confidence limits are used to address the statistical test requirements covered through parts 40 CFR 257.93, 257.94, 257.95, and 257.102.

As recommended by the EPA Unified Guidance (2009b), upper prediction limits (UPLs) are proposed to be used to establish BTVs for each of the Appendix III and IV constituents at each site for the purposes of complying with the detection monitoring requirements to confirm SSIs or with the assessment monitoring requirements to confirm if the owner or operator may return to detection monitoring.

The assessment monitoring phase also includes a requirement to compare Appendix IV constituents from downgradient wells to their groundwater protection standards (GPS) (40 CFR 257.95(g)). For constituents which do not have a GPS such as a maximum contaminant levels (MCLs), the Unified Guidance (2009b) recommends using the upper tolerance limits (UTLs) estimated from the background samples as statistically equivalent BTVs. The results of the evaluation as to whether or not an Appendix IV constituent is above its GPS based on SSLs determines if the CCR Unit remains in assessment monitoring or moves into corrective action.

A decision flow chart which summarizes the logic and statistical methods used to determine which groundwater data are suitable to establish or update background and which types of BTVs can be used to describe background levels is shown in **Figure 1** below.

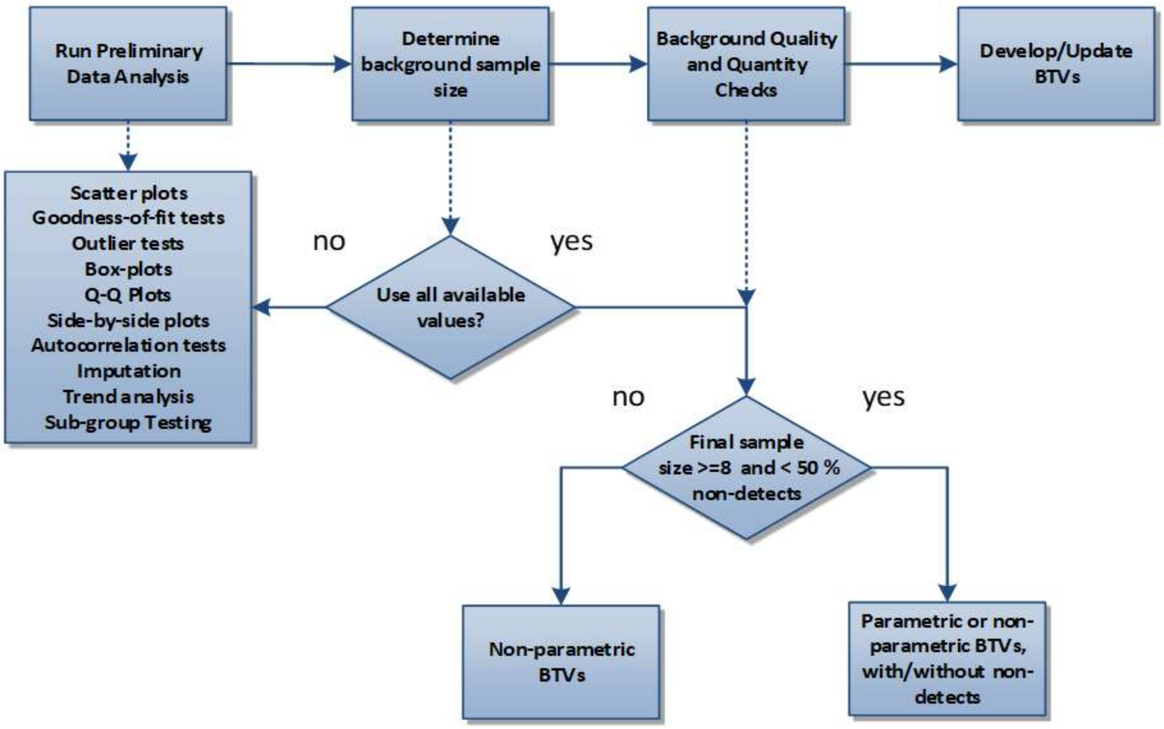

Figure 1. Decision Flow Chart for Preliminary Data Analysis and BTVs

The decision flow diagram allows for updates to the BTVs as samples from the background wells continue to be collected at either the scheduled semi-annual or annual sampling events, depending on the quality or quantity of the samples. While the initial required 8 sampling events prior to October 17, 2017 provide the minimum number of samples from which to estimate BTVs[8], as additional samples are collected, the BTVs can be updated at scheduled time intervals. In that way, the BTVs may change periodically.

5.1 Preliminary Data Analysis

The CCR Rule references requirements that statistical assumptions and data quality conditions associated with the test procedures are validated as described in 40 CFR 257.93 (g)(5)(6). A preliminary data analysis (PDA) is conducted to confirm such assumptions and bring awareness to the quality of data at the time background concentrations are estimated. A type of statistical analyses to support sub-group testing of differences in population means and medians is given special treatment at the end of this section as different aspects of the PDA will draw from it depending on the purpose of the statistical testing collected from the upgradient and downgradient wells.

[8] "The Unified Guidance recommends that a minimum of at least 8 to 10 independent background observations be collected before running most statistical tests. Although still a small sample size by statistical standards, these levels allow for minimally acceptable estimates of variability and evaluation of trend and goodness-of fit. However, this recommendation should be considered a temporary minimum until additional background sampling can be conducted and the background sample size enlarged", page 5-3.

a. Descriptive Statistics

Descriptive statistics will be developed per constituent from the background monitoring well and where there are multiple background wells, from the data pooled across the multiple wells. With respect to the downgradient monitoring wells, descriptive statistics will be developed per well per constituent within a location. The purpose of descriptive analysis is to characterize data and assess quality of information. The following descriptive statistics will be produced.

- Sample size
- Number of detects
- Percentage of detects
- Number of non-detects
- Percentage of non-detects
- Number of distinct observations
- Number of distinct MDLs
- Range of collection period in months: Difference between last sampling date and first sampling date
- Mean
- Median
- Minimum
- Maximum
- Standard deviation
- Coefficient of variation
- Skewness
- Kurtosis

b. Graphical Analysis

Scatter plots of observations will be produced as a function of time. Different colors will be used to differentiate detects from non-detects (NDs). The graphs visually provide clues as to whether the period of record is reflective of a steady-state baseline period. The graphs should be evaluated to determine if all data can be incorporated into analysis or if older historical data may need to be dropped (multiple detection limits over time may affect usability of the data). Outliers and seasonality can also be visually detected. Further statistical tests will need to be conducted to confirm assumptions from visual inspections.

c. Identify Outliers

A statistical outlier is defined as a value originating from a different statistical population than the rest of the sample. Outliers or observations not derived from the same population as the rest of the sample violate the basic statistical assumption of identically distributed measurements. If an outlier is suspected, options such as producing a probability plot of the ordered sample data versus the standardized normal distribution can be helpful, as well as, identifying observations that are greater than three standard deviations from the mean or visually inspecting box-and-whisker plots for values that are greater than three times the interquartile range above the third quartile. Such exceedances can be flagged as potential outliers.

Two tests will be used to test for possible outliers. Dixon's Outlier Test is appropriate for data series with sample sizes less than 25, and Rosner's Outlier Test is applicable to those with a sample size larger than 25. These outlier tests assume that the rest of the data except for the suspect observation(s) are normally distributed.

If outliers are found from the tests, the anomalous numbers will be investigated. If they are correct values and collected under standard, consistent protocols, they should remain in the data series. Otherwise, they can be dropped before proceeding. Some distributions naturally have anomalously low or high values. The subsequent tests for distribution types should find the best fitting distribution that can explain the anomalous values.

While some literature suggests repeating the statistical procedures with and without the outliers, the risk of this method is that the estimated distributions and statistics tend to be chosen to suit a goal. After a comparison of the estimates is made, a decision needs to be made as to which data set is representative. The decision to use or reject outliers will be done at the data collection and assessment stage. An example would be where a sample was qualified as "J+" (biased high), due to equipment blank contamination. If such a sample was seen as an outlier, it may be possible to eliminate it from further analysis for this reason. If there is a doubt as to the authenticity and reliability of the measured value, it should not be used. Otherwise, it is a value that was generated by the system regulating the water quality conditions of the tested groundwater well.

d. Identify Distributions

Since many tests make an explicit assumption concerning the distribution represented by the sample data, the form and exact type of distribution must be checked using a goodness-of-fit (GOF) test. A goodness-of-fit test assesses how closely the observed sample data resemble a proposed distributional model. The best goodness-of-fit tests attempt to assess whether the sample data closely resemble the tails of the candidate distributional model. The models under consideration for water quality samples are normal, lognormal, or gamma distributions.

The Shapiro-Wilk and Lilliefors tests will be used to test for normal distribution. Note that these two tests can be used to test for lognormal distributions after the data are transformed using the natural log function. The empirical distribution function (EDF) based methods, the Kolmogorov-Smirnov (K-S) and Anderson-Darling (A-D) test, are used to test for a gamma distribution. For determining whether the data fit an assumed distribution, the five percent level of significance is used. If all GOF tests fail, a non-parametric estimation method will be used.

The process of conducing GOF tests can produce results that show more than one parametric distribution fits the data. A decision logic is proposed that balances research that the gamma distribution is an appropriate distribution to describe variability in groundwater constituent concentrations with the risk of using small sample sizes (with often high levels of variability) to identify the appropriate distribution based on GOF tests.

With respect to small samples with less than 10 observations, GOF tests have sufficient data on which to calculate tests statistics such as critical values and probability values. Since tests are conducted at the five percent test significance level, the statistical power to correctly reject that the distribution is not parametric (in particular for tests of normality) may be low. HDR will review outcomes where parametric distributions have fit the data with small sample sizes by assessing the probability values and measure of sample skewness supplemented by visual adds such as histograms and boxplots to assess distributional fit.

Table 5 contains the logic used to determine which distribution is used to model sample statistics such as upper prediction or tolerance limits. When multiple distributions can appropriately fit the data, a determining factor is the level of sample skewness. USEPA's ProUCL Technical Guide (Singh and Singh 2015) has categorized skewness levels based on the standard deviation (sd) of the natural- logarithm (logged) of the detected data. When the sd of the logged data is less than one (<1), then the data set is symmetrically to mildly skewed; otherwise, it is moderately to highly skewed. When sample sets have symmetric to mild skewness and multiple distributions fit the data at the 5 percent level of significance, the normal takes presence as the recommended distribution. Sample sets with moderate or higher skewness levels are better described by a skewed distribution such as the gamma or lognormal distributions. However, the ProUCL Technical Guide has cautioned against using the lognormal distribution when the sd of logged values is greater than one due to the possibility of extremely high estimates for upper limits. This guidance is also considered for this procedures plan. In the table below, a FALSE indicates that the sample does not exhibit the column specific condition, while a TRUE indicates that is does. For example, for conditions one and two, since none of the three tested distributions pass the GOF test and regardless of the sd of logged detected data, a nonparametric distribution is assumed. For condition 11, since both gamma and normal pass the GOF test and the sd of the logged detected data is less than one, the normal distribution is recommended.

Table 5. Distribution Decision Logic

Condition	Gamma	Lognormal	Normal	sd logged detected data >= 1	Recommended Distribution
1	FALSE	FALSE	FALSE	FALSE	Nonparametric
2	FALSE	FALSE	FALSE	TRUE	Nonparametric
3	FALSE	FALSE	TRUE	FALSE	Normal
4	FALSE	FALSE	TRUE	TRUE	Normal
5	FALSE	TRUE	FALSE	FALSE	Lognormal
6	FALSE	TRUE	FALSE	TRUE	Nonparametric
7	FALSE	TRUE	TRUE	FALSE	Normal
8	FALSE	TRUE	TRUE	TRUE	Normal
9	TRUE	FALSE	FALSE	FALSE	Gamma
10	TRUE	FALSE	FALSE	TRUE	Gamma
11	TRUE	FALSE	TRUE	FALSE	Normal
12	TRUE	FALSE	TRUE	TRUE	Gamma
13	TRUE	TRUE	FALSE	FALSE	Gamma
14	TRUE	TRUE	FALSE	TRUE	Gamma
15	TRUE	TRUE	TRUE	FALSE	Normal
16	TRUE	TRUE	TRUE	TRUE	Gamma

e. Test for Spatial Variability

Spatial variability exists when the distribution or pattern of concentration measurements changes from well location to well location, either from natural or anthropogenic factors. Natural spatial variability refers to a pattern of changing mean levels in groundwater associated with normal geochemical conditions unaffected by human activities such as variation in contents of COIs in the soil and variation in geochemical conditions resulting in different solubility of COIs. Natural spatial variability is not an indication of groundwater contamination, even if concentrations at one or more compliance wells exceed (upgradient) background concentrations. Sources of anthropogenic spatial variability can include recent or historic releases from an on-site source or migration of contaminants from off-site sources. In groundwater monitoring, *mean or median* levels of a given constituent are usually compared from one well to the next to determine if natural or anthropogenic spatial variability is present[9]. Side-by-side box-and-whisker plots will be developed for each constituent at each well where data permit to evaluate the potential for natural spatial variability in the upgradient wells. If sufficient data are available on a per well basis, sub-group testing for differences in population means and medians will be conducted as described in section (i) below. Results indicating statistically significant differences among the multiple background wells will be noted; however, these results alone, and especially in light of the smaller sample sizes available from groundwater monitoring, are not sufficient to rule out a well or wells for the purpose of conducting an interwell analysis for the reasons explained above.

f. Test for Serial Correlation

Sources for serial correlation in water samples can be due to seasonal effects or temporal effects related to the timing of the sample collections. Trend analysis using regression techniques of a water quality constituent sampled over time is confounded if the data exhibits serial correlation. The regression errors from adjacent observations may be correlated. For example, if the residual from a given month's observation is high, then it is likely that the residual from the next month's observation will also be high. The same logic follows for low residuals giving rise to other low residuals. This type of correlation is referred to as serial correlation or autocorrelation. The autocorrelation function test will be run at the 1 percent level of significance.

g. Test for Seasonality

As explained in the previous paragraph, there are different reasons why a series of water quality constituent samples exhibit serial correlation. A common reason arises from changes in season as evidenced from varying temperatures and precipitation. These changes impact water quality constituents in a predictable and cyclical manner over the months. The study of water quality changes over time is focused on the ability to discern true trend through regression analysis amidst the cyclical nature of the data or its "seasonality". The correct use of these regression analyses rests on the crucial assumption that regression errors or residuals arising from the model fitting are independent of each other. This is often not the case with data that is seasonal in nature. If seasonality exists, then the autocorrelation function test described in step "f" will pick up the pattern. To better understand the type of seasonality (monthly, quarterly, bi-annually) which factors into the observed variability of data, a visual inspection of the data as a function of time is recommended.

Box-and-whisker plots of observations on a monthly or quarterly basis will be developed (provided one has at least 8-10 observations per sampling period). These results will be used to determine how to group the data into seasons. If sufficient data are available on a per season basis, sub-group

[9] Analysis of variance (ANOVA) techniques (see Section 5.1 for details on these techniques) can also be used to establish evidence of spatial variation. If there is evidence of spatial variation, the Unified Guidance recommends using an intrawell statistical analysis instead of an interwell analysis. For an intrawell analysis to be meaningful at the downgradient sites, samples would have had to be taken prior to human activity such the installation of ash basins or ponds. Since the activity has occurred, it is important that the selection of groundwater wells at both upgradient and downgradient sites be done to minimize spatial variability to the extent possible for the purpose of conducting an interwell analysis.

testing for differences in population means and medians will be conducted as described in sub-section (i) below.

h. Test for Trend

The samples from background wells represent water quality conditions exhibiting natural variability and unaffected by anthropogenic activities. As such, the measurements taken at regular intervals over time (three or more years) are expected to demonstrate a steady or stationary time series. Provided the data has more than 50 percent detected observations, the data from the background wells will be tested to determine whether trends exist (values steadily increasing or steadily decreasing). Depending on whether the data follow parametric or non-parametric distributions), one of the following linear regression tests will be selected:

- Maximum Likelihood Estimation (MLE) Regression (parametric, with or without NDs)
- Mann-Kendall (non-parametric, with or without NDs, 1 distinct value for MDL)

Both methods assume there is no seasonality in the data or if there is, the data have been deseasonalized prior to estimating average trend.

After the first initial one or two years of sampling from background wells in which a minimum of eight samples is collected, initial trends based on the first eight sampling events may change over time as additional sampling is completed. Generally, linear regression approaches detect monotonic trends and do not account for the existence of structural breaks in a parameter's time-series of observations. Linear regression attempts to fit an "average" trend based on the patterns in the observations.

A structural break may occur when the trend changes its magnitude, direction, or significance over time. As with the case with samples of groundwater quality data, the patterns can be highly erratic and generally do not follow strictly linear trends over time. A statistically significant upwards or downwards trend does not as a rule identify when groundwater quality conditions changed. The piece-wise polynomial regression approach can augment the results of the trend analysis.

Piece-wise polynomial regression has proven useful in circumstances when changes in trend may occur within the time-series for a constituent. The model provides another line of evidence that may be performed should environmental conditions or other factors indicate shifts in trends may have occurred. This approach attempts to find an appropriate mathematical model to express the relationship between the constituent's values and the sampling dates by using piece-wise regressions.

Examples of two types of piece-wise models for studying trends include the: linear-linear model and linear-linear-linear model. The linear-linear regression model assumes and identifies one structural break in a constituent's data series, in which the two portions of the data separated by the break point follow two different trends as modeled by two different linear equations. Similarly, the linear-linear-linear model attempts to identify two structural breaks to separate three different linear trends.

The piece-wise models since they do not account for censorship or if the data follow non-parametric distributions can be applied mainly as a visual guide to identify changes in trend that may have occurred within the time-series of a constituent.

For the breaks in a time-series to be meaningful, at least eight observations per segment are available. Assessment to changes in the average trend will be done at a minimum after the second set of eight observations are collected from the background site. The pooled data will be evaluated for overall average linear trend (i.e., linear regression) and for structural breaks (i.e., piece-wise linear regression) in the pooled data over time.

The approximate date of a structural break should one be statistically significant will be used to determine if factors post-structural break date may have contributed to the change in the trend relative to the initial background data trend.

A risk in using linear or piece-wise regression analyses for the small datasets available to assess variability of overall well field conditions is that trends or structural breaks may be outcomes of spurious, shorter-term trends and that a longer time-series (e.g., 10 years or more of sampling events) would better represent overall trend patterns.

To mitigate this risk, anthropogenic, environmental, well installation methods, laboratory measurement protocols, or other factors will be determining factors as to whether or not older background sampling events should be removed, and background data is updated with the latest data.

If such external factors can be corroborated, provided there are at least eight observations in the latest available data post-structural break date, and the average of that data is statistically different from the average of previous background reference values (see Section 5.1i for statistical methods to test for differences in sub-groups), background data will be updated using the latest available data.

i. Test for Sub-Group Testing

When assessing if concentration means or medians are statistically different across wells, seasons or between two different background collection periods, various statistical procedures are available. This section describes the tests which may be used depending on the nature of the data and number of tests required. A significance level of 1 percent is used to decide whether to accept or reject the null hypothesis that there are no differences across the sub-group means or medians. In instances where multiple comparisons are made, adjustments will be incorporated to control for false positive rate (e.g., Bonferroni's adjustment) or statistical tests used with built-in functionality to address the multiple comparison issue (e.g., Tukey-Kramer test).

Before proceeding to test for differences across the sub-group means, one needs a sufficient sample size of at least 8-10 samples per sub-group. Testing for sub-groups can be done in three steps: 1. Graphical analysis, 2. Hypothesis tests for sub-group differences, and 3. Tests to identify which sub-groups are different.

Graphical Analysis

Background groundwater data can be assessed for sub-groups using graphical representation tools such as box-and-whisker plots. Multiple box-and-whisker plots can be constructed for comparing constituent concentrations and variability across potential sub-groups. Investigations may be done using Q-Q plots, if necessary, to supplement findings based on box-and-whisker plots.

Hypothesis Tests for Sub-Group Differences

The following methods can be used to detect for population differences across the sub-groups:

- ANOVA (under normal distribution assumptions)
- Log-ANOVA (under log-normal distribution assumptions)

- Kruskal-Wallis One-Way Analysis on Ranks (distribution free assumptions/non-parametric, presence of non-detects, corrected for ties)
- Kaplan-Meir (non-parametric, useful with heavy censoring).

The decision as to which test to use is predicated on the presence of censorship and whether the distribution follows a parametric distribution of either normal, log-normal, or gamma type or does not have a discernible distribution and hence is non-parametric. Note that the Log-ANOVA is simply the ANOVA approach applied to the natural-logarithm of the time series.

The ANOVA tests require that normality assumptions are valid for each sub-group. In addition, the variances across the groups should be approximately equal.

Testing for potential sub-groups within background groundwater data sets will be performed using a significance level of 1 percent.

<u>Tests to Identify Which Sub-Groups Are Different</u>

Provided any of the tests described above show sub-group differences, further tests may be performed to identify which sub-group(s) is different from the others provided each sub-group has at least 20-30 observations.

- Post-Hoc Test for Multiple Comparisons
  - Tukey-Kramer Test (parametric)
  - Dunn's Test (non-parametric)

5.2 Background Threshold Values

Using the upgradient data from the background well(s) specific to each CCR unit (for example at the time of this update, wells MW-3, MW-4B, and MW-6 for the landfill and W-2C for the Bottom Ash Pond), the appropriate BTVs will be computed for each constituent. If a site has more than one background well, the upgradient data are defined by data pooled over the wells, as appropriate.

As recommended in the Unified Guidance (2009b), background values should be updated every four to eight measurements (e.g., every two to four years if samples are collected semiannually). New background groundwater data will be evaluated against the existing background dataset, as appropriate. If the new background data does not indicate a statistically significant difference using the approaches described in the trend testing section 5.1(h) and sub-group testing section 5.1(i), the new data will be combined with the existing background data to calculate updated BTVs. Increasing the background dataset will increase the power of subsequent statistical tests. If the new background data do indicate a significant difference between the two populations, the data should be reviewed to evaluate the cause of the difference. In the absence of evidence of a release, the combined dataset should be considered more representative of present-day groundwater conditions and used for background. Details as to the steps taken to determine if newer sampling events can be combined with previously established background sampling events are as follows:

5.2.1 Updating Background Threshold Values

Analysis to update published BTVs will be done at a minimum after eight sampling events have been collected per well or if there is a change to the background wells.

The analysis includes tests of differences in averages between the previously established background sampling events and the newer sampling events per constituent. An evaluation of the concentration trends over time using all data collected to date will be done. To provide context to observed patterns in the concentrations over time and with interest in differences in patterns since the establishment of published BTVs, investigations will be done to check if anthropogenic activities, changes to laboratory protocols, climate events or other factors have occurred during the time since the publication of the current BTVs.

Given the smaller sample sizes available for updating and that the sample size may not capture the full natural variability in concentrations over time, interpretation of inferential test results will be informed by outlier tests (Section 5.1(c)) and trend tests (Section 5.1 (h)) of the pooled data, sub-group testing (Section 5.1(i)) between the data from the sampling events pre- and post-current BTV publication.

A discussion will be included that evaluates the sets of constituents that had statistically significant differences as to whether the differences are due to a change in the hydrogeology of the site's groundwater system or reflect the natural variability in concentrations or trends. Changes to the inclusion or exclusion of sampling events will be consistently applied across the constituent-well pairs at the site. This does not preclude removal of specific data observations that are deemed to be erroneous or not representative of groundwater conditions (e.g., observation collected during high turbidity).

If both statistical and environmental evidence suggests a shift in the background reference values at the site level at some point since the initial background sampling event (including the point in time since the publication of the current BTVs), the most recent data (with a minimum of eight samples) will be combined with previously collected data should the shift in site conditions occurred during the last background reference period. If not, the latest set of sampling events will be used exclusively to update the BTVs.

If there is not sufficient evidence to support field conditions shift in concentrations since the publication of the current BTVs, the background reference concentrations will be updated to include data from the latest set of eight or more sampling events.

For the situation where there are changes to the background wells the process to establish BTVs will anew, and all the data collected for the new background wells will be used.

Whichever sampling events or wells are used to define the background reference period, the statistical process described in this plan will be applied to that data.

5.2.2 Detection Monitoring

Under the detection monitoring programs of 40 CFR 257.94, Appendix III monitoring results will be statistically compared to BTVs through interwell statistical methods. As recommended by the Unified Guidance (2009b), the statistical test to define the BTV for detection monitoring is the upper prediction limit. The formulation of the prediction limit may vary slightly with the particulars of the test to be made and the characteristics of the data involved such as whether the data follow parametric or non-parametric distributions and the percentage of NDs. For example, if the recommended distribution follows a normal distribution according to Table 4, a normal-based parametric prediction interval is used. If the recommended distribution follows a gamma distribution, then a gamma-based parametric prediction interval is used, and if the recommended distribution is lognormal, then a lognormal-parametric prediction interval is used. If the data cannot be explained by parametric distributions, a non-parametric prediction interval on the median is used.

The confidence level associated with each upper prediction limit test is selected such that the site-wide false positive rate does not exceed 10 percent as recommended by the Unified Guidance (2009b). The achieved per-test confidence levels will typically range between 95 and 99 percent. Whatever the formula specification, prediction limits represent a range where a future result is expected to lie at a given confidence level. Both the upper and lower prediction limits (LPL) will be produced for pH since lower and higher pH values relative to background are of concern.

Determination of Statistically Significant Increases above Background

If the groundwater concentration of any Appendix III constituent at any downgradient well is greater than the BTV, that is, the UPL, then that concentration represents an SSI over background. One exception is pH, which can exhibit an SSI if the concentration in a monitoring well is either greater than the UPL or less than the LPL.

The CCR Rule, as described in 40 CFR 257.94(e), indicates that if an SSI over background is identified at the waste boundary for one or more Appendix III constituents during detection monitoring, then the owner or operator of the CCR unit must, within 90 days: 1) establish an assessment monitoring program, 2) demonstrate that a source other than the CCR unit caused the SSI over background, or 3) demonstrate that the SSI over background resulted from error in sampling, analysis, statistical evaluation, or natural variation in groundwater quality. Written documentation for either demonstration above must be completed and certified by a qualified professional engineer within the 90-day timeframe.

If sources other than the CCR Unit, natural variation or errors have been ruled out as the reason for the exceedance above the BTV, a type of verification sampling method called the one-of-m pass method, as described in the Unified Guidance (2009b), allows for an efficient plan to confirm if the initial exceedance over background identified during detection monitoring resulted from the CCR unit. Resampling of wells where an exceedance has occurred can either verify the initial exceedance after a planned number of additional samples or disconfirm it, thereby reducing false positives.

Depending on the number of background samples, the selected site-wide false positive rate, and the 90-day time period in which to do the resampling (according to 40 CFR 257.94(e)(2)), either a 1-of-2 or 3 pass method is recommended should verification sampling be considered.

To allow for verification sampling should the opportunity become available, UPLs are based on the 1-of-m plan. Initial exceedances are technically not SSIs until the verification sampling is initiated. However, as a conservative measure, the first exceedance will represent an SSI.

5.2.3 Assessment Monitoring

Under the assessment monitoring program in 40 CFR 257.95, Appendix III and IV monitoring results are compared to BTVs as described in 40 CFR 257.95(e). The UPLs discussed in section 5.2.1 are also used to compare Appendix III and IV assessment monitoring results to background values.

According to 40 CFR 257.95(e), the CCR unit may return from assessment monitoring to detection monitoring when all Appendix III and Appendix IV constituents are "shown to be at or below background values, using the statistical procedures in paragraph 40 CFR 257.93(g) for two consecutive sampling events." A notification letter stating that detection monitoring is resuming for the CCR unit will be placed in the facility's operating record as required by 257.105(h)(7).

According to 40 CFR 257.95(f), if assessment monitoring concentrations of all Appendix III and Appendix IV constituents are above background concentrations (UPLs) and Appendix IV constituents are below the groundwater protection standard (GPS), then assessment monitoring will continue. As required in 40 CFR 257.95(h), the CCR owner must establish GPS for each constituent in Appendix IV detected in the groundwater. The GPS shall be defined as the following:

- The U.S. EPA Maximum Contaminant Level (MCL) for constituents for which an MCL has been established;
- for cobalt, lead, lithium, and molybdenum the concentrations established in §257.95(h)(2) (6, 15, 40, and 100 ug/L, respectively); or
- the background concentration for constituents for which the background level is higher than the MCL or concentrations in §257.95(h)(2).

The Unified Guidance recommends the upper tolerance limit (UTL) to represent the background concentration for this purpose. The limits can be considered as statistically equivalent BTVs to an MCL or other health-based numbers. The UTLs are derived from the same background data sourced to produce the UPLs and are used in these situations to represent the GPS. Tolerance intervals represent a range where a proportion of the population is expected at a given confidence level. For the purpose of this certification plan, a 95 percent confidence level is assumed. Similarly to the specification for prediction limits, specification for tolerance limits vary depending on whether the background data follow parametric or non-parametric distributions and the incidence of NDs. For example, if the recommended distribution follows a normal distribution according to Table 4, a normal-based parametric tolerance interval is used. If the recommended distribution follows a gamma distribution, then a gamma-based parametric tolerance interval is used, and if the recommended distribution is lognormal, then a lognormal-parametric tolerance interval is used. If the data cannot be explained by parametric distributions, a non-parametric tolerance interval on the median is used. Both the upper and lower tolerance limits will be produced for pH to establish lower and upper GPS.

Determination of Statistically Significant Levels above GPS

The CCR Rule stipulates in 40 CFR 257.95(g) that if Appendix IV constituents are detected as statistically significant levels (SSLs) above the GPS, the following actions are required to be taken by the owner:

- Place a notification in the operating record identifying the GPS exceedances.
- Characterize the nature and extent of the release and any relevant site conditions that may affect the remedy ultimately selected in accordance with 40 CFR 257.97.
- Notify all persons who own the land or reside on the land that directly overlies any part of the plume of contamination.
- Within 90 days:
    - Prepare an alternative source determination for the exceedance, or

- Initiate an assessment of corrective measures in accordance with 40 CFR 257.96.

Therefore, if Appendix III and detected IV COIs exceed BTVs according to 257.95(e), and detected Appendix IV COIs exceed GPS per 257.95(f), then detected Appendix IV constituents will be statistically compared to the GPS to identify SSLs above the GPS per 257.95(g). In order to evaluate if an exceedance of the GPS is statistically significant, the lower confidence limit of the sample mean or median concentrations from downgradient monitoring wells are used.

During the statistical analysis of confidence intervals from each detected Appendix IV constituent, if the lower confidence limit exceeds the GPS at the 95 percent confidence level, then the constituent has been detected at a SSL above the GPS at a particular monitoring well. As with the UPL and UTLs, the particularities of the lower confidence limit are based on whether parametric or non-parametric distributions best fit the data and the incidence of NDs observed in the monitoring data. For example, if the recommended distribution follows a normal distribution according to Table 4, a normal-based parametric confidence interval is used. If the recommended distribution follows a gamma distribution, then a gamma-based parametric confidence interval is used, and if the recommended distribution is lognormal, then a lognormal-parametric confidence interval is used. If the data cannot be explained by parametric distributions, a non-parametric confidence interval on the median is used. To maintain statistical power in correctly rejecting that the average (mean or median) of downgradient concentrations is less than the GPS when the average is higher than the GPS, a minimum of eight samples will be used.

Table 22-3, page D-258 of the Unified Guidance (2009b) indicates that for detecting a true mean 50 percent higher than the GPS, a sample size of 8 achieves 50 percent power with a minimum individual test significance level of 19 percent when conservatively assuming that the population coefficient of variation is 1. Increasing the true mean by 100 percent over the GPS, a sample of eight has 80 percent power of correctly rejecting the null hypothesis when the true population mean is twice the GPS with a test significance of 31 percent. Note that the lowering the test significance level increases power for a fixed sample size and increasing sample size while holding the test significance level constant, also increases statistical power.

If waste boundary well SSLs are identified, nature and extent wells will be installed as needed to define the contaminant plume(s) including at least one well at the facility boundary in the direction of contaminant migration per 257.95(g)(1). These nature and extent wells will be sampled at an increased frequency (5-week frequency) immediately after installation in effort to have sufficient samples (minimum 8) from each new well (as soon as possible) to complete the statistical comparison against the GPS. Once a nature and extent well has 8 or more sample events, the entire available data set from that well is used to calculate the LCLs, and if the LCL is below the GPS then the well will not be considered part of the plume and if the LCL is above the GPS then the well will be considered part of the plume. Between the time a new nature and extent well has been installed and 8 samples have been collected (approximately a 10-month window), concentrations from each sample event will be compared to the GPS on a single event basis and the exceedance will be described in any reporting documents as single event exceedances. Determination for whether additional nature and extent wells are warranted to define the plume will not require a statistical comparison (8 sample events), nor should be made after a single sample event, but may be completed with approximately two sample events singe event comparisons to the GPS. . For example, if two sample events have GPS exceedances, that will be an indication that additional nature and extent wells are warranted to define the plume, and conversely if two sample events do not have GPS exceedances, that will be an indication that additional nature and extent wells are now warranted at that time.

5.3 Criteria for Conducting Clean-Closure

40 CFR 257.102(c) indicates that removal and decontamination of the CCR Unit are complete when constituent concentrations throughout the CCR unit and any areas affected by releases from the CCR unit have been removed and groundwater monitoring concentrations do not exceed the GPS. If the site is in assessment monitoring, post-clean-out Appendix IV groundwater concentrations are compared to GPS and if concentrations are below GPS, the site will be re-sampled following assessment monitoring semi-annual sampling and follow the guidance in 257.95(e,f). According to 257.95(e) if two consecutive sample event concentrations of Appendix III and IV are below background the operator may return to detection monitoring but because the site has been closed it will be considered clean closed. If groundwater concentrations are above GPS, the site will be re-sampled following assessment monitoring semi-annual monitoring protocols and will follow the assessment monitoring guidance in 257.95(g).

If and when a corrective action program is implemented, these plans will be revised to include monitoring and statistical procedures appropriate for corrective actions monitoring.

6.0 References

Singh, Anita and Ashok K. Singh, 2015. ProUCL Version 5.1 Technical Guide: Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. U.S. Environmental Protection Agency, EPA/600/R-07/041.

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USEPA, 2015. SOP No. HW-3b Revision 0, ISM02.2, ICP-MS Data Validation. July 2015.

Attachment 2

Geotech Bladder Pump Installation and Operation Manual

Geotech
Bladder Pumps

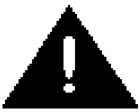
Installation and Operation Manual

Rev 6/15/2020 Part # 21150035

Table of Contents

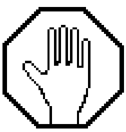
DOCUMENTATION CONVENTIONS

This document uses the following conventions to present information:



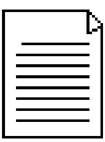
An exclamation point icon indicates a **WARNING** of a situation or condition that could lead to personal injury or death. You should not proceed until you read and thoroughly understand the **WARNING** message.

WARNING



A raised hand icon indicates **CAUTION** information that relates to a situation or condition that could lead to equipment malfunction or damage. You should not proceed until you read and thoroughly understand the **CAUTION** message.

CAUTION



A note icon indicates **NOTE** information. Notes provide additional or supplementary information about an activity or concept.

NOTE

Section 1: System Description

Function and Theory

Geotech's pneumatic Bladder Pumps operate with a unique air-driven action, ideal for both gentle low-flow sampling and high-flow rate purging. Timed ON/OFF cycles of compressed air alternately squeeze the flexible bladder to displace water out of the pump to the surface then exhaust the air allowing the pump to refill.

Fluid enters and fills the pump through the fluid inlet check valve at the bottom of the pump body via hydrostatic pressure. Once filled with fluid, compressed air enters the space between the bladder and the interior of the pump housing, squeezes the bladder, and pushes the fluid to the surface (see Figure 1-1). Operated by the BP Controller or Geocontrol PRO, this logic automatically repeats.
Air does not contact the sample. The bladder prevents contact between the pump driven air and the sample. All wetted pump parts are 316 Grade stainless steel to ensure the purity of the sample is maintained.

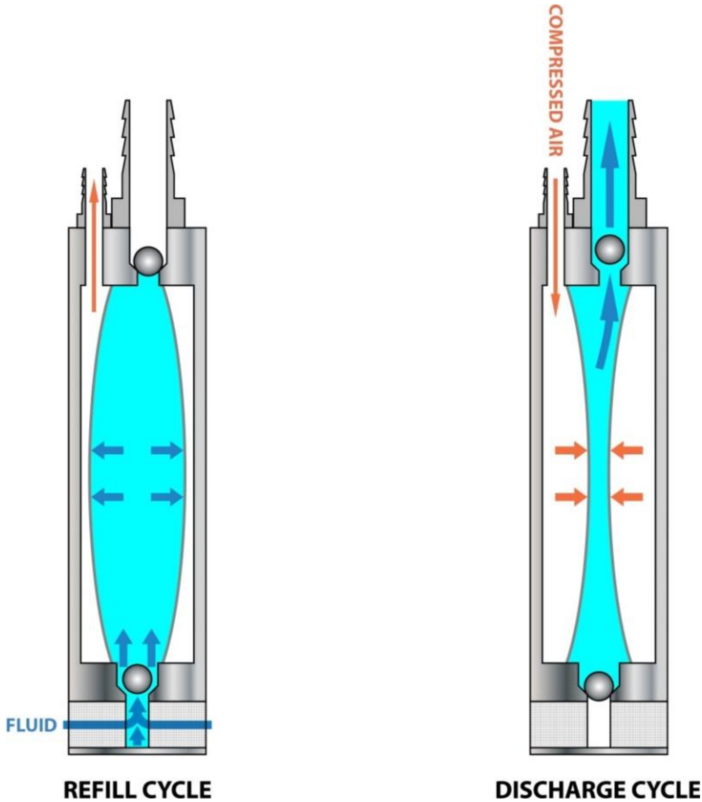


Figure 1-1: Bladder Pump Operation
Not to scale

Be sure to read and understand your portable generator and/or portable air compressor user manual for proper installation, operation, and Earth grounding instructions. If using portable compressed gas tanks, exercise caution, use safety protection devices as outlined by the supplier, and observe any additional safety requirements mandated by local jurisdiction.

System Components

The Geotech Bladder Pump features four accessible parts (see Figure 1-2):
- Intake Screen
- Pump Housing
- Air and Sample Line Connections
- Bladder Assembly

*Optional: Drop Tube Intake Assembly

Intake Screen

The intake filter screen is constructed of 316 Stainless Steel and is easily removed and disassembled for field maintenance. The intake filter screen is intended to protect and extend the life of the bladder material (see *The Warranty*).

Pump Housing

The Geotech Bladder Pump housing is constructed of electropolished 316 Stainless Steel. Viton O-rings provide the high-pressure seals between the end caps and the housing walls. Always lubricate the O-rings with deionized water before installing the housing and intake screen.

Air and Sample Line Connections

The 1.66” Bladder Pump is provided in both low and high-pressure configurations. The low-pressure model is equipped with hose barbs for air and sample line connections, whereas the high-pressure model is equipped with heavy-duty compression fittings. The .850” and .675” models are both considered low pressure. See *Section 6: System Specifications* for operating depths and pressures.

Bladder assembly

The bladders are extruded Polytetrafluoroethylene (PTFE) to provide a long life and to ensure undisturbed samples. The internal bladders are easily replaceable, see *Section 4: System Maintenance*.

Drop Tube Intake Assembly (Optional)

An optional drop tube can be used to sample from depths below the specified maximum sampling depth. The drop tube assembly connects a remote intake feature to the pump through a tube connected to the pump inlet. The intake depth can be any custom length of tubing. The pump assembly itself must still be submerged below the water level. This means the depth to water cannot exceed the maximum pumping depth of the pump.

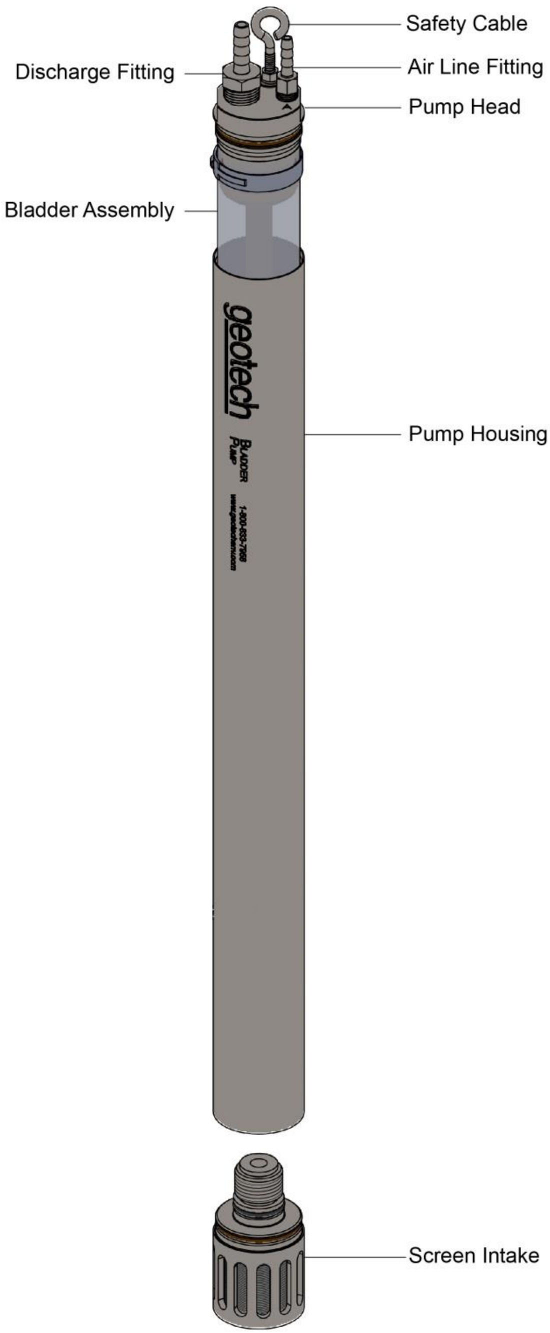


Figure 1-2: Basic* Bladder Pump Assembly

**Example above is based on 1.66" Low Pressure configuration*

Section 2: System Installation

Determine site-specific parameters such as water level, recharge rate and adherence to low flow purging guidelines. Speak with your Geotech Customer Service Representative to ensure the right equipment is being used.

Pump Controller

Geotech Bladder Pumps can be operated using a variety of controllers. Site requirements will determine the optimal control unit. Use the table below as a guide:

Controller	Air Source	Max Operating Depth
Geocontrol Pro	Internal compressor	180’ (55m)
BP Controller 300 PSI	Externally supplied	690’ (210m)
BP Controller 500 PSI	Externally supplied	1000’ (305m)

Pump Tubing Lines

Geotech’s Bladder Pumps are engineered for easy installation and use. Dedicated Bladder Pump systems are available with the tubing and well cap attached for ease of deployment. Well identifications (supplied by customer) are located on tags connected to the tubing, and on the tubing bags.

If not pre-attached, at the wellhead connect the airline tubing to air line connection at the top of the Bladder Pump (see Figure 1-2). The letter “A” has been stamped near the airline port on the top of each pump. See *Section 6: System Specifications* for air line system sizes.

Next, attach the discharge line to the discharge line connection at the top of pump (see Figure 1-2).

Failure to attach air and fluid lines to the appropriate ports could result in damage to the bladder.

Compression Fitting Installation

1. Ensure tubing is cut at a square, 90° angle.
2. Attach nut, back ferrule, and front ferrule to the tubing.
3. Ensure the front of the ferrule is touching the inlet, then slide the nut over the ferrule and tighten it finger-tight.
4. Mark the nut with a line.
   - This line will indicate the initial start point of the nut.
5. Hold the fitting body steady with a wrench. Turn the nut 1 ¼ turns.
   - Do not overtighten.
   - If re-installing compression fitting after repair/regular maintenance, turn the nut 1 turn after hand-tightening.

Safety Cable

Before deploying any sampling pump, secure a safety cable from an anchoring point at or near the wellhead to the top of the pump.

Carefully lower the Bladder Pump into the well using the Reverse Coil Method to avoid kinking, until the desired depth is achieved or until the well cap seats Reverse Coil Method

When lowering the pump into the well, it is important to reverse the natural bend of the coiled tubing so that the tubing straightens as it is lowered (see Figure 2-1). As the pump and tubing are lowered into the well, the direction of the bend should be reversed from the direction in which it is coiled. If the tubing is allowed to uncoil naturally and the natural bend not interrupted, the tubing will continue its coil into the well. Using the reverse coil method will avoid any difficulty while lowering the pump into the well, especially when the well is not completely vertical, or has come out of alignment for any reason.

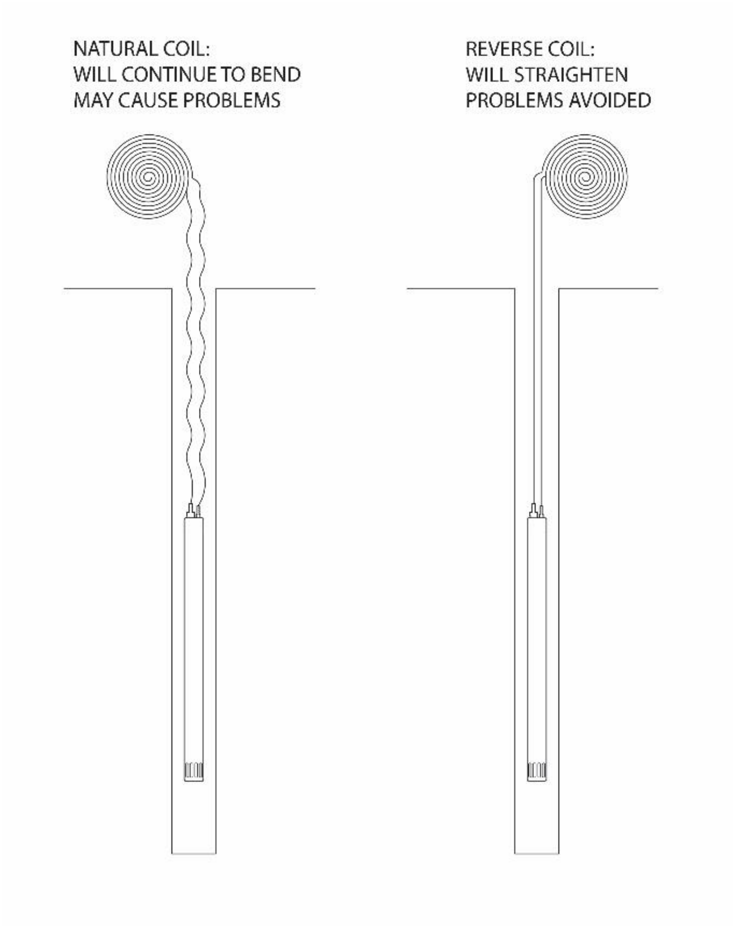


Figure 2-1: Reverse Coil Method

Optional Drop Tube Assembly

If a Drop Tube Intake Assembly is employed, a third tubing line is necessary to connect from the bottom of the bladder pump to the top of the drop tube intake.

For deployment of optional Drop Tube Intake Assembly, attach desired length of drop tube between the intake's hose barb and hose barb on bottom of pump. For added security, a safety cable may be installed to support the drop tube intake to the bottom of pump.

Send the drop tube intake down the well followed by the drop tube tubing, then the pump, and finally the air and fluid discharge line.

Section 3: System Operation

Bladder Pump Operation

Fluid enters the pump through the fluid inlet check valve at the bottom of the pump body via hydrostatic pressure. The pump MUST be submerged to operate. The bladder then fills with fluid. Compressed air enters the space between the bladder and the interior of the pump housing. The intake check valve closes and the discharge check valve (top) opens. Compressed air squeezes the bladder, pushing the fluid to the surface. The discharge check valve prevents back flow from the discharge tubing.

Selecting an Air Source

Air consumption depends on the volume of tubing and the size of deployed Bladder Pump. Follow the general guidelines and examples below to calculate the air consumption for specific sampling configurations.

Air Volume of Tubing

	TUBING LENGTH					
TUBE I.D.	1 ft/ 0.3 m	10 ft/ 3 m	50 ft/ 15 m	100 ft/ 30 m	250 ft/ 76 m	500 ft/ 152 m
0.17 in/ 0.43 cm	0.3 in³/ 5 cm³	3 in³/ 50 cm³	15 in³/ 246 cm³	30 in³/ 492 cm³	75 in³/ 1230 cm³	150 in³/ 2460 cm³
0.25 in/ 0.64 cm	0.6 in³/ 10 cm³	6 in³/ 100 cm³	30 in³/ 492 cm³	60 in³/ 984 cm³	150 in³/ 2460 cm³	300 in³/ 4920 cm³

Air Volume of Bladder Pumps

BP DIAMETER	BP LENGTH	VOLUME (in³)
1.66 in/ 4 cm	36 in/ 91 cm	78 in³/ 1278 cm³
1.66 in/ 4 cm	18 in/ 46 cm	39 in³/ 640 cm³
0.85 in/ 4 cm	18 in/ 46 cm	10 in³/ 164 cm³
0.675 in/ 4 cm	18 in/ 46 cm	6 in³/ 100 cm³

Calculation guideline:
Volume of Tubing (in³/cm³)
+ Volume of Bladder Pump (in³/ cm³)
= Air Consumption per cycle (in³/ cm³)

If planning to use an air compressor, use one with a reserve tank to insure proper air supply to the pump. If using a Nitrogen Tank, see Figure 3-1 for Nitrogen Tank Volume vs. Bladder Pump consumption.

Determining Operation Pressure

Determine the air pressure needed to operate the Bladder Pump based on the length of the air supply line to the pump (well depth).

Use the simplified formula:

> 0.5 PSI (per foot) + 10 PSI (to account for tubing friction) = required PSI
> 0.12 bar (per meter) + 0.7 bar (to account for tubing friction) = required bar

As mentioned above, the additional 10 PSI (0.7 bar) is to account for the pump itself and friction loss along the air line tubing. When the length of the airline is 50’ (15m) or less, there is no need for the additional pressure.

To determine minimum operating pressures for the specific Bladder Pump model you are using, consult the pump’s specifications. Typically, the minimum operating pressure will be 5 PSI (0.4 bar) above static head.

The formulas stated above are not absolute, and are meant to provide baseline information.

Flow Rates

Bladder Pump flow rates are influenced by pump size (diameter and length); pump depth and submergence, as well as controller selection (i.e. compressor performance, valve flow coefficient). Generally, a large pump at shallow depths will produce the most flow, and a small pump at maximum depths will produce the least amount of flow.

Example flow rates:

Pump Size:	**Depth: (3ft (0.9m) submergence)**	**Tubing Size**		**Flow Rate:**
		Air line:	**Discharge:**	
1.66 x 36"	@ 275 ft (84 m)	.17"ID x 1/4"OD (4.3mm x 6.4mm)	1/4"ID x 3/8"OD (6.4mm x 9.5mm)	22 oz/min (0.7 L/min)
	@ 500 ft (152 m)	1/4"ID x 3/8"OD (6.4mm x 9.5mm)		17 oz/min (0.5 L/min)
1.66 x 18"	@ 275 ft (84 m)	.17"ID x 1/4"OD (4.3mm x 6.4mm)	1/4"ID x 3/8"OD (6.4mm x 9.5mm)	12 oz/min (0.4 L/min)
	@ 500 ft (152 m)	1/4"ID x 3/8"OD (6.4mm x 9.5mm)		8 oz/min (240 mL/min)
.850 x 18"	@ 150 ft (46 m)	.17"ID x 1/4"OD (4.3mm x 6.4mm)		2 oz/min (59 mL/min)
.675 x 18"	@ 150 ft (46 m)	.17"ID x 1/4"OD (4.3mm x 6.4mm)		1 oz/min (27 mL/min)

The above example flow rates are based on 3’ (0.9 m) of pump submergence. Typically, field environments will provide greater submergence (more than 10’ (3 m)), which will dramatically increase flow.

Factors that increase flow:

- increased submergence (depth of pump below water line)
- a strong compressor, like the Geocontrol PRO, will enable fast pressure build up in the air line tubing and pump cavity
- a clean intake screen will maximize the amount of water entering into the pump

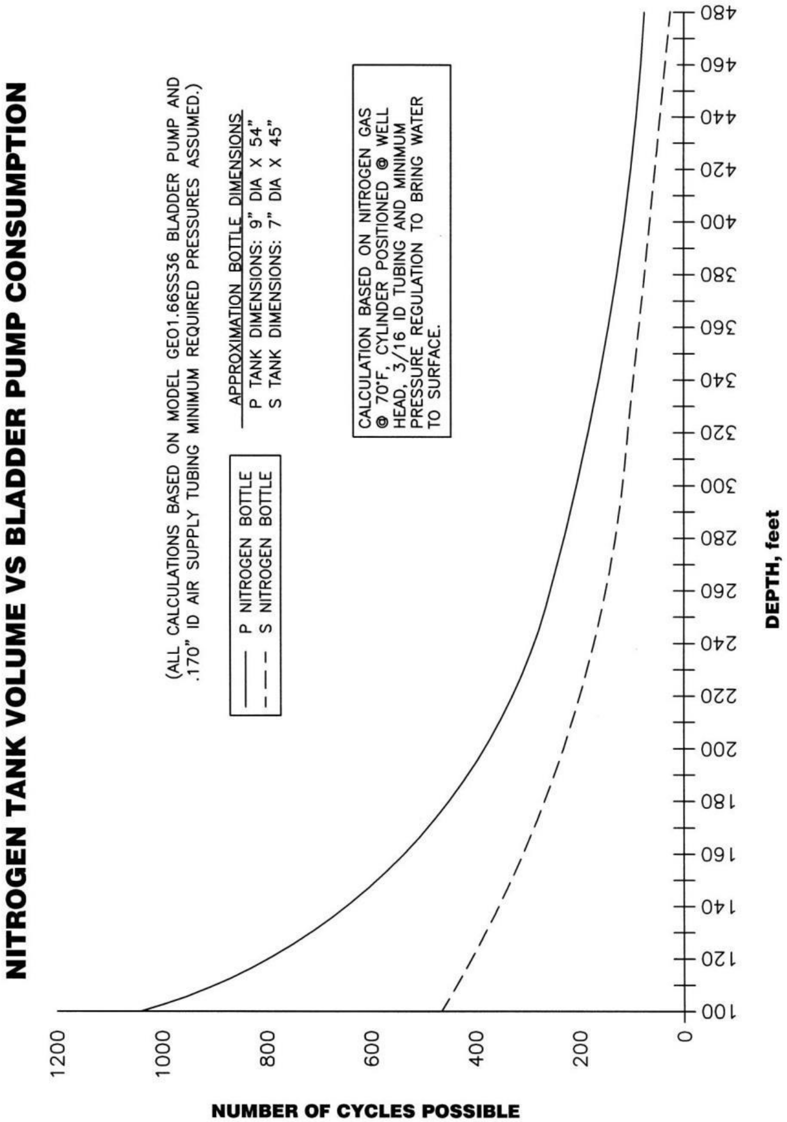


Figure 3-1: Tank Volume vs. BP Consumption

Section 4: System Maintenance

Bladder Pump

As with any pump, scheduled or periodic maintenance should be performed according to your sampling program and specific site conditions. Generally, the more turbid or sandy the water, the more maintenance and cleaning are required.

Replacement bladders, as well as other key components, can be found in *Section 7: Replacement Parts List*.

Disassemble Bladder Pump per instructions in this section, decontaminate or replace parts as needed, then reassemble.

Inspect O-rings and check balls for damage.
Replace Bladder if torn, ripped, or excessively worn.

Replacing the Bladder

<u>1.66” Models</u>

Pull pump from the well, it is not necessary to remove the air and sample lines from the pump. Take care, as the pump may be filled with fluid.

1. Hold the pump by its head with a towel or use the wrench flats, and turn the screen intake counter-clockwise to remove (see Figure 4-1).
   - The intake may be snug due to the high-pressure O-ring seal. Once the seal is broken, then intake should disengage easily.

2. Hold the pump by its head and slide or twist the housing off the pump body (see Figure 4-1).

3. Locate the Bladder clamps (see #3 on Figure 4-1).

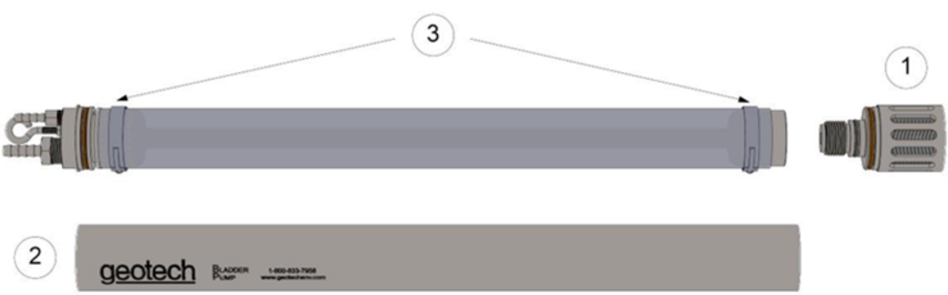


Figure 4-1: Accessing the Bladder Assembly

4. Obtain the clamp pincher tool (Geotech part # 11150031).

5. Pinch the tension hook and lift the end of the clamp until it releases from the retaining hooks (see Figure 4-2).

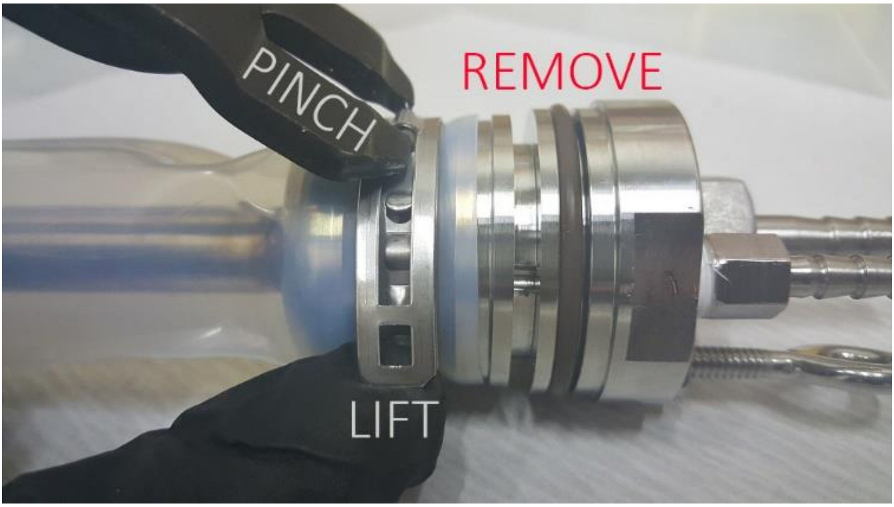


Figure 4-2: Removing the Bladder Clamp

6. Slide clamp off bladder.
    - Do this for both the top and the bottom bladder clamps.

7. Set the clamps aside, they are reusable.

8. Slide the bladder down over the pump body, decontaminate or replace as necessary.

9. Inspect O-rings for damage.

10. Replace O-rings as necessary.

<u>Reassemble the 1.66" Models:</u>

1. Slide the decontaminated or new bladder up the pump body and over the O-rings.

2. Ensure the O-rings are not dislodged and the bladder covers both O-rings with at least a 1/4" (.6cm) of clearance.

3. Slide the bladder clamps over the bladder and position each clamp over an O-ring, making sure the clamp and O-ring are aligned on center.

4. Using the clamp tool (Geotech part # 11150031). Pinch the tension hook and use your thumb to guide the end of the clamp over the retaining hooks until the clamp is locked in place (see Figure 4-4).

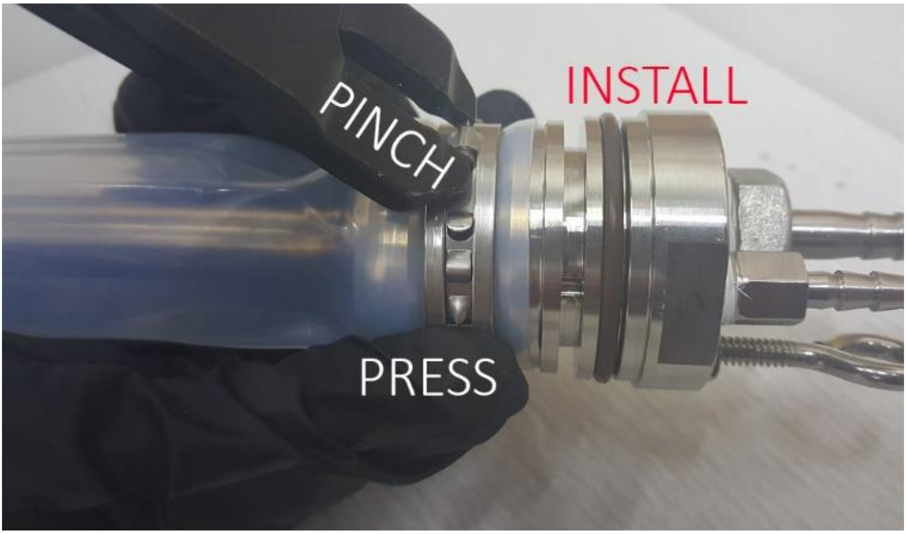


Figure 4-4: Installing the Bladder Clamp

5. Slide the housing over the pump body.

6. Lubricate the upper cap's O-ring using deionized water to ensure a pressure-ready installation.

7. Twist the housing on the body until it is flush with the upper cap.

8. Install the screen intake by lubricating the O-rings with deionized water and then turning clockwise into the pump's body.

9. Hold the pump by its head to ensure the screen intake is fully secured.
   - There should be no gaps between the outer housing and top or bottom caps.

10. Ensure the pump's fittings and safety cable are in good condition.

The pump is ready for service.

Remove the pump from the well. It is not necessary to remove the air and sample lines from the pump. Upon removal, the pump may be filled with fluid.

.850 and .675 Bladder Removal Steps

1. Remove the bottom intake assembly and outer housing by turning the housing counter-clockwise.
    - Use your hand or a strap wrench
    - DO NOT grip the hose barbs.
    - For .85 and .675 models, use a wrench that is one size bigger than the bolts on the hose barbs. (EX: use a 7/16 wrench on a .850 model)
        - Using a larger wrench will prevent the hose barbs from being removed. The tool should only be used for leverage to loosen the part.
    - If the bottom intake is difficult to remove, remove the snap ring, disc, and screen and then use a wrench for removal.

Figure 4-1: Removal of the bottom intake and outer housing

2. Remove the lower Compression Ring by pulling it off the end of the internal center tube assembly.

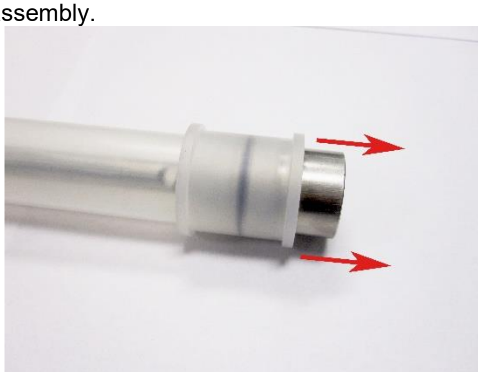


Figure 4-2: Removal of bottom Compression Ring

3. Remove the upper Compression Ring by sliding it over the bladder and over the end of the internal center tube assembly.

Figure 4-3: Removal of upper Compression Ring

4. Pulling from the lower end of the bladder, slide the bladder off the internal center tube weldment assembly.

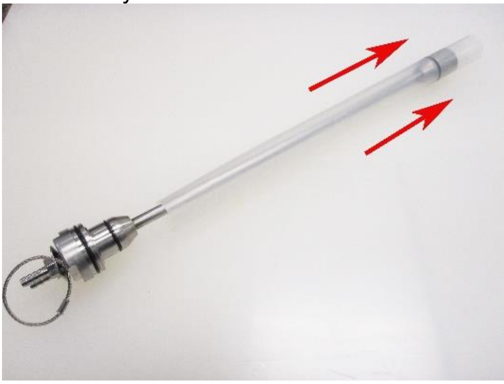


Figure 4-4: Removal of Bladder

5. Remove all O-rings.
   - If needed, use a flat object to help the O-ring out of the groove on the center tube weldment assembly,
   - Do not over-stretch, damage, or puncture the O-rings in any way.

Figure 4-5: Removal of O-rings

6. Clean and prepare replacement parts as needed.

Bladder Reassembly

1. Install O-ring on the cap of the center tube weldment assembly.

Figure 4-10: Cap O-ring

2. Install O-ring on the upper end of the center tube weldment assembly.

Figure 4-11: Upper end O-ring

3. Install O-ring on the lower end of the center tube weldment assembly.

Figure 4-12: Lower O-ring

4. Slide bladder onto the internal center tube weldment assembly, over the O-ring on the bottom end of the center tube assembly, and then over the O-ring on the upper end of the center tube weldment assembly.
   - Do not to roll the O-rings.
   - If needed, use Deionized water or a silicone based lubricant on the O-ring seals to help the bladder slide over the O-rings.

Figure 4-13a: Sliding bladder on

Figure 4-13b: Bladder entirely on

5. Slide the Compression Ring over the bladder to the upper end of the center tube weldment assembly.

Figure 4-14a: Compression Ring on Bladder

Figure 4-14b: Compression ring secured

6. With the upper end of the bladder secured by the Compression Ring slide the second compression ring over the end of the bladder until the O-ring is visible in the middle of the Compression Ring.
    - Compression rings that are made from other materials (ex: PTFE), will not be clear. The O-ring will not be visible.

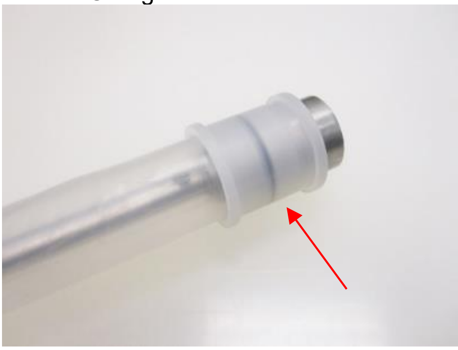


Figure 4-15: Bottom Compression ring with visible O-ring

7. An alternate way to assemble the bladder is to:
    a) Place both Compression Rings on the center tube weldment assembly

b) Slide the bladder over the bottom O-ring, through the compression rings, and over the top O-rings until the bladder is flush with the upper end of the center tube weldment assembly (see Figure 4-13b)
c) Slide the top compression ring to the upper end of the center tube weldment assembly (see Figure 4-14b)
d) Slide the bottom compression ring to the lower end of the center tube weldment assembly (see Figure 4-15)

8. Replace the outer housing.
   - Be sure the outer housing is sealed against the upper cap.

Figure 4-16a: Incorrect Installation

Figure 4-16b: Correct Installation

9. Replace the bottom intake assembly by screwing it into the bottom of the pump.
   - Reassemble bottom intake if previously disassembled by inserting the screen, disc, and snap ring into the lower cap.
   - Be sure the bottom intake assembly is sealed against the outer housing.

Figure 4-17a: Incorrect Installation

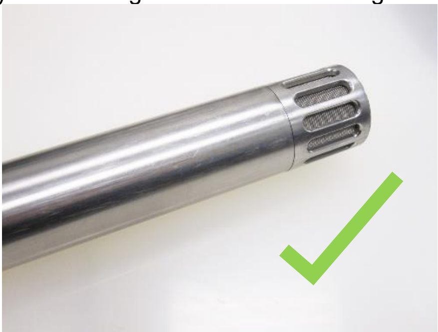


Figure 4-17b Correct Installation

Inspect O-rings and bladder for damage.
Replace if torn, ripped, or excessively worn.

Compression Fittings

Tubing can wear out over time if compression fittings are overtightened. After repair, ensure that compression fittings are "snug". One full rotation after hand tightening of the nut should be enough to tighten the compression fitting.

Section 5: System Troubleshooting

Problem: Air is cycling through controller but will not pump.
Solutions

- Discharge and Fill times are not set correctly. Check and adjust Discharge and Fill cycle times (i.e. if Discharge time is too long or if Fill and Discharge time is too short).
- Possible compromise in air line tubing. Check airline pumps for leaks. If needed, repair using compression union or replace tubing.
- Check pump intake screen for blockage and clean as needed.

Problem: Controller is cycling but the pump stops producing water.
Solutions

- Check drawdown level of water in the well. Ensure the pump is fully submerged and off of the bottom of the well.
- Check air pressure at the regulator and adjust as necessary (See *Section 3: Determining Operation Pressure*.)
- Check for kinks in the discharge line.
- Check pump intake screen for obstructions.
- Discharge time is too long or Fill time is too short; causes pressure build up in pump, causing the pump not to fill.
- Check power source, assure a strong reliable power supply. If using old or weak battery, the control valves may not operate properly.

Problem: Getting air bubbles in sample line.
Solutions

- Overcharging pump. Reduce discharge cycle time so the discharge cycle ends as fluid discharge trails off. Inspect pump for compromised bladder or O-rings.
- Pump is being over pressurized. Reduce air pressure to what is necessary to overcome pumping head.
- Check discharge line for holes or kinks. Repair using compression union or replace tubing.
- Ensure Bladder clamps are properly installed.

Problem: Discharge line drains back into pump.
Solution

- Check valve at the top of the pump is compromised. Remove hose barb on pump discharge outlet. Check the check ball seat for debris. Clean and re-install.
- Check the upper ball for roundness, pitting or scaling.

Problem: Discharge sucks up water at sampling end, especially during fill cycle.
Solution
The compression fitting ferrule has cut into the tubing. Follow installation instructions in *Section 2: System Installation*.

If you are experiencing other problems than mentioned above, please call Geotech Technical Support for immediate assistance, (800) 833-7958.

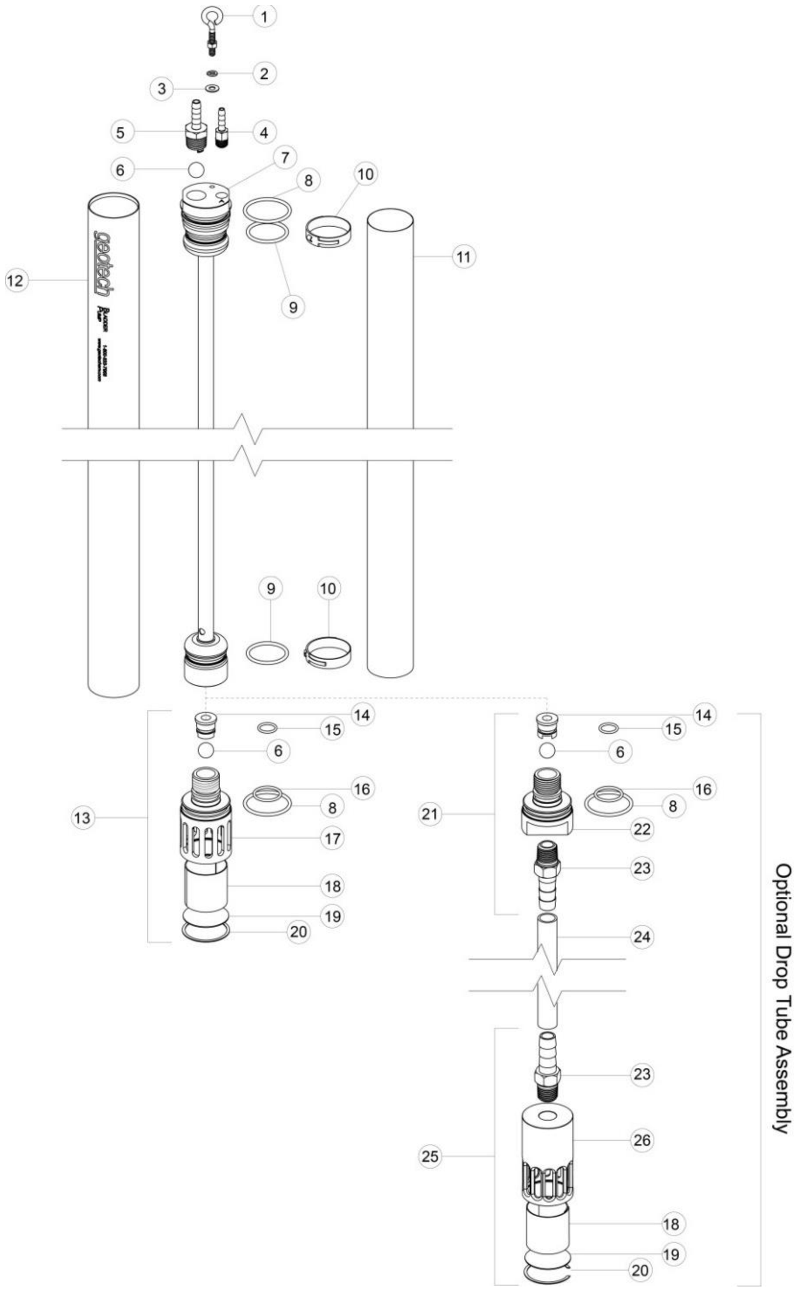
Section 6: System Specifications

	1.66 36"		1.66 18"		0.850"	0.675"
	High Pressure	Low Pressure	High Pressure	Low Pressure		
Pump Body	316 SS					
Fittings	316 SS					
Fitting Type	Compression	Hose barb	Compression	Hose barb	Hose barb	
Bladder Material	PTFE *Optional PE*					
Bladder Retainer	316 SS Clamp				PTFE Collar	
Pump O.D.	1.66" (4.2 cm)				.850" (2.2 cm)	.675" (1.7 cm)
Length	38" (96.5 cm)		20" (51 cm)		18 5/8" (47.3 cm)	18 3/4" (47.6 cm)
Weight	5.5 lbs. (2.5 kg)		3.5 lbs. (1.6 kg)		1.1 lbs. (0.5 kg)	.8 lbs. (0.4 kg)
Volume/ Cycle	22 oz. (650 mL)		11 oz. (325 mL)		1 oz. 29 mL	0.5 oz. 15 mL
Max Operating Temp.	PTFE Bladder: 32°F-212°F (0°C-100°C) *PE Bladder: 32°F -185°F (0°C -85°C)*					
Min. Well I.D.	2" (5 cm)				1" (2.5 cm)	.75" (1.9 cm)
Max. Sample Depth	1000 ft. (305 m)	290 ft. (88 m)	1000 ft. (305 m)	290 ft. (88 m)	200' (61 m)	
Min. Operating Pressure	5 psi ash* (.34 bar)					
Max. Operating Pressure	500 psi (34 bar)	125 psi (8.6 bar)	500 psi (34 bar)	125 psi (8.6 bar)	100 psi (7bar)	
Proof Pressure	675 psi (46 bar)	187 psi (13 bar)	675 psi (46 bar)	187 psi (13 bar)	150 psi (10 bar)	
Burst Pressure	1000 psi (69 bar)	300 psi (21 bar)	1000 psi (69 bar)	300 psi (21 bar)	300 psi (20 bar)	
Tubing Size (I.D. x O.D.)						
Air Line	1/4" x 3/8" (6 x 10 mm)	.17" x 1/4" (4 x 6 mm)	1/4" x 3/8" (6 x 10 mm)	.17" x 1/4" (4 x 6 mm)	.17" x 1/4" (4 x 6 mm)	
Discharge Line		1/4" x 3/8" (6 x 10 mm)		1/4" x 3/8" (6 x 10 mm)		

*ash = above static head

Section 7: Replacement Parts List

1.66 Bladder Pump Components (36” & 18” LOW Pressure Models)



Bladder Pump, 1.66, Stainless Steel, 36", Low Pressure - 81150120

Item	Qty	Description	Part No.
1	1	EYEBOLT, SS6, 10-24, 1" SHANK	16600347
2	1	WASHER, SS6, #10, LOCK	11150449
3	1	WASHER, SS6, #10	11150450
4	1	HOSEBARB, SS6, .170 x 1/8" MPT, AIR LINE	21150019
5	1	HOSEBARB, SS6, MOD, 1/4" x 3/8 MPT, DISCHARGE	21150145
6	2	BALL, SS6, 1/2"	17500082
7	1	CAP, UPPER WELDMENT, SS, 166x36"	21150143
8	2	O-RING, VITON, 2.5mm x 36mm, BROWN	11150318
9	2	O-RING, VITON, #123, BROWN	11200299
10	2	CLAMP, SS6, LOW PROFILE	11150444
11	1	BLADDER, PTFE, BP, 166SS36,DEDICATED	51150139
12	1	HOUSING, SS6, DED, 166x36"	51150142
13	1	ASSY, BOTTOM INTAKE, 166 BP	51150067
14	1	PLUG, BALL RETAINER, 166 BP	21150096
15	1	O-RING, VITON, #014, BROWN	17500119
16	1	O-RING, VITON, 2mmx20mm	11150332
17	1	CAP, LOWER, SS6, 166 BP	21150094
18	1	SCREEN, INTAKE, SS6, 166 BP	21150095
19	1	DISC, SS, 1.66, PBP	21150148
20	1	RING, SNAP, SS6, INTERNAL, 166 BP	11150051
21	§	ASSY,LOWER CAP,166 DROP TUBE WITH 1/2" HOSEBARB	51150128
22	§	DROPTUBE, CAP LOWER, SS6, 166	21150098
23	§	HOSEBARB, SS6, 1/2 x 3/8" MPT	16600217
24	§	TUBING, PE, 1/2 x 5/8"	87050504
25	§	ASSY, INTAKE, 166, DROP TUBE, WITH 1/2" HOSE BARB	51150071
26	§	INTAKE, DROPTUBE, SS6, 166	21150113
Not Shown:			
	1	MANUAL, BLADDER PUMPS	21150035
	§	TOOL, BLADDER PUMP, PINCER, 5mm	11150031
	§	KIT, 166 SS BP, O-RING SET, O-RING SERVICE SET [Item 8 (2), 9 (2), 15 (1), 16 (1)]	91150023

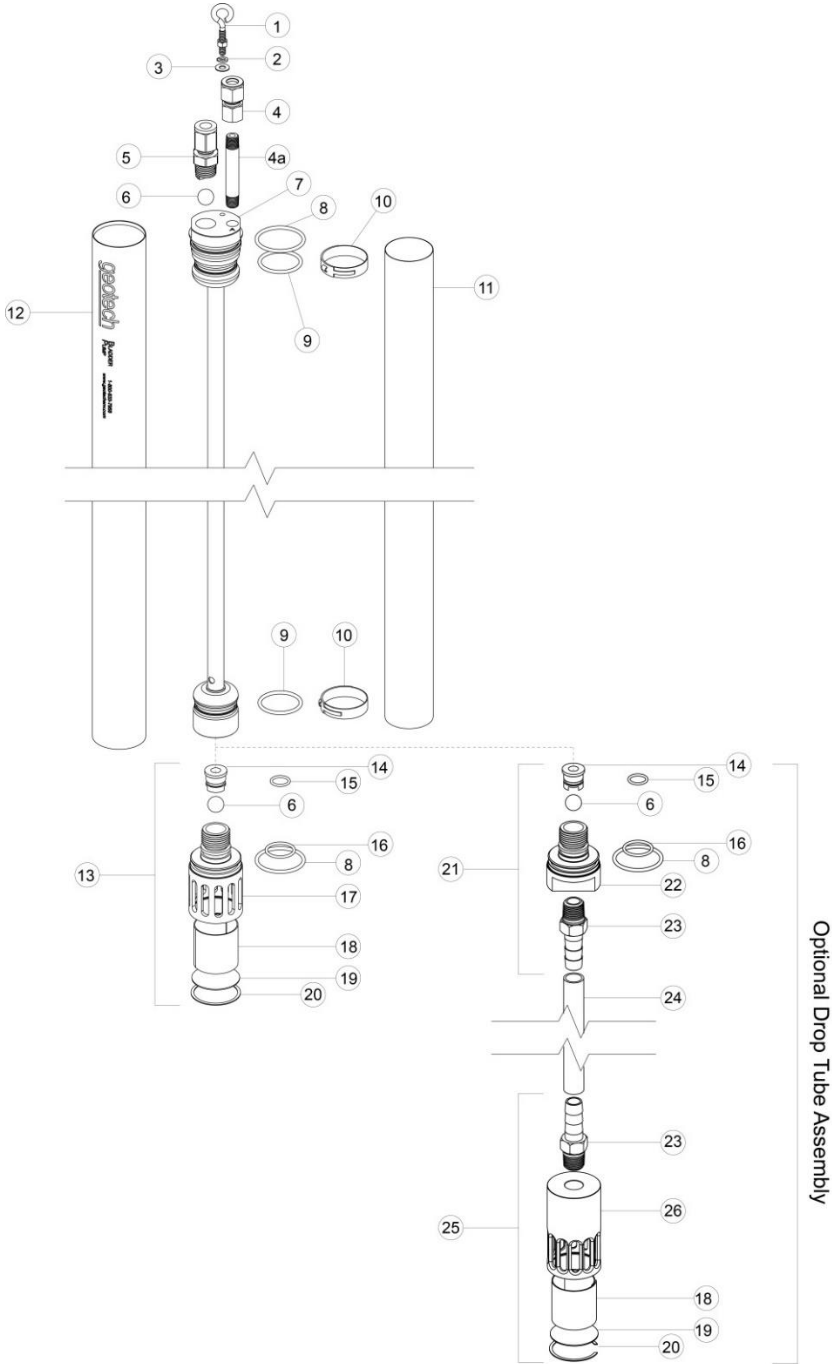
§ *= Sold Separately*

Bladder Pump, 1.66, Stainless Steel, 18", Low Pressure - 81150122

Item	Qty	Description	Part No.
1	1	EYEBOLT, SS6, 10-24, 1" SHANK	16600347
2	1	WASHER, SS6, #10, LOCK	11150449
3	1	WASHER, SS6, #10	11150450
4	1	HOSEBARB, SS6, .170 x 1/8" MPT, AIR LINE	21150019
5	1	HOSEBARB, SS6, MOD, 1/4 x 3/8" MPT, DISCHARGE	21150145
6	2	BALL, SS6, 1/2"	17500082
7	1	CAP, UPPER WELDMENT, SS, 166 x 18"	21150147
8	2	O-RING, VITON, 2.5mm x 36mm, BROWN	11150318
9	2	O-RING, VITON, #123, BROWN	11200299
10	2	CLAMP, SS6, LOW PROFILE	11150444
11	1	BLADDER, PTFE, BP, 166SS18, DEDICATED	51150140
12	1	HOUSING, SS6, DED, 166 x 18"	51150143
13	1	ASSY, BOTTOM INTAKE, 166 BP	51150067
14	1	PLUG, BALL RETAINER, 166 BP	21150096
15	1	O-RING, VITON, #014, BROWN	17500119
16	1	O-RING, VITON, 2mm x 20mm	11150332
17	1	CAP, LOWER, SS6, 166 BP	21150094
18	1	SCREEN, INTAKE, SS6, 166 BP	21150095
19	1	DISC, SS, 1.66, PBP	21150148
20	1	RING, SNAP, SS6, INTERNAL, 166 BP	11150051
21	§	ASSY,LOWER CAP,166 DROP TUBE WITH 1/2" HOSEBARB	51150128
22	§	DROPTUBE, CAP LOWER, SS6, 166	21150098
23	§	HOSEBARB, SS6, 1/2 x 3/8" MPT	16600217
24	§	TUBING, PE, 1/2 x 5/8"	87050504
25	§	ASSY, INTAKE, 166, DROP TUBE, WITH 1/2" HOSE BARB	51150071
26	§	INTAKE, DROPTUBE, SS6, 166	21150113
Not Shown:			
	1	MANUAL, BLADDER PUMPS	21150035
	§	TOOL, BLADDER PUMP, PINCER, 5mm	11150031
	§	KIT, 166 SS BP, O-RING SET, O-RING SERVICE SET [Item 8 (2), 9 (2), 15 (1), 16 (1)]	91150023

§ *= Sold Separately*

1.66 Bladder Pump Components (36” & 18” HIGH Pressure Models)



Bladder Pump, 1.66, Stainless Steel, 36", High Pressure - 81150119

Item	Qty	Description	Part No.
1	1	EYEBOLT, SS6, 10-24, 1" SHANK	16600347
2	1	WASHER, SS6, #10, LOCK	11150449
3	1	WASHER, SS6, #10	11150450
4	1	CMPRSN FITTING, SS6, 3/8 TUBE x 1/8 FPT	11150446
4a	1	NIPPLE, SS6, 1/8" NPT x 2.5"	11150447
5	1	CMPRSN FITTING, MOD, SS6, 3/8 TUBE x 3/8" MPT	21150144
6	2	BALL, SS6, 1/2"	17500082
7	1	CAP, UPPER WELDMENT, SS, 166 x 36"	21150143
8	2	O-RING, VITON, 2.5mm x 36mm, BROWN	11150318
9	2	O-RING, VITON, #123, BROWN	11200299
10	2	CLAMP, SS6, LOW PROFILE	11150444
11	1	BLADDER, PTFE, BP, 166SS36,DEDICATED	51150139
12	1	HOUSING, SS6, DED, 166x36"	51150142
13	1	ASSY, BOTTOM INTAKE, 166 BP	51150067
14	1	PLUG, BALL RETAINER, 166 BP	21150096
15	1	O-RING, VITON, #014, BROWN	17500119
16	1	O-RING, VITON, 2mmx20mm	11150332
17	1	CAP, LOWER, SS6, 166 BP	21150094
18	1	SCREEN, INTAKE, SS6, 166 BP	21150095
19	1	DISC ,SS, 1.66,PBP	21150148
20	1	RING, SNAP, SS6, INTERNAL, 166 BP	11150051
21	§	ASSY,LOWER CAP,166 DROP TUBE WITH 1/2" HOSEBARB	51150128
22	§	DROPTUBE, CAP LOWER, SS6, 166	21150098
23	§	HOSEBARB, SS6, 1/2 x 3/8" MPT	16600217
24	§	TUBING, PE, 1/2 x 5/8"	87050504
25	§	ASSY, INTAKE, 166, DROP TUBE, WITH 1/2" HOSE BARB	51150071
26	§	INTAKE, DROPTUBE, SS6, 166	21150113
Not Shown:			
	1	MANUAL, BLADDER PUMPS	21150035
	§	TOOL, BLADDER PUMP, PINCER, 5mm	11150031
	§	FERRULE SETS, SS6, 3/8"	57200010
	§	KIT, 166 SS BP, O-RING SET, O-RING SERVICE SET [Item 8 (2), 9 (2), 15 (1), 16 (1)]	91150023

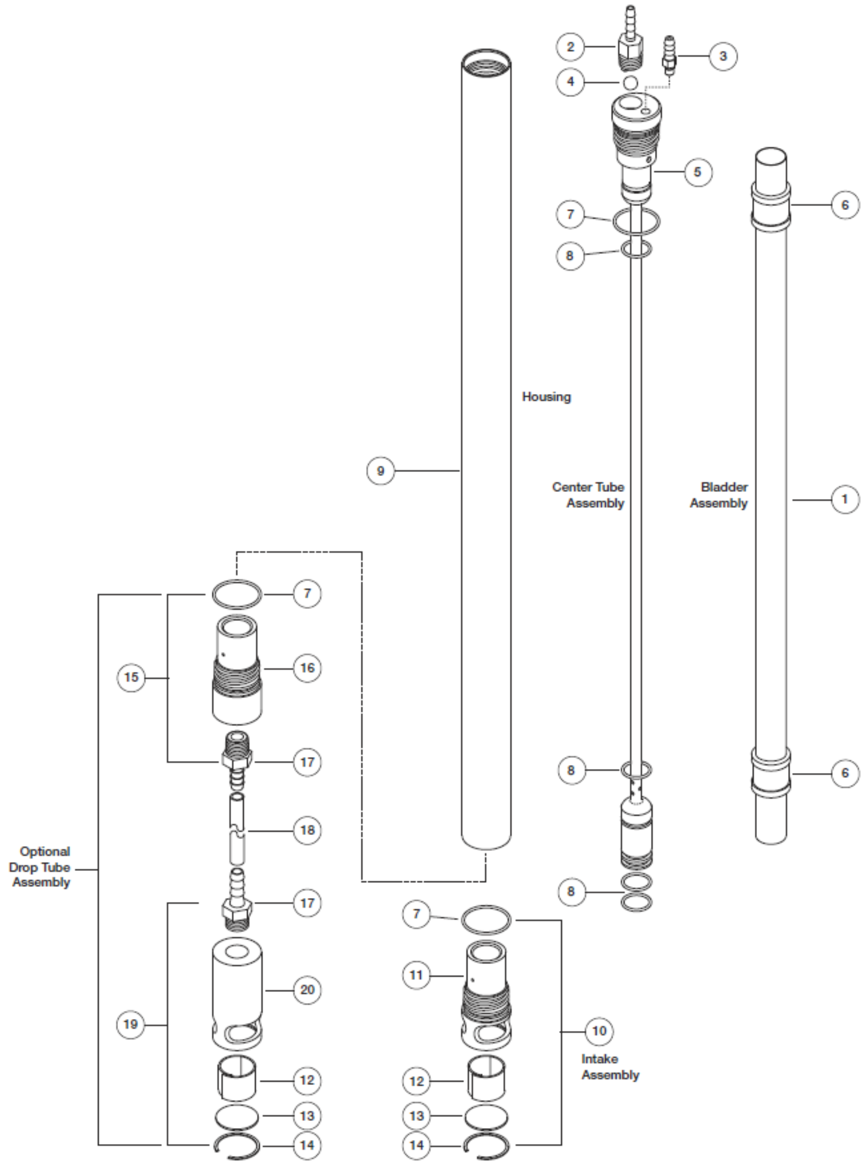
§ *= Sold Separately*

Bladder Pump, 1.66, Stainless Steel, 18", High Pressure - 81150121

Item	Qty	Description	Part No.
1	1	EYEBOLT, SS6, 10-24, 1" SHANK	16600347
2	1	WASHER, SS6, #10, LOCK	11150449
3	1	WASHER, SS6, #10	11150450
4	1	CMPRSN FITTING, SS6, 3/8 TUBE x 1/8 FPT	11150446
4a	1	NIPPLE, SS6, 1/8" NPT x 2.5"	11150447
5	1	CMPRSN FITTING, MOD, SS6, 3/8 TUBE x 3/8" MPT	21150144
6	2	BALL, SS6, 1/2"	17500082
7	1	CAP, UPPER WELDMENT, SS, 166x18"	21150147
8	2	O-RING, VITON, 2.5mm x 36mm, BROWN	11150318
9	2	O-RING, VITON, #123, BROWN	11200299
10	2	CLAMP, SS6, LOW PROFILE	11150444
11	1	BLADDER, PTFE, BP, 166SS18, DEDICATED	51150140
12	1	HOUSING, SS6, DED, 166x18"	51150143
13	1	ASSY, BOTTOM INTAKE, 166 BP	51150067
14	1	PLUG, BALL RETAINER, 166 BP	21150096
15	1	O-RING, VITON, #014, BROWN	17500119
16	1	O-RING, VITON, 2mmx20mm	11150332
17	1	CAP, LOWER, SS6, 166 BP	21150094
18	1	SCREEN, INTAKE, SS6, 166 BP	21150095
19	1	DISC, SS,1.66, PBP	21150148
20	1	RING, SNAP, SS6, INTERNAL, 166 BP	11150051
21	§	ASSY,LOWER CAP,166 DROP TUBE WITH 1/2" HOSEBARB	51150128
22	§	DROPTUBE, CAP LOWER, SS6, 166	21150098
23	§	HOSEBARB, SS6, 1/2 x 3/8" MPT	16600217
24	§	TUBING, PE, 1/2 x 5/8"	87050504
25	§	ASSY, INTAKE, 166, DROP TUBE, WITH 1/2" HOSE BARB	51150071
26	§	INTAKE, DROPTUBE, SS6, 166	21150113
Not Shown:			
	1	MANUAL, BLADDER PUMPS	21150035
	§	TOOL, BLADDER PUMP, PINCER, 5mm	11150031
	§	FERRULE SETS, SS6, 3/8"	57200010
	§	KIT, 166 SS BP, O-RING SET, O-RING SERVICE SET [Items 8 (2), 9 (2), 15 (1), 16 (1)]	91150023

§ *= Sold Separately*

.850 Stainless Steel Bladder Pump Components

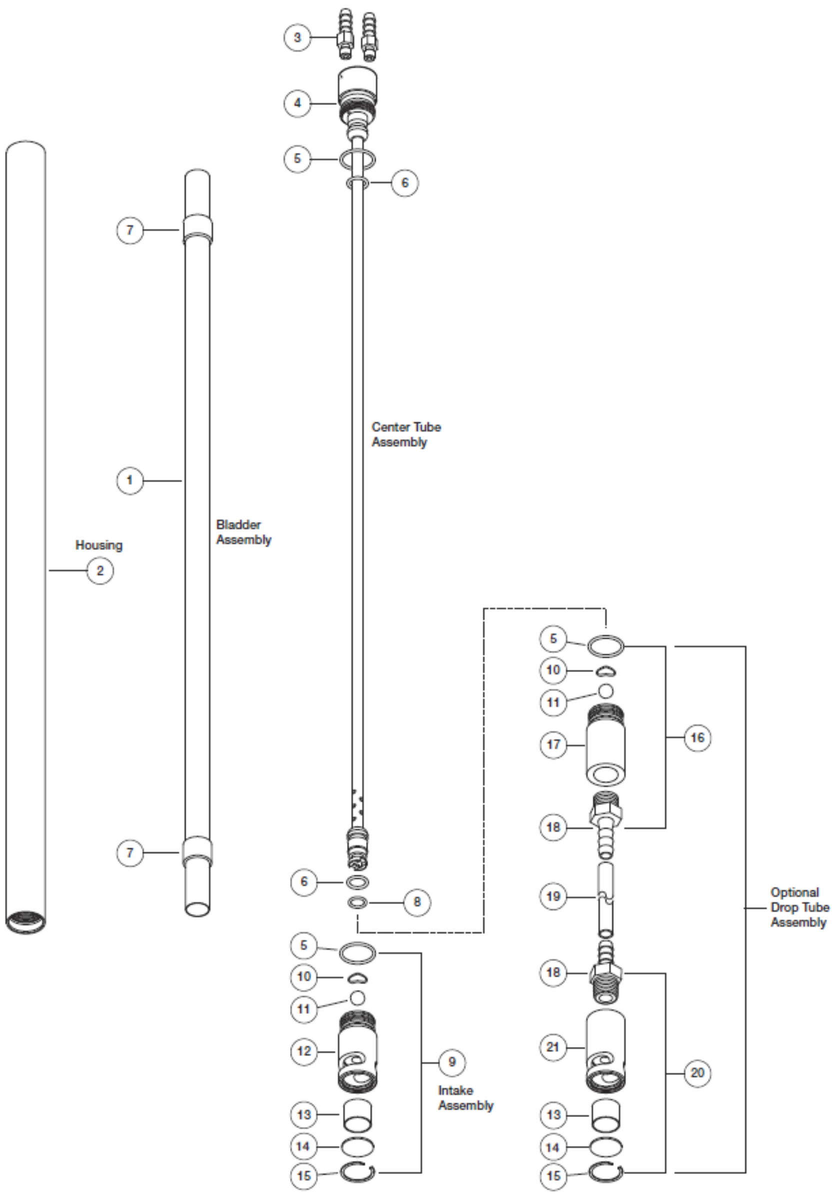


Bladder Pump, .850, Stainless Steel, Screened - 81150115

Item	Qty	Description	Part No.
1	1	BLADDER ,PTFE, .85 BP	51150051
1	§	BLADDER, PE, .85 BP, EA	21150100
1	§	BLADDER, PE, .85, CE, 12PK	21150099
2	1	HOSEBARB, SS6, MOD, .170 X 1/8 NPT DISCHARGE	11150118
3	1	HOSEBARB, SS6, .170 X 10/24 AIR	17200245
4	2	BALL, SS6, 1/4"	17500079
5	1	CAP UPPER WELDMENT, SS6, .85 BP	21150045
6	2	RING, COMPRESSION, PTFE, .850, CE, BP	21150048
7	2	O-RING, VITON, CS .0629, ID 17.1MM	17500112
8	4	O-RING, VITON, #012	17500111
9	1	HOUSING, SS6, .850, BP	21150047
10	1	ASSY, BOTTOM INTAKE, .85 BP	51150118
11	1	CAP, LOWER, SS6, .850, BP	21150046
12	1	SCREEN, INTAKE, SS6, .85 BP	21150050
13	1	DISC, SS, .85 BP	21150049
14	1	RING, SNAP, SS6, INTERNAL, .85 BP	11150053
15	§	ASSY, LOWER CAP, .850 BP, DROP TUBE, CE, W/ 1/4" HOSEBARB	51150129
16	§	DROP TUBE, CAP LOWER, .850 BP, CE SS	21150109
17	§	HOSEBARB, SS6, 1/4 X 1/8 MPT	17200072
18	§	TUBING, PE, 1/4 X 3/8, FT POLYETHYLENE	87050502
19	§	ASSY, INTAKE, .850 BP, DROP TUBE, CE, W/ 1/4" HOSEBARB	51150069
20	§	INTAKE, DROP TUBE, .850 BP, CE, SS	21150111
Not Shown:			
	1	MANUAL, BLADDER PUMPS	21150035
	§	SPARE PARTS KIT, .85, BP, CE [Items 4 (2), 6 (2), 7 (2), 8 (4), 12, 13, 14]	51150123
	§	KIT, .85 BP, O-RING SET, CE, O-RING SERVICE KIT [Items 7 (2), 8 (4)]	91150013

§ *= Sold Separately*

.675 Stainless Steel Bladder Pump Components



Bladder Pump, .675, Stainless Steel, Screened - 81150117

Item	Qty	Description	Part No.
1	1	BLADDER, PTFE, .675, BP, CE	51150126
1	§	BLADDER, PE, .675, EA	21150102
1	§	BLADDER, PE, .675, CE, 12PK	21150101
2	1	HOUSING, SS6, .675, BP	21150032
3	2	HOSEBARB, SS6, .170 X 10/24 AIR	17200245
4	1	WELDMENT, INNER, SS6, .675 BP	51150125
5	2	O-RING, VITON, #014	17500119
6	2	O-RING, VITON, #107	17500604
7	2	RING, COMPRESSION, PTFE, .675 BP, CE	21150106
8	1	O-RING, VITON, #009	17500113
9	1	ASSY, BOTTOM INTAKE, .675, BP	51150120
10	1	RETAINER, BALL, .675 BP, TACO	21150087
11	1	BALL, SS6, 1/4"	17500079
12	1	CAP, LOWER, SS6, .675 BP	21150031
13	1	SCREEN, INTAKE, SS6, .675 BP	11150317
14	1	DISC, SS, .675 BP	21150033
15	1	RING, SNAP, SS, .675 BP	11150182
16	§	ASSY, LOWER CAP, .675 BP, DROP TUBE, CE	51150130
17	§	DROP TUBE, CAP LOWER, .675 BP, CE SS	21150110
18	§	HOSEBARB, SS6, 1/4 X 1/8 MPT	17200072
19	§	TUBING, PE, 1/4 X 3/8, FT POLYETHYLENE	87050502
20	§	ASSY, INTAKE .675 BP, DROP TUBE CE	51150070
21	§	INTAKE, DROP TUBE, .675 BP, CE, SS	21150112
Not Shown:			
	1	MANUAL, BLADDER PUMPS	21150035
	§	SPARE PARTS KIT, .675, BP, CE [Items 5(2), 6 (2), 7(2), 8, 10, 11, 13, 14, 15]	51150124
	§	KIT, .675 BP, O-RING SET, CE O-RING SERVICE KIT [Items 5 (2), 6 (2), 8]	91150014

§ = *Sold Separately*

DOCUMENT REVISIONS		
Project#	DESCRIPTION	REV/DATE
1375	Release, SP	3/11/2014
EDCF # 1870	Corrected Replacement Parts List (Ch. 7) for 1.66 pump, SP	2/17/2015
0992	Updated Manual to show new style 1.66 pump, SP	1/11/2015
EDCF #2001	Updated part numbers and minor formatting, SR	10/27/16
1560	Adding temperature spec to Section 6: System Specifications. (185F/85C), PTFE to SS Disc in 1.66 models, StellaR	5/25/2017
1565	Added compression fitting instructions, StellaR	9/18/2017
1597	Added part # 91150023 – O-ring service kit, - StellaR	1/17/2018
1597	Clarified part list – notes between included and items sold separately from pump. Included items in O-ring service kit for 1.66 pumps – StellaR	1/22/2018
1749	Changed EDCF to Project in Document Revisions. Removed all "project". Indicated an EDCF where changes were made in an EDCF. Changed all PTFE disc description to SS. (.675 and .850 builds) – StellaR	3/18/2019
1918	Updated maintenance instructions with alternate way to reassemble bladder. Removed specified part numbers – StellaR	1/14/2020
-	Corrected table of contents – StellaR	6/15/2020

The Warranty

For a period of one (1) year from date of first sale, product is warranted to be free from defects in materials and workmanship. Geotech agrees to repair or replace, at Geotech's option, the portion proving defective, or at our option to refund the purchase price thereof. Geotech will have no warranty obligation if the product is subjected to abnormal operating conditions, accident, abuse, misuse, unauthorized modification, alteration, repair, or replacement of wear parts. User assumes all other risk, if any, including the risk of injury, loss, or damage, direct or consequential, arising out of the use, misuse, or inability to use this product. User agrees to use, maintain and install product in accordance with recommendations and instructions. User is responsible for transportation charges connected to the repair or replacement of product under this warranty.

Equipment Return Policy

A Return Material Authorization number (RMA #) is required prior to return of any equipment to our facilities, please call 800 number for appropriate location. An RMA # will be issued upon receipt of your request to return equipment, which should include reasons for the return. Your return shipment to us must have this RMA # clearly marked on the outside of the package. Proof of date of purchase is required for processing of all warranty requests.

This policy applies to both equipment sales and repair orders.

FOR A RETURN MATERIAL AUTHORIZATION, PLEASE CALL OUR SERVICE DEPARTMENT AT 1-800-833-7958 OR 1-800-275-5325.

Model Number: ________________
Serial Number: ________________
Date: ________________

Equipment Decontamination

Prior to return, all equipment must be thoroughly cleaned and decontaminated. Please make note on RMA form, the use of equipment, contaminants equipment was exposed to, and decontamination solutions/methods used.

Geotech reserves the right to refuse any equipment not properly decontaminated. Geotech may also choose to decontaminate equipment for a fee, which will be applied to the repair order invoice.

Geotech Environmental Equipment, Inc.
2650 East 40th Avenue Denver, Colorado 80205
(303) 320-4764 ● **(800) 833-7958** ● FAX (303) 322-7242
email: sales@geotechenv.com website: www.geotechenv.com