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Dominion

July 14, 2016

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

Mr. Justin L. Williams
Land Protection & Revitalization Division Director
Commonwealth of Virginia
Department of Environmental Quality
629 East Main Street
Richmond, Virginia 23219

Re: **Chesterfield Power Station – Response to Technical Comments for Groundwater Monitoring Plan – Solid Waste Permit SWP 617**

Dear Mr. Williams:

The Virginia Department of Environmental Quality (DEQ) provided technical comments on February 26, 2016 regarding Dominion's solid waste permit application (SWP 619) submittal for the closure of the Chesterfield Power Station Upper Ash Pond. In response to the DEQ's comments, Dominion provides the enclosed Response to Comments and Groundwater Monitoring Plan. The following responses and enclosures address each comment from the DEQ.

Please contact Dennis Slade at dennis.a.slade@dom.com with any questions.

Sincerely,

Paula A. Hamel
Director, Generation Environmental Services

Enclosures

cc: Geoff Christe, Virginia DEQ, Geoff.Christe@deq.virginia.gov

RESPONSE TO COMMENTS – DEQ LETTER DATED FEBRUARY 26, 2016
UPDATED *GROUNDWATER MONITORING PLAN*
CHESTERFIELD POWER STATION, UPPER ASH POND
CHESTERFIELD COUNTY, VIRGINIA

Comments and Responses

Groundwater Monitoring Well Network

1. *In the Groundwater Monitoring Plan (GMP) it is stated that some of the groundwater monitoring wells will be screened from the invert elevation of the adjoining toe drain (where it intersects the water table) to approximately 10 feet below the invert elevation. Since metals sampling results can be affected by complex solution/dissolution reactions that take place in the capillary fringe zone, the well screens should be located at least 5 feet below the seasonal low water table such that they are submerged all year long.*

As requested, Section 4.3 of the Plan has been updated to indicate the screened interval for new wells that will be installed for this project will be constructed so that the top of the screened interval is at least 5 feet below the seasonal low water table. Furthermore, the wells are designed so that the top of the screen will be 5 feet below the lowest elevation associated with the seasonal low water table [estimated at 4 feet above mean sea level (MSL) or the bottom of the pond being monitored (0 feet MSL for the Lower Ash Pond and 2.5 feet above MSL for the upper ash pond].

2. *The MW's proposed for use must be installed such that they will not be submerged during a flood event. During a flood event, water must not be able to enter the well bore at any time. Existing wells that have a top of casing elevation less than the elevation of the 100-yr flood will need to be modified.*

Based on available Federal Emergency Management Agency (FEMA) mapping, the 100-year flood elevation for the UAP is estimated at approximately 15.8 feet above AMSL based on the 1988 North American Vertical Datum (NAVD). Due to site conditions, it is not feasible to locate all of the wells in areas that have ground surface elevations above the 100-year floodplain elevation. Due to health and safety concerns, the use of extended well casings and elevated sampling platforms was also eliminated from consideration. Rather, Dominion has determined that a double surface casing combined with a simple air release valve mechanism complete with protective bollards around the wellhead will be sufficient to protect the wells from flood debris and surface water inflow from flooding. The design will also allow for wellhead venting as the potentiometric surface elevation rises and falls and periodic functional testing of the air release valve. The proposed design will not allow for sampling during a flood event, but flood events are known to be rare, such that the semi-annual sampling events can be scheduled around the flood events.

Details for the proposed wellhead installation are presented on Figure 1 in Appendix I. Dominion intends to install the modified wellhead design on existing and proposed wells that are located within the 100-year floodplain (*i.e.*, wells with ground surface elevations that are less than 16 feet above MSL). After installing the flood-proof well head, the well casings will be secured with a locking fiberglass utility cabinet that will be attached to a concrete pad centered on the well casing.

3. *In Appendix 1, the facility states that the drilling method for installation of new wells will be air rotary. Since the upper aquifer at the facility is in unconsolidated sediments, the facility should also list hollow stem auger as an additional drilling method.*

The Groundwater Monitoring Well Construction specification in Appendix I of the Plan has been updated to indicate that other drilling technology as applicable for subsurface conditions may be used at this facility. It is noted that multiple drilling technologies are expected to be used at the site due to the variable geologic conditions that are expected to be encountered.

4. *The facility has proposed monitoring wells in the underlying Potomac Aquifer system. Based on the relatively shallow depth of the Petersburg Granite at the facility depicted in the cross-sections and boring logs within the GMP, the facility should install additional wells within the Petersburg Granite to act as an additional deeper monitoring well system. The facility should make a note in the GMP ensuring that the proposed up-gradient wells are screened in the same lithologic unit as the down-gradient wells and that the proposed up-gradient wells are located on land owned by Dominion.*

Dominion has re-reviewed the available hydrogeological data for the site. Based on DEQ's comment and the available information, Dominion is proposing three downgradient monitoring wells (MW-1DD, MW-6DD, and MW-16DD) that will be used to monitor groundwater quality and the static water level elevation in the saprolite/fractured granitic bedrock beneath the UAP. Based on the available information, no additional wells should be required to due to the depth to the basement bedrock unit and the presence of an underlying "aquitard" unit between the uppermost aquifer (and the bottom of the UAP) and the basement bedrock unit.

The newly proposed wells (MW-1DD, MW-6DD, and MW-16DD) will be nested with existing proposed monitoring wells. If water level gauging data indicate that there is an upward gradient in the vicinity of the nested wells, Dominion will request a permit amendment to modify the monitoring requirements for these deep wells to water level gauging only.

With respect to the proposed upgradient wells, the Plan has been updated to indicate that the upgradient wells for the compliance monitoring network must be located on Dominion property and that the wells should be screened within the same lithologic unit(s) as the downgradient monitoring wells. As shown on Drawing 2, the upgradient wells for the Columbia Aquifer, the Potomac Aquifer, and the underlying bedrock are located on the west side of the outwash channel on Dominion property.

5. *Groundwater monitoring wells near the toe drain pump stations should be considered.*

Dominion has re-reviewed the available hydrogeological information for the site. Based on the observed hydraulic gradient (vertical), the expected aquifer coefficients of dispersion and diffusion, and the unlined design of the perimeter toe drain and the UAP, placement of monitoring wells immediately adjacent to one or both of the toe drain pump stations is not required to ensure that the monitoring network is protective of human health and the environment.

Specifically, the proposed groundwater network was developed based on review of existing well locations and screened intervals, the expected drawdown associated with the toe drain, and an approximate average well spacing of 500 feet around the downgradient waste management unit boundary. As presented on Drawing 2 and Drawing 3, proposed monitoring well MW-17 is located close to the southern toe drain sump, and the northern sump, which is not located on Dominion property, has wells on both sides to the east and west (*e.g.*, MW-9 and MW-10).

Hydrogeologically, placement of a monitoring well in close proximity to the sumps is not recommended because pumping of the unlined sumps and associated toe drain structure induces an upward vertical and inward horizontal gradient to the sump location. Therefore, with the proposed well design that has the top of the well screens at least 5 feet below the seasonal low water table or the bottom of the UAP (whichever is the lower elevation), any well that is placed near the sumps would be monitoring groundwater that is moving toward the sumps from a lower elevation (*i.e.*, not monitoring groundwater that could be impacted by the waste disposal unit). Therefore, Dominion believes that the existing proposed network as modified is sufficient to meet the intent and requirements of the applicable regulations.

6. *Drawing 2 depicts some of the proposed down-gradient monitoring wells potentially between the toe drain and the waste mass. No groundwater monitoring wells should be located between the toe drain and the waste mass.*

Dominion has adjusted most well locations to place the wells on the outside of the toe drain where site conditions will allow. It is noted that wells MW-7 through MW-12 are located inside of the toe drain on Dominion property. These locations were selected for health and safety, well security, and well access reasons. Specifically, the toe drain in this area of the site appears to be located off of Dominion property. Drawing 2 has been updated to illustrate the updated well locations.

Sampling and Analysis

7. *It is stated in Section 5.1.2 that the down-gradient wells will be sampled during the background sampling period. Since waste is already in place, sample collection from the down-gradient monitoring wells during development of background is not necessary.*

Dominion acknowledges this comment. However, based on the requirements in the CCR Final Rule and discussions with the USEPA, Dominion intends to complete a minimum of 8 background sampling event for each proposed compliance well.

8. *Additional VSWMR constituents that are required to be monitored under the Modified Assessment Monitoring program shall include Copper, Cyanide, Nickel, Silver, Vanadium, and Zinc. Please add these constituents to Table 4 of the GMP.*

Dominion has re-reviewed Table 4 (Modified Assessment Monitoring Program analyte list) in the Plan that was submitted to the DEQ (version that is stamped, signed, and dated February 4, 2016), and it appears that the requested constituents are already listed in Table 4.

9. *Section 7.3 should state that in accordance with 9VAC20-81-250.A.4.i verification samples are to be obtained within the 30-day statistically significant increases (SSI) determination period defined in 9VAC20-81-250.A.4.h.(2).*

Section 7.3 of the Plan has been updated to clearly reflect that verification samples are to be obtained within the 30-day statistically significant increase determination period defined in 9VAC20-81-250.A.4.h(2).

10. *The GMP did not appear to contain any discussion of the process of any 3rd party validation of the lab data as discussed in 9VAC20-81-250.A.4.j. Some facilities simply rely on the laboratory QA/QC procedure as the validation tool. If so, this should be clarified in the text.*

Dominion intends to have the groundwater monitoring results reviewed and validated, either in-house or externally by its groundwater monitoring consultant, to ensure that the data meet the project data quality objectives. Dominion understands that the data review must be performed within the 30-day statistically significant increase determination period. No changes to the Plan were completed based on this comment.

11. *Section 5.2.3 discusses the use of Alternate Concentration Level (ACL) based Groundwater Protection Standards (PS). The use of ACL values as GPS is not allowed in the CCR Final Rule and any reference to ACL based GPS should be removed from the GMP.*

As requested, Section 5.2.3 has been updated to remove any discussions on the potential use of Alternate Concentration Limit (ACL)-based Groundwater Protection Standards (GPS).

12. *It should be noted in Section 6.9.2 that sample will be reported as totals only. The GMP should also have a statement in Section 6.4 that compliance monitoring samples will not be filtered.*

Section 6.9.2 of the Plan has been updated to clearly indicate that compliance groundwater sample results will be reported on a total basis. Similarly, Section 6.4 of the Plan has been updated to indicate that compliance samples will not be filtered.

Reporting

13. *Sections 5.2.5.7 should state that the facility has 30 days to determine if there is an SSI above GPS per 9VAC-20-81-250.A.4.h.(2) and 14 days to notify the DEQ if an SSI has been determined as required by 9VAC-20-81-250.C.3.e.(3).(a).*

As requested, Section 5.2.5.7 of the Plan has been updated to reflect the 30-day statistical evaluation period and the 14-day GPS exceedance notification period.

14. *Drawing 2 should depict the edge of surface water.*

As requested, Drawing 2 of the Plan has been updated to clearly illustrate the approximate mean high water line for the James River, as well as other water bodies in the project area.

15. *In Section 5.2.4 it is stated that installation of additional monitoring wells may be necessary if a release above GPS is detected. Due to the close proximity of surface water, alternate methods of plume delineation may need to be considered in the event that a release above GPS is detected.*

Dominion acknowledges this comments and agrees that monitoring of surface water and/or the shallow interface zone between the groundwater table and surface water may be required to assist with plume delineation in the event of one or more GPS exceedances, due to the close proximity of surrounding water bodies. No changes to the Plan were completed based on this comment.

16. *There does not appear to be any discussion of periodic well inspections in the GMP. The Department recommends that a visual field inspection of the groundwater monitoring wells take place at least once every quarter by a designated site representative and a process be established so that repairs (if needed) can be made prior to the upcoming groundwater sampling event.*

As requested, Section 4.5 of the Plan has been updated to include provisions for quarterly exterior well inspections and a detailed (exterior and interior) annual inspection, with typical logs for the quarterly and annual inspections incorporated into Appendix I of the Plan for reference.

GROUNDWATER MONITORING PLAN

CHESTERFIELD POWER STATION
UPPER ASH POND, SOLID WASTE PERMIT NO. 619
CHESTERFIELD COUNTY, VIRGINIA

JULY 2016

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1.0 INTRODUCTION

This *Groundwater Monitoring Plan* (GMP) was prepared for the Dominion Chesterfield Power Station Upper Ash Pond (Facility) in Chesterfield County, Virginia, in accordance with the requirements of the amended Virginia Solid Waste Management Regulations (VSWMR) as adopted by the Virginia Waste Management Board on December 4, 2015. The provisions outlined in the GMP are consistent with the requirements in USEPA's *Disposal of Coal Combustion Residuals* (CCR) *from Electric Utilities* (Final Rule; Federal Register Vol. 80, No. 74, 21302-21501) as published on April 17, 2015, and the VSWMR.

This GMP has been prepared in general accordance with Department of Environmental Quality (DEQ) guidance and the VSWMR, and sets forth the requirements and procedures for collecting, analyzing, and managing groundwater samples and data from the uppermost aquifer underlying the Facility. In the event that future amendments to the VSWMR or Federal regulations conflict with any provisions of this GMP, the applicable regulation will supersede this GMP with the exception of DEQ-approved variances and Alternate Source Demonstrations (ASDs) and permit-specific conditions.

2.0 SITE LOCATION INFORMATION

The Dominion Chesterfield Power Station Upper Ash Pond is located in Chesterfield County, east of I-95 on the south side of the James River (Dutch Gap Cutoff Channel) near its confluence with the Old Channel of the James River. The Upper Ash Pond is on property owned and controlled by Dominion and is part of the Chesterfield Power Station. A site location map is presented as Drawing 1.

As presented on Drawings 2 and 3, the Upper Ash Pond covers approximately 112 acres, and the Facility Boundary, based on the Upper Ash Pond parcel of the Chesterfield Power Station, covers approximately 141.7 acres. The limits of the Upper Ash Pond waste management unit boundary, the Facility Boundary, and the property boundary are shown on Drawing 3.

Site access will be from the existing access road off of Henricus Park Road on the northeast corner of the Site (Drawing 3). The Facility's eastern, southern, and western boundaries are bordered by undeveloped land, tidal flats, and river bottom associated with the Old Channel of the James River. The Facility is bordered to the northwest by the Chesterfield Power Station Lower Ash Pond, and to the north and northeast by the Henricus Historical Park, including the partially in-filled Old Channel of the James River.

2.1 Site History

The Facility was formerly operated by Lone Star Industries, Inc. as a sand and gravel pit. The Facility property was originally leased by Virginia Electric and Power Company (VEPCO) for construction and operation of the Upper Ash Pond *circa* 1983. Subsequently, Dominion Virginia Power acquired the Facility property and annexed it to the Chesterfield Power Station. The Upper Ash Pond was constructed within earthen perimeter embankments with a crest elevation of approximately 42 feet above mean sea level (AMSL). Available design information for the Upper Ash Pond indicates that the base of the impoundment is located at an approximate elevation of 2.5 feet AMSL.

Available site records indicate that the Upper Ash Pond has only received CCR and associated coal combustion process waste for disposal. The Upper Ash Pond is currently undergoing closure in-place with final engineered cover placement scheduled to be completed in 2018.

3.0 SITE GEOLOGY AND HYDROGEOLOGY

A number of water quality and hydrogeological investigations have been completed for the Facility and surrounding area. A list of the investigations and reports that have been used to prepare the Site Conceptual Model that is presented herein is presented as follows:

- *Water Quality Impact Evaluation from Proposed Ash Tailings Impoundment at VEPCO's Chesterfield Power Station, Farrar Island, Virginia.* Prepared by Dames and Moore, Bethesda, Maryland, July 15, 1983.
- *Late Mesozoic and Cenozoic Stratigraphic and Structural Framework near Hopewell, Virginia.* Dischinger, Jr., J.B., 1987. U.S. Geological Survey Bulletin 1567.
- *Ground-Water Resources of the York-James Peninsula of Virginia.* Laczniak, R.J., and A.A. Meng III, 1988. U.S. Geological Survey, Water-Resources Investigation Report No. 88-4059.
- *Hydrogeology and Analysis of the Ground-Water Flow System in the Coastal Plain of Southeastern Virginia.* Hamilton, P.A., and Larson, J.D. 1988. Virginia State Waste Control Board: U.S. Geological Survey.
- *Geologic Map and Generalized Cross Sections of the Coastal Plain and Adjacent Parts of the Piedmont, Virginia.* Mixon, R.B., C.R. Berquist, Jr., W.L. Newell, G.H. Johnson, D.S. Powars, J.S. Schindler, and R.K. Radar. 1989. United States Department of the Interior, U.S. Geological Survey. Miscellaneous Investigation Series. MAP I-2033. 1:250,000 scale.
- *Oil Discharge Contingency Plan, Groundwater Characterization Study, Virginia Power, Chesterfield Power Station.* Prepared by Environmental Service and Technology Corporation, May 1, 1993.
- *Supplemental Investigation of Groundwater Conditions at the Bellwood Extrusion Plant, Chesterfield County*, Virginia. Environmental Resource Management (ERM). September 2001.
- *The Virginia Coastal Plain Hydrogeologic Framework*, Professional Paper No. 1731. McFarland, E.R., and T.S. Bruce, 2006. U.S. Department of Interior, U.S. Geological Survey.
- *Hydrogeologic and Geotechnical Report for the Dominion Chesterfield Power Station Fossil Fuel Combustion Products Management Facility, Chesterfield County, Virginia.* Golder Associates Inc. July 2010.

- *Revised Groundwater Quality and Risk Assessment Report, Chesterfield Power Station – Old Ash Pond, VPDES Permit No. VA0004146, 500 Coxendale Road, Chesterfield County, Virginia.* URS Corporation, Richmond, Virginia. March 22, 2012.

- *Facility Background Concentration Report for Groundwater Analytes, Chesterfield Power Station Fossil Fuel Combustion Products Management Facility.* Golder Associates Inc. May 2012.

Based on review of the information presented in these investigations, a summary of the regional and site hydrogeology information comprising the Site Conceptual Model is presented in the following sections.

3.1 Regional and Site Geology

The Facility is located approximately 2.5 miles east of the Fall Line in the western part of the Virginia Coastal Plain Physiographic Province. The surrounding area is characterized by gently rolling topography incised by a number of dendritically patterned, well established stream channels flowing in a general easterly direction towards the James River. The Coastal Plain Physiographic Province is composed of an extensive complex of interlayered, unconsolidated to semi-consolidated strata deposited between the Quaternary and Cretaceous Periods. The thickness of the strata is variable within the Coastal Plain, varying from a "feather's edge" where the sediments overlap the Piedmont Physiographic Province rocks and saprolitic sediment, to massively bedded formations near the continental shelf.

Structurally, the Facility is located within the easterly dipping Coastal Plain physiographic province with the northern limits of the inactive Dutch Gap Fault (normal fault with a west footwall) mapped immediate south of and beneath the Facility along the south bank of the James River (Old Channel).

In the vicinity of the Facility, the Cretaceous and Tertiary sedimentary deposits are variable in thickness and overlie the Petersburg Granite, a Paleozoic crystalline basement composed primarily of quartz, sodic plagioclase, potassium feldspar, biotite, and hornblende, with minor amounts of ilmenite, magnetite, pyrite, zircon, apatite, titanite, muscovite, and fluorite (VDMR, 1993). The bedrock surface in the vicinity of the site is interpreted to be inclined to the east. The lower Cretaceous and overlying Tertiary sediments are in turn overlain by Quaternary alluvium associated with the present day James River.

3.1.1 Site Geology

Drawing 4 shows the extent of the surficially exposed geologic formations in the vicinity of the Site (Mixon *et al.*, 1989). As presented, the Upper Ash Pond is immediately underlain by unconsolidated, undifferentiated Quaternary alluvium associated with the James River. These sediments are variably described as sand and gravel that locally has a clayey matrix. The alluvial sediments are interbedded with terraced deposits of fluvial and marine origin, consisting of silts and clays associated with Pleistocene transgression and regression events (Hamilton, 1988). The lower Pleistocene sediments of the Charles City Formation are mapped approximately 2,500 feet to the northwest of the Facility on the Drewry's Bluff Quadrangle, indicating that these sediments also likely underlie the Facility.

Underlying the Quaternary and Pleistocene sediments are undifferentiated Tertiary sedimentary deposits. These sediments are variably described as dense greenish-gray clayey silts to silty clays of marine origin. The Tertiary sediments are underlain by the greenish fine sand and silt sediments of the Cretaceous Potomac Formation. As presented in Drawing 4, these sediments are mapped to the south of the site across the tidal flats of the Old Channel (James River).

Based on the various site investigations that have been completed to date, the natural deposits beneath the Facility have been variously described as consisting of 11 different layers. A summary of these layers is presented in the following table, and the horizontal and vertical extent of the layers are illustrated on Drawings 5 and 6 as reproduced from previous site reports (Dames & Moore, 1983).

Layer Number	Description	Notes
Layer 1	Up to 30 feet thick, laterally continuous except where the former pond was located. Comprised of medium to fine silty sand with clayey sand lenses. Locally this layer includes fill materials used for road and berm construction. Interpreted Quaternary terrace deposit. Interpreted sediments of the Columbia Group.	Lowest mapped elevation of -5.0 feet MSL. Uppermost water-bearing layer beneath some of the Facility.
Layer 2	Discontinuous soft organic clayey silt layer. Mapped beneath the central and southwestern portions of the Facility. Interpreted sediments of the Columbia Group. Estimated permeability of 1.0E-07 centimeter per second (cm/s).	Discontinuous semi-confining unit.
Layer 3	Clean sand and gravel. Hydraulically connected to the James River based on observed tidal fluctuations. Interpreted sediments of the Yorktown Formation. Estimated permeability of 1.0E-01 cm/s.	Identified uppermost aquifer (Yorktown Aquifer) for the Facility.
Layer 5A	Discontinuous stiff clayey silt with organic material. Interpreted Tertiary terrace or overbank deposit that was observed to overlie Layers 4 and 5 in the southeastern portion of the Facility. Interpreted sediments of the Nanjemoy Formation and/or Marlboro Clay unit.	Discontinuous confining unit.
Layer 4	Discontinuous dense fine to medium silty sand with clay lenses. Previously interpreted as sediments of the Lower Cretaceous Patuxent Formation. Interpreted sediments (this study) of the Aquia Formation. Permeability of 1.0E-03 to 1.0E-04 cm/s.	Semi-confined Aquia Aquifer unit

Layer Number	Description	Notes
Layer 5	Hard silty clay that is observed to underlie all of the Facility except the south central area where it appears to have been eroded away by the ancestral James River. Interpreted sediments of the middle Potomac Formation confining unit. Estimated permeability of 1.0E-08 cm/s.	Discontinuous middle Potomac confining unit.
Layer 6	Dense, massively bedded silty sand, measured permeability of 1.0E-05 to 1.0E-06 cm/s. Interpreted sediments of the middle Potomac Formation.	Layers 6, 7, 8, and 9 interpreted as fining upward sequences of the middle Potomac Aquifer unit.
Layer 7	Horizontally bedded dense silty sand and gravel, estimated permeability of 1.0E-02 to 1.0E-04 cm/s. Interpreted sediments of the middle Potomac Formation.	
Layer 8	Dense, massively bedded silty sand, measured permeability of 1.0E-05 to 1.0E-06 cm/s. Interpreted sediments of the lower Potomac Formation.	
Layer 9	Horizontally bedded dense silty sand and gravel, estimated permeability of 1.0E-02 to 1.0E-04 cm/s. Interpreted sediments of the lower Potomac Formation.	
Layer 10	Hard silty clay, measured permeability of 2.1E-08 cm/sec. Interpreted sediments of the lower Potomac Formation.	Discontinuous Lower Potomac Confining unit.
Layer 11	Dense saprolite and fractured igneous granitic rock. Interpreted to be the weathered Petersburg granite. Rises in elevation from -124 feet AMSL near soil boring location DM-6; -96 feet AMSL at soil boring location DM-3, -28 feet AMSL at soil boring location DM-1, to -14 feet AMSL at soil boring location DM-10.	Basement bedrock aquifer system.

3.2 Site Soil Units

The United States Department of Agriculture (USDA) has mapped a variety of soils at the site, including Ochrepts and Udults soils, Fluvaquent soils, Chewacla loam, Toccoa fine sandy loam, Buncombe loamy fine sand, Chastin loam, and the Pamunkey loam (USDA, 2006). The Fluvaquent soils are classified as hydric soils and the remaining soils as upland soils. The distribution of Fluvaquent soils, as mapped by the USDA, correlates well with the surveyed site-specific wetland delineation limits.

3.3 Site Hydrogeology

The groundwater surface generally mimics area topography with groundwater movement from topographically high areas to topographically low areas (*i.e.*, James River channel). The uppermost aquifer beneath the Facility is unconfined and found in the surficially exposed overburden, and is comprised of Quaternary and upper Tertiary sediments, hereafter referred to as the Columbia Aquifer (the water table aquifer system, which includes unconfined sections of the Yorktown Formation). The Columbia Aquifer is an unconfined water table aquifer that is underlain by sediments of the lower Tertiary Aquia Formation and the Cretaceous Potomac Formation. Regionally, the Potomac Formation is a confined aquifer. The Potomac Aquifer overlies the fractured bedrock aquifer associated with the Petersburg Granite.

3.3.1 Description of the Uppermost Aquifer

The uppermost aquifer for this Facility is the Columbia Aquifer, herein defined as being comprised of Layers 1, 2, and 3. Layer 2 is a discontinuous aquitard-type unit. Layer 1, where saturated, and Layer 3 comprise the water-bearing portion of the Columbia Aquifer for this Facility. In the vicinity of the site, the Columbia Aquifer thickness ranges from approximately 30 feet to 0 feet where it has been eroded by the James River.

The depth to groundwater in the Columbia aquifer is variable depending on topographic elevation. In the immediate vicinity of the Facility, the groundwater elevation ranges from sea level along the banks of the James River up to approximately 15 feet AMSL where the Facility abuts the Lower Ash Pond, with higher groundwater elevations documented in the western portion of the Chesterfield Power Station to the west of the Facility. In the immediate area of the Facility, the Columbia aquifer is bounded by groundwater discharge sinks associated with the tidal James River to the west, south, and east, with a similar groundwater sink (discharge) area located immediately north of the Facility in the abandoned James River channel.

The tidal range for the James River in the vicinity of the Facility is variable and averages approximately 3 feet with a typical river elevation range of 0.35 feet AMSL at low tide to 3.35 feet AMSL at high tide. The tidal range is expected to influence the groundwater table within the Columbia Aquifer for those areas that are located at elevations that are less than 5 feet AMSL, and past monitoring activities have documented a measurable degree of tidal fluctuation in the sediments of Layer 3.

In addition to the natural recharge and discharge cycles associated with precipitation infiltration and vertical recharge to stratigraphically lower water-bearing units and gradient controlling discharges to the James River, the water table surface in the Columbia Aquifer beneath the Facility is influenced by a perimeter toe drain that was installed around the outside of the Upper Ash Pond berm when it was constructed in the 1980's. The approximate location of the perimeter toe drain is shown on Drawing 3. The toe drain was installed as an engineering control during construction of the UAP to remove collected water from the impoundment berm to maintain and protect the berm's structural integrity. The toe drain is largely constructed in Layer 1 with sections that extend through Layer 2 into Layer 3. Based on review of the design drawings for the toe drain, approximate invert elevations for the toe drain are indicated on Drawing 3 every 500 feet (approximate). These invert elevations, where they are lower than the inferred groundwater surface, indicate that the toe drain will influence the water table elevation when it is being pumped. The toe drain is currently in operation and is expected to remain in operation during the post-closure period of the Upper Ash Pond.

3.3.2 Uppermost Aquifer Hydraulic Properties

Depth-to-water measurements have been obtained periodically from site wells since the 1980's. These measurements indicate that the regional water table is present at an elevation near MSL, with some mounding beneath the Upper Ash Pond and the adjoining Lower Ash Pond to the west-northwest. The mounding is believed to be associated with the infiltration of residual impounded process water and impounded precipitation.

Available slug test data for various observation and monitoring wells in the area of the Upper Ash Pond and generally within the Chesterfield Power Station boundary are summarized in Table 1. As presented, slug testing data indicate that the hydraulic conductivity of the sediments comprising the uppermost aquifer range over approximately four (4) orders of magnitude, with a geometric average of 9.06E-04 cm/s, or 2.57 feet per day.

Based on review of the materials that comprise the uppermost aquifer, the average effective porosity of the unconfined aquifer is estimated at 20% (Saunders, 1998).

3.3.3 Horizontal Component of Flow

Using the groundwater contours presented as an overlay on Drawing 3, the average hydraulic gradient for the unconfined aquifer in the vicinity of the facility was calculated at 2.8E-02 (unitless) as shown below.

$$i_{gw} = \left({}^{h_L}/_{L} \right)$$

Where: h_L = head loss (elevation difference)
L = length (horizontal distance)

i = h_L/L = (5.0 ft AMSL – 1.0 ft AMSL) / 250 feet = 1.6E-02
i = h_L/L = (5.0 ft AMSL – 1.0 ft AMSL) / 100 feet = 4.0E-02
i (average) = 2.8E-02

Using the estimated effective porosity value of 20%, the reported hydraulic conductivity value of 2.57 ft/day, and the calculated gradient, the average rate of groundwater flow (V_{gw}) in the unconfined aquifer was calculated using the algorithm below.

$$V_{gw} = K\, i\, \left({}^{1}/_{n_e}\right)$$

Where: V_{gw} = Groundwater velocity
K = Hydraulic conductivity
i = Hydraulic gradient
n_e = Effective porosity

V_{gw} = [(2.57 ft per day) x (2.8E-02)] / 0.20
V_{gw} = 0.36 ft per day, or 131 ft per year

As presented above, the estimated horizontal rate of groundwater flow in the shallow unconfined aquifer beneath the study area is expected to average approximately 131 feet per year.

3.3.4 Vertical Component of Flow

Using depth to water and elevation data from nested wells DM-5, DM-6, and DM-7, the vertical component of flow within the water-bearing formations beneath the Facility were evaluated. As presented in Table 2, DM-5 is screened in the Columbia Aquifer (-5.4 to -15.4 feet AMSL); DM-7 is screened in the Potomac Aquifer (-39.8 to -44.8 feet AMSL); and DM-6 is screened in the lower portion of the Potomac Aquifer (-73.7 to -83.7 feet AMSL). The vertical gradient between DM-5 and DM-7; and DM-7 and DM-6 was calculated as shown below.

$$i_{gw} = \left({}^{h_L}/_{L}\right)$$

Where: h_L = head loss (elevation difference)
L = length (vertical distance – midpoint of the well screens)

$i_{DM\text{-}5/DM\text{-}7}$ = h_L/L = (1.84 feet AMSL – 0.95 feet AMSL) / 31.9 feet (midpoint to midpoint)
= 2.80E-02 (downward; unitless)

$i_{DM\text{-}7/DM\text{-}6}$ = h_L/L = (0.95 foot AMSL – 1.47 feet AMSL) / 38.5 feet (midpoint to midpoint)
= -1.35E-02 (upward; unitless)

The positive gradient between DM-5 and DM-7 suggest a downward gradient from the Columbia Aquifer to the Potomac Aquifer and the negative gradient between DM-7 and DM-6 indicates that the hydraulic gradient in the Potomac Aquifer is upward. Using the estimated effective porosity value of 20%, a vertical hydraulic conductivity value of 2.57E-01 ft/day (estimated at 10% of the horizontal hydraulic conductivity), and the calculated gradients, the vertical rate of groundwater flow (*V_{gw}*) in the unconfined aquifer is expected to range from 13 feet per year downward to 6 feet per year upward based on the following calculations.

$$V_{gw} = Kv\, i\, \left(1/n_e\right)$$

Where:

V_{gw} =	Groundwater velocity
K_v =	Hydraulic conductivity
i =	Hydraulic gradient
n_e =	Effective porosity

DM-5 and DM-7 Well Pair

V_{gw} = [(0.257 foot/day) x (2.80E-02)] / 0.20
V_{gw} = 3.6E-02 foot/day, or 13.1 feet/year downward

DM-7 and DM-6 Well Pair

V_{gw} = [(0.257 foot/day) x (-1.35E-02)] / 0.20
V_{gw} = -1.73E-02 foot/day, or 6.3 feet/year upward

These results, combined with available information on the site hydrogeology, indicate that the area surrounding the Facility is likely a recharge area for the Columbia Aquifer.

4.0 DESIGN OF THE GROUNDWATER MONITORING SYSTEM

The monitoring wells proposed for the compliance monitoring network are, or will be, located and constructed with a sufficient number of wells to yield groundwater samples representative of the conditions in the uppermost unconfined aquifer beneath the Facility that:

1. Accurately represent the quality of background groundwater that has not been affected by leakage from the waste management unit (CCR unit).

2. Accurately represent the quality of groundwater passing the waste boundary of the waste management unit (CCR unit). The downgradient monitoring system installed at the waste boundary will ensure detection of groundwater contamination in the uppermost aquifer. Dominion will monitor potential contaminant pathways related to the waste management unit (CCR unit).

Dominion will obtain a certification from a qualified professional engineer stating that the groundwater monitoring system has been designed and constructed to meet the requirements of the CCR Final Rule [§257.91(f)] as adopted under the VSWMR. The certification will be placed in the Facility operating record in accordance with the recordkeeping requirements of §257.105 as adopted by the VSWMR. Pursuant to §257.106 and §257.107 (as adopted by the VSWMR, the owner/operator will notify the DEQ when the certification is placed in the operating record and on the owner/operator's publicly accessible internet site.

Well placement, construction, development, and decommissioning procedures are discussed in the following sections. Recommended monitoring well construction, development, and decommissioning procedures are included in Appendix I.

4.1 Special Conditions

Special conditions are site conditions that can affect the design of a groundwater monitoring system. These conditions may include:

- Waste management units, including CCR units, located above mounded groundwater table;
- Waste management units, including CCR units, located above aquifers with seasonally variable groundwater flow directions;
- Waste management units, including CCR units, located in areas where nearby surface water features or proximity to tidally influenced surface water bodies may influence groundwater levels or expected flow directions;
- Waste management units, including CCR units, located near intermittently or continuously used groundwater production wells; and/or

- Waste management units, including CCR units, located in karst (carbonate bedrock) or faulted areas where subsurface geologic features may modify expected groundwater flow paths.

Based on the available hydrogeologic information for the Facility, other than the considerations listed below, Dominion is not aware of any special conditions, including those listed above, that would affect the design of a downgradient groundwater monitoring network that can effectively monitor the uppermost aquifer:

1. Due to the surrounding low lying topography and discharges to the James River, a radial flow regime is indicated beneath the northern, eastern, southern, and southwestern limits of the Upper Ash Pond; and
2. A perimeter toe drain system that intersects the uppermost water table aquifer around the northern, western, and southern limits of the Upper Ash Pond.

The tidal fluctuation observed along the adjoining James River and in the lower Potomac Aquifer system does not appear to be significant in elevation range or gradient reversal impact within the Columbia Aquifer in the immediate vicinity of the Upper Ash Pond. Therefore, this natural variable is not expected to impact the placement of downgradient wells.

Due to the location of the Upper Ash Pond, which is bounded by the James River and a former channel of the James River, and the radial-like flow system in the uppermost water table aquifer beneath the Upper Ash Pond, a suitable upgradient well location that reflects upgradient groundwater quality that could not potentially be impacted by the Upper Ash Pond is not available in the immediate vicinity of the Upper Ash Pond. Therefore, Dominion's proposed groundwater monitoring system for the Upper Ash Pond includes downgradient wells located around the perimeter of the Upper Ash Pond and two alternative upgradient well locations as discussed in the following section.

4.2 Monitoring Well Placement

The monitoring network described herein is designed to meet the performance standards specified in the VSWMR consistent with the CCR Final Rule, and to ensure protection of human health and the environment. Accordingly, the monitoring network is designed so that adequate monitoring coverage is provided to represent the quality of groundwater upgradient and downgradient of the waste management unit (CCR unit). Consistent with Dominion's policy, the proposed monitoring wells will be installed on property that is owned by Dominion and affiliated companies.

The Upper Ash Pond will be monitored with 25 downgradient monitoring wells (MW-1 through MW-17, MW-B32, MW-1D, MW-1DD, MW-3D, MW-6D, MW-6DD, MW-16D, and MW-16DD) and three upgradient monitoring wells (MW-29U, MW-30U, and MW-31U). The approximate locations of the proposed compliance wells (plus or minus 50 feet) are illustrated on Drawings 2 and 3. The upgradient wells will be constructed so that they are monitoring the same lithologic units as the downgradient wells. A summary of the well construction information for the existing wells, including nearby observation wells, is provided below and in Table 2.

As presented, 18 of the downgradient wells will monitor the upper water table aquifer, the Columbia Aquifer. Four of the proposed downgradient wells (MW-1D, MW-3D, MW-6D, and MW-16D) will monitor the underlying Potomac Aquifer system along the southern and eastern boundaries of the Facility, and three of the downgradient wells (MW-1DD, MW-6DD, and MW-16DD) will monitor the lower saprolite/fractured bedrock unit. The three upgradient wells are proposed to monitor the Columbia Aquifer, Potomac Aquifer, and lower fractured bedrock/saprolite aquifer. Additional upgradient wells may be proposed at a later date if significant spatial water quality differences are observed.

4.3 Monitoring Well Construction

Logs for MW-B31 and MW-B32 are not readily available. However, historical tabulated information indicates that these two wells are believed to be constructed with 10 feet of 2-inch ID PVC screen located within the upper portion of the Columbia Aquifer beneath the Upper Ash Pond.

The remaining proposed downgradient monitoring wells (MW-1 through MW-17, MW-1D, MW-1DD, MW-3D, MW-6D, MW-6DD, MW-16D, and MW-16DD) will be constructed with 10 feet of 2-inch ID PVC casing and 0.010-inch factory slotted, flush-threaded well screen. The bottom of the wells will be equipped with a flush-threaded end cap and the well casing will be extended to approximately 30 inches above grade. In general, these wells will be constructed so that the top of the screened interval is at least 5 feet below the season low water table surface or the bottom of the adjacent pond, whichever is lower. Additionally, based on the hydrogeological model for the site, the top of the well screens for proposed wells (MW-1 through MW-17) will be located to extend from at least 5 feet below the invert elevation of the adjoining toe drain (where it intersects the water table). The upgradient wells will be screened in the upper 15 to 20 saturated feet of the Columbia Aquifer, the lower section of the Middle Potomac Aquifer, and the lower fractured bedrock.

Monitoring wells that are located above the 100-year floodplain elevation will be completed with a locking protective standpipe and a concrete apron for surface protection. Monitoring Wells that will be installed in areas that are below the 100-year floodplain elevation will be finished with a water-tight casing equipped with a self-vented, self-sealing air release value. The casings will be equipped with a water-tight clean-out that will allow access to the well head for sampling. The normally open air-release valve will allow the well casing to breath as the water level in the well fluctuates and will automatically close in the event that floodwaters begin to encroach upon the well casing. Wells equipped with the water tight casing will be secured in a locking fiberglass or similar construction utility cabinet that will be secured to a concrete pad centered on the well casing. Details for the water tight well casing are presented on Figure 1 in Appendix I. The designs as presented will prevent surface water from entering the wells in the event of a flood, will protect the wells from floating debris, and will provide access to the wells for sampling with dedicated equipment during normal site conditions (*i.e.*, non-flood conditions).

If additional wells are required in the future, construction will be performed in general accordance with the specifications presented in Appendix I. Monitoring wells will be maintained such that they perform to design specifications throughout the life of the monitoring program. Dominion will document and include in the Facility operating record the design, installation, and development of any monitoring wells, piezometers, and other measurement, sampling, and analytical devices as required by §257.91(e)(1) and in accordance with the recordkeeping requirements of §257.105 as adopted in the VSWMR.

Soil boring and well construction logs for the proposed wells will be incorporated into Appendix II upon construction within 120 days of DEQ's approval of the GMP.

4.3.1 Drilling Methods

Drilling of new monitoring wells will be performed in general accordance with the specifications presented in Appendix I. It is anticipated that a number of different drilling technologies may be used at this facility based on the geologic conditions that are expected to be encountered. A qualified groundwater scientist will prepare a boring and well construction log for each new well. The owner/operator will transmit the boring logs, well construction logs, and appropriate maps for any wells to be included in the permitted network to the DEQ within 14 days of certification by the qualified groundwater scientist in accordance with the VSWMR. Available boring logs and well construction diagrams for current monitoring wells are provided in Appendix II.

4.3.2 Well Development

Existing wells will be redeveloped with the new wells following installation of the initial compliance network wells. Specifically, existing and newly constructed wells will be developed to remove particulates that are present in the well casing, filter pack, and adjacent aquifer matrix due to construction activities. Development of new monitoring wells will be performed at least 24 hours after well construction. Wells may be developed with disposable bailers, a well development pump, or other approved method. Well development procedures are presented in Appendix I.

Samples withdrawn from the Facility's monitoring wells should be clay- and silt-free; therefore, wells may require redevelopment from time to time based upon observed turbidity levels during sampling activities. If redevelopment of a monitoring well is required, it will be performed and documented in a manner similar to that used for a new well.

4.3.3 Documentation

Documentation of future well construction activities will be in accordance with the VSWMR and CCR Final Rule. New wells will be surveyed by a licensed surveyor to within ±0.05 foot on the horizontal plane and ±0.01 foot vertically in reference to mean sea level. A boring log, well construction log, groundwater monitoring network map, and installation certification will be submitted to the DEQ within 14 days of certification by the qualified groundwater scientist in accordance with the VSWMR. Separately, a copy of the boring log, well construction log, groundwater monitoring network map, and installation certification will be incorporated into the Facility operating record as required under §257.105 of the CCR Final Rule as adopted in the VSWMR. The certification shall occur within 30 days of well construction (including the licensed well survey).

4.4 Monitoring Well Decommissioning Procedures

If a monitoring well becomes unusable during the life of the monitoring program, the Facility operator will make reasonable attempts to decommission the monitoring well in accordance with procedures presented in Appendix I.

4.4.1 Documentation

DEQ approval will be obtained prior to decommissioning any monitoring wells that are in the Facility's compliance monitoring network. A report describing the decommissioning procedures will be transmitted to DEQ following completion of the decommissioning activities. Separately, a copy of the report will be included in the Facility operating record in accordance with the recordkeeping requirements of §257.105 as adopted in the VSWMR.

4.5 Well Operations and Maintenance

In accordance with the VSWMR and §257.91(e)(2), the compliance monitoring wells will be operated and maintained so they perform to their design specifications throughout the life of the monitoring program. Maintenance activities for the compliance wells are as follows:

Activity	Schedule
Lock Inspection	Each Monitoring Event
Protective Casing Inspection	Annually
Pump Inspection & Cleaning	Annually
Depth to well bottom	Annually

Activity	Schedule
Concrete Pad Inspection	Annually
Surface Water Infiltration Evaluation	Annually
Grass Mowing	Semi-Annually as needed
Air Vent Testing (floodplain wells)	Annually

The results from the well inspections will be recorded on a Well Inspection Log during the routine semi-annual sampling events. Samples of typical well inspection logs are presented in Appendix I.

5.0 GROUNDWATER MONITORING PROGRAM

This GMP is intended to provide a framework for consistent sampling and analysis procedures (as provided in Section 6.0) that are designed to ensure monitoring results from the detection and assessment monitoring programs provide an accurate representation of groundwater quality data at the background and downgradient wells. As such, provisions for both a modified Detection Monitoring Program and a modified Assessment Monitoring Program are presented herein. Both programs are modeled on the requirements of the CCR Final Rule and the VSWMR, with additional monitoring for constituents historically monitored pursuant to Chesterfield Power Station's VPDES permit that have been documented in the groundwater at the Facility. Based on the existing VPDES constituents that have been documented, groundwater monitoring activities for the Upper Ash Pond will commence under the requirements of a modified Assessment Monitoring Program.

Consistent with the VSWMR and the CCR Final Rule, Dominion will annually certify each waste management unit (CCR unit) is in compliance with the groundwater monitoring provisions, provide the certification to the DEQ, and place a copy in the Facility operating record and on the publicly available website in accordance with the recordkeeping and notification requirements of §257.105, §257.106, and §257.107 as adopted in the VSWMR.

Records of the background groundwater quality data and subsequent measurements, including concentration data, will be kept in the Facility operating record, provided to DEQ, and placed on the publicly available website in accordance with the recordkeeping and notification requirements of §257.105, §257.106, and §257.107 as adopted in the VSWMR. These records will be maintained throughout the active life of the Facility and the post-closure care period. For each parameter, the laboratory certificates-of-analysis will identify the analytical Limit of Quantitation (LOQ), the analytical Limit of Detection (LOD), the reported concentration, and applicable laboratory quality assurance/quality control (QA/QC) data on surrogate and standards analyses. Statistical evaluations of the analytical data (if completed), Groundwater Protection Standard (GPS) comparisons, static water level determinations and evaluations, and use of other measurement, sampling, and analytical devices, will be retained throughout the active life of the Facility and the post-closure care period.

Details for the VSWMR and CCR Final Rule monitoring programs, including background sampling requirements, are presented in the following sections.

5.1 Modified Detection Monitoring Program

The modified Detection Monitoring Program is designed to identify the presence and concentration of targeted potential CCR constituents in the uppermost aquifer beneath the Facility. Components of the CCR

Detection Monitoring Program, including analytical requirements, sampling frequency, and data evaluation, are discussed in the following sections.

5.1.1 Constituents

The modified Detection Monitoring Program will involve purging and sampling the compliance monitoring wells for analysis of the modified Detection Monitoring Program constituents listed in Table 3. These samples will be analyzed at least semi-annually during the remaining active life and the post-closure period. Typical analytical methods and associated Practical Quantitation Limits (PQLs) for these parameters are summarized in Table 3.

5.1.2 Background Sampling

A minimum of eight independent samples shall be collected from each upgradient compliance well during the background sampling period (within 30 months after the date of publication of the CCR Final Rule in the Federal Register; therefore, no later than October 17, 2017) as adopted in the VSWMR. The background sampling events will be performed on a temporal schedule that accounts for both seasonal and spatial variability in groundwater quality for the constituents listed in Tables 3 and 4.

5.1.3 Sampling Schedule

After establishing Facility background concentrations, the CCR Detection Monitoring Program sampling schedule will be based on a semi-annual schedule in accordance with the CCR Final Rule (once every 180 days plus or minus 30 days) as adopted in the VSWMR.

5.1.4 Detection Evaluation and Response

After establishing Facility background concentrations, Dominion will perform the following evaluations in response to the quantified detection of the modified Detection Monitoring Program constituents and parameters in downgradient wells.

- If all monitoring parameters and constituents are shown to be at or below established Facility background concentrations using appropriate statistical procedures, sampling and analysis activities will continue under the modified Detection Monitoring Program with the sampling and analysis results reported with the statistical evaluation results in a semi-annual or annual monitoring report, as applicable, with a copy placed in the Facility operating record and on the publicly available website in accordance with §257.90(e) as adopted in the VSWMR. Pursuant to §257.106(h)(1) as adopted in the VSWMR, Dominion will notify the DEQ when the report is placed in the operating record and on the publicly available website.

- If determined, pursuant to §257.93(h) as adopted in the VSWMR, that there is a statistically significant increase (SSI) over background levels for one or more of the constituents listed in Table 3 at any monitoring well at the waste boundary specified under §257.91(a)(2) as adopted in the VSWMR, Dominion will:
  - Unless an alternate source is demonstrated and approved by the DEQ within 90 days of identifying the SSI, prepare a background exceedance notification indicating the owner/operator's intent to initiate a modified Assessment Monitoring Program, and place the notice in the Facility's operating record and on the publicly available website, followed by establishment of a modified Assessment Monitoring Program pursuant to §257.95 as adopted in the VSWMR within 90 days of detecting a SSI over background levels. Additionally, pursuant to §257.106(h) as adopted in the VSWMR, Dominion will notify the DEQ when the notification is placed in the operating record and on the publicly available website.

5.1.5 Detection Monitoring Program Reporting Requirements

Reporting and recordkeeping requirements are summarized in the following sections.

5.1.5.1 Facility Background Report

A Facility Background Determination Report shall be submitted to the DEQ consistent with the timeframe in 9VAC20-81-250.C.3.b(2) of the VSWMR.

5.1.5.2 Well Installation Report

Following issuance of the permit, well installation reports as may be required shall be submitted to the DEQ within 44 days of well completion (including the licensed survey). The well installation reports shall include permit-required information and shall be certified by a qualified groundwater scientist.

5.1.5.3 Well Decommissioning Report

Following issuance of the permit, well decommissioning reports as may be required shall be submitted to the DEQ within 44 days of completing the physical well decommissioning activities. The well decommissioning reports shall include permit-required information and shall be certified by a qualified groundwater scientist.

5.1.5.4 Well Non-performance Notification

Following issuance of the permit, well non-performance reports as may be required shall be submitted to the DEQ within 30 days of recognizing the non-performance issue.

5.1.5.5 Statistically Significant Increase (SSI) Notifications

Consistent with the VSWMR, the permittee will submit a SSI (over Facility background concentrations) notification with a notice of intent to either complete an Alternate Source Demonstration or establish an Assessment Monitoring Program. The notification will be submitted to the DEQ within 14 days of identifying the SSI and no more than 120 days after completing the semi-annual sampling and analysis activities.

5.1.5.6 Semi-annual Groundwater Monitoring Report

A semi-annual groundwater monitoring report prepared pursuant to the VSWMR and applicable permit conditions shall be submitted to the DEQ no later than June 30th of each year. The report will include a determination of the groundwater flow rate and direction.

5.1.5.7 Annual Groundwater Monitoring Report

An annual groundwater monitoring report prepared pursuant to the CCR Rule, as adopted in the VSWMR, and applicable permit conditions shall be submitted to the DEQ no later than December 31st of each year. The report will include a determination of the groundwater flow rate and direction.

5.1.6 Alternate Source Demonstration

In accordance with the CCR Final Rule as adopted in the VSWMR, the operator may demonstrate that a source other than the UAP caused the SSI over background levels, or that an SSI resulted from an error in sampling procedures, analysis, statistical procedures, or natural variation in groundwater quality. If an alternative source other than the CCR unit is demonstrated, the owner/operator must complete the written demonstration within 90 days of detecting the SSI over background levels, to include obtaining a certification from a qualified professional engineer verifying the accuracy of the information in the report. If a successful demonstration is completed and approved by the DEQ within the 90-day period (beginning on the date of the SSI notification), the owner/operator may continue with the modified Detection Monitoring Program.

If a successful demonstration is not completed within the 90-day period, the owner/operator of the CCR unit must initiate a modified Assessment Monitoring Program pursuant to §257.95 as adopted in the VSWMR unless an extension is granted by the DEQ for good cause.

5.2 Modified Assessment Monitoring Program

Dominion will initiate the groundwater monitoring program at the Facility pursuant to a modified Assessment Monitoring Program as described herein. The modified Assessment Monitoring Program is designed to identify the presence and concentration of targeted potential solid waste constituents in the uppermost aquifer beneath the Facility and to determine if those constituents are derived from the UAP at concentrations that would require groundwater corrective action. Components of the modified Assessment

Monitoring Program, including analytical requirements, sampling frequency, and data evaluation, are discussed in the following sections. In accordance with the CCR Final Rule as adopted in the VSWMR, a notification must be prepared and placed within the Facility operating record and on the publicly available website stating that a modified Assessment Monitoring Program has been established. Pursuant to §257.106 as adopted in the VSWMR, the DEQ must be notified when the notice has been placed.

5.2.1 Constituents

The modified Assessment Monitoring Program will involve purging and sampling the compliance monitoring wells for analysis of the CCR Final Rule constituents, VSWMR Table 3.1 Column B metals, and selected Virginia Water Control Board (VWCB) parameters. A list of the modified Assessment Monitoring Program constituents and parameters for this Facility is presented in Table 4.

Under the modified Assessment Monitoring Program, Dominion will, on a semi-annual basis during the active life and the post-closure period, sample the wells and analyze for all constituents and parameters in Table 4. Following each modified Assessment Monitoring Program event, the owner/operation must record the constituent/parameter concentrations in the Facility's operating record. Typical analytical methods and associated PQLs for these parameters and constituents are presented in Table 4.

5.2.2 Sampling Schedule

Sampling for the modified Assessment Monitoring Program is conducted on a semi-annual schedule in accordance with the CCR Final Rule and VSWMR (once every 180 days plus or minus 30 days).

5.2.3 Groundwater Protection Standards

Pursuant to §257.95(h) as adopted in the VSWMR, GPS will be established for the CCR Final Rule Appendix IV constituents and VSWMR Table 3.1 Column B metals listed on Table 4. The proposed GPS will be developed based on:

- For constituents for which a USEPA MCL has been established, the MCL for that constituent;
- For constituents for which MCLs have not been established, the background concentration established from the upgradient well or wells; or
- For constituents for which the background level is higher than the MCL, the background concentration established from the upgradient well(s).

The established GPS will be included in the annual monitoring report required by §257.90(e) as adopted by the VSWMR and the corrective action report (if required). The MCL-based GPS will be updated upon EPA's promulgation of new or revised MCLs. The background-based GPS will be updated every 2 years such that the eight most recent background well sampling results shall replace the oldest eight background well sampling results.

Following the establishment of background concentrations for the Table 4 constituents, proposed GPS for the applicable constituents (CCR Final Rule Appendix IV constituents and VSWMR Table 3.1 Column B metals) will be submitted to the DEQ consistent with the VSWMR. The GPS based on MCLs will become effective immediately upon proposal. The GPS based on Facility background concentrations will become effective upon written DEQ approval.

5.2.4 Assessment Evaluation and Response

After each monitoring event, the modified Assessment Monitoring Program constituents and parameters detected in the downgradient compliance wells will be evaluated as follows:

To determine if a release from the disposal unit has occurred following commencement of disposal activities, the groundwater monitoring results will be compared to Facility background levels and GPS.

1. Within 30 days of completing the semi-annual sampling and laboratory analysis, Dominion must determine whether there has been a SSI over background levels for any monitoring constituent/parameter listed in Table 4 at each downgradient monitoring well. Detections and concentrations of required constituents will be recorded within the next semi-annual or annual groundwater monitoring report as required, and placed in the Facility operating record, posted on the publicly available website, and provided to DEQ in accordance with the recordkeeping and notification requirements of §257.105, §257.106, and §257.107 as adopted by the VSWMR. If no statistical exceedances over background are identified in any downgradient well, monitoring will continue under the modified Assessment Monitoring Program. If two consecutive annual sampling events pass with no SSIs over Facility background concentrations, the permittee may revert the groundwater monitoring program to the modified Detection Monitoring Program after notifying the DEQ.

2. If there is a SSI over Facility background levels for one or more constituent/parameter listed in Table 4 in any downgradient well, Dominion will compare the sampling result(s) from the downgradient well(s) to the established Facility GPS concentration. If the sampling result(s) are less than the Facility GPS concentration, monitoring will continue under the modified Assessment Monitoring Program.

3. If the sampling result(s) for any Table 4 constituent is greater than the Facility GPS concentration, Dominion will provide a GPS exceedance notification to the DEQ within 14 days of the determination. A copy of the notification will be placed in the Facility operating record and on the publicly available website. The GPS exceedance notification

will identify the constituent(s) that has/have exceeded the GPS. The notification will indicate Dominion's intent to:

a. prepare and submit an ASD within 90 days of the GPS exceedance notification,
b. propose an alternative GPS,
c. propose an Alternative Point of Compliance, or
d. initiate an assessment of corrective measures within 90 days of the GPS exceedance notification.

4. If the assessment of corrective measures is initiated, Dominion will place a notice regarding the initiation in the Facility operating record and on the publicly available website in accordance with the requirements of §257.105 and §257.107 as adopted in the VSWMR. Pursuant to §257.106(h)(6), the owner/operator will notify the DEQ when the required notice has been placed. Dominion will also:

   a. Within 90 days of the GPS exceedance notification, characterize the nature and extent of the release and any relevant site conditions that may affect the remedy ultimately selected. The characterization must be sufficient to support a complete and accurate assessment of corrective measures, as is necessary to effectively remediate releases from the CCR unit pursuant to §257.96 as adopted in the VSWMR. Characterization of the release includes the following minimum measures:
      i. Install additional monitoring wells necessary to define the contaminant plume(s);
      ii. Collect data on the nature and estimated quantity of material released, including specific information on the constituents detected at concentrations above the GPS, and the levels at which they are present in the material released;
      iii. Install at least one additional monitoring well at the Facility boundary in the direction of contaminant migration, and sample this well in accordance with Section 5.2.1; and
      iv. Sample the compliance and assessment of corrective measures wells for analysis of constituents and parameters listed in Table 4 to characterize the nature and extent of the release.

5. Pursuant to §257.95(g)(2), §257.105(h)(8), and §257.106(h)(6) as adopted in the VSWMR, within 30 days of detecting one or more constituents at statistically significant levels above the Facility background concentration, Dominion will notify the DEQ and all persons who own the land or reside on the land that directly overlies any part of the plume of contamination (GPS-exceeding concentration) if contaminants have migrated off-site as

indicated by sampling of wells. The notification is deemed completed when it is placed in the Facility operating record.

6. If a successful ASD is made within the 90-day period (beginning with the date of the GPS exceedance notification), monitoring will continue under the modified Assessment Monitoring Program.

7. If a successful ASD has not been made at the end of the 90-day period (beginning with the date of the GPS exceedance notification), Dominion will initiate and complete an assessment of corrective measures and selection of remedy in accordance with §257.96 and §257.97 as adopted in the VSWMR, respectively. Pursuant to §257.106(h)(9) and (10) as adopted in the VSWMR, the owner/operator must notify the DEQ with separate notices when both the required assessment of corrective measures initiation notice and the assessment of corrective measures availability notice are placed in the Facility's operating record and on the publicly available website. The owner or operator must also include the assessment of corrective measures in the annual groundwater monitoring and corrective action report required by §257.90(e) as adopted in the VSWMR.

8. During the assessment of corrective measures, groundwater will continue to be monitored in accordance with the modified Assessment Monitoring Program.

9. A semi-annual report will be prepared describing the progress in selecting and designing the remedy. Upon selection of a remedy, the a final report will be prepared describing the selected remedy and how it meets the standards specified in §257.96(b) as adopted in the VSWMR. Dominion will also obtain a certification from a qualified professional engineer that the remedy selected meets the requirements of this section. The selection of remedy report must be maintained until the remedy is completed via corrective action.

10. Dominion will comply with the recordkeeping requirements specified in §257.105(h), the notification requirements specified in §257.106(h), and the internet requirements specified in §257.107(h) as adopted in the VSWMR.

If there are no GPS exceedances and Dominion is able to demonstrate that there are no Table 4 constituents present in the groundwater at statistically significant concentrations over background using approved statistical procedures for two consecutive annual sampling events, Dominion may revert the monitoring program to the modified Detection Monitoring Program pursuant to §257.95(e) as adopted in the VSWMR. If the monitoring program is reverted, pursuant to §257.105(h)(7), Dominion will place a notice in the Facility's operating record and on the publicly available website, and pursuant to §257.106(h)(5) as adopted in the VSWMR, will notify the DEQ when the required notice has been placed.

5.2.5 Assessment Monitoring Program Reporting Requirements

Reporting and record keeping requirements are summarized in the following sections.

5.2.5.1 Facility Background Report

If not completed under the modified Detection Monitoring Program, a Facility Background Determination Report shall be submitted to the DEQ consistent with the timeframe in 9VAC20-81-250.C.b(2) of the VSWMR.

5.2.5.2 Well Installation Report

Following issuance of the permit, well installation reports as may be required shall be submitted to the DEQ within 44 days of well completion (including the licensed survey). The well installation reports shall include permit-required information and shall be certified by a qualified groundwater scientist.

5.2.5.3 Well Decommissioning Report

Following issuance of the permit, well decommissioning reports as may be required shall be submitted to the DEQ within 44 days of completing the physical well decommissioning activities. The well decommissioning reports shall include permit-required information and shall be certified by a qualified groundwater scientist.

5.2.5.4 Well Non-performance Notification

Following issuance of the permit, well non-performance reports as may be required shall be submitted to the DEQ within 30 days of recognizing the non-performance issue.

5.2.5.5 Detection Monitoring Program Reversion Notification

Consistent with §257.95(e) as adopted in the VSWMR, if there are no SSIs over Facility background concentrations for two consecutive annual monitoring events, the permittee may revert the groundwater monitoring program to the Detection Monitoring Program. This reversion shall be documented in a notification submitted to the DEQ before the next compliance monitoring event.

5.2.5.6 Groundwater Protection Standard Update Notifications

Notifications for GPS updates due to changes in EPA MCLs and/or Facility background concentrations shall be submitted to the DEQ within 30 days of the update.

5.2.5.7 Groundwater Protection Standard Exceedance Notifications

Consistent with §257.93(h)(2) as adopted in the VSWMR and 9VAC20-81-250.C.3.e(3)(a) of the VSWMR, the permittee will submit a GPS exceedance notification for Table 4 constituents to the DEQ within 14 days of identifying a statistical exceedance of a GPS. Consistent with 9VAC20-81-250.A.4.h(2) of the VSWMR, the permittee has 30 days from the date of the laboratory report issuance to identify any statistically significant exceedances of the Facility-specific GPS.

5.2.5.8 Off-site Plume Notification

In the event that a groundwater plume (concentrations above GPS) is determined to extend off site onto adjacent downgradient property, the permittee will notify the DEQ and the affected landowner within 30 days of the determination consistent with the VSWMR and §257.95(g)(2), §257.105(h)(8), and §257.106(h)(6) as adopted in the VSWMR.

5.2.5.9 Semi-annual Groundwater Monitoring Report

A semi-annual groundwater monitoring report prepared pursuant to 9VAC20-81-250.E of the VSWMR and applicable permit conditions shall be submitted to the DEQ no later than June 30th of each year. The report will include a determination of the groundwater flow rate and direction.

5.2.5.10 Annual Groundwater Monitoring Report

An annual groundwater monitoring report prepared pursuant to §257.90(e)(1-5), 9VAC20-81-250.E.2.a(2) of the VSWMR, and applicable permit conditions shall be submitted to the DEQ no later than December 31st of each year. As adopted in the VSWMR, the annual groundwater monitoring report must comply with the recordkeeping requirements specified in §257.105(h)(1), the notification requirements specified in §257.106(h)(1), and the internet requirements specified in §257.107(h)(1). The report will include a determination of the groundwater flow rate and direction.

5.2.6 Alternate Source Demonstration

The operator may demonstrate that a source other than the UAP caused the contamination, or that a SSI or GPS exceedance resulted from an error in sampling procedures, analysis, statistical procedures, or natural variation in groundwater quality. The ASD must include a certification from a qualified professional engineer verifying the accuracy of the information in the report within 90 days of confirming the GPS exceedance (date of the GPS exceedance notification) to avoid advancing into the Corrective Action Program. The ASD must be included in the annual groundwater monitoring report as required by §257.90(e) as adopted by the VSWMR, and must include a certification by a qualified engineer.

If the ASD confirms an alternate source, as approved by the DEQ, the operator may continue with the modified Assessment Monitoring Program.

If the ASD does not confirm an alternate source, the operator will continue to implement the modified Assessment Monitoring Program and initiate an assessment of corrective measures in accordance with Section 5.2.4.

6.0 SAMPLE AND ANALYSIS PROGRAM

Proper sampling procedures are an important and fundamental aspect in an effective monitoring program. The following sections, which are consistent with EPA guidance, the requirements of the CCR Final Rule, and the VSWMR, outline the proposed sample collection procedures.

6.1 Sampling Order

The compliance wells are/will be equipped with dedicated purging and sampling equipment; therefore, the likelihood of cross-contamination at this Facility is minimized. Accordingly, the anticipated sampling order will follow a sequence based on consideration of field conditions at the time of sampling.

6.2 Water Level Gauging

Prior to purging each monitoring well, the static water level will be gauged using an electronic water level indicator accurate to 0.01 foot. The measurement will be obtained from the surveyed measuring point on each well.

Prior to initial use and between wells, the portion of the water level indicator that comes in contact with the groundwater in the well will be decontaminated to avoid cross-contamination between monitoring wells. In addition to decontaminating the downhole equipment, sampling personnel will don new gloves between wells, and more frequently as needed, to avoid cross-contamination between monitoring wells.

6.3 Purging Procedure

The monitoring wells in the monitoring network will be sampled using a micropurge technique. Micropurge sampling can greatly reduce the volume of water that must be purged from a well before representative samples can be collected, and typically provides for the collection of more representative samples than do other purge methods, as well as consistency in analytical results between sampling events. Micropurging is accomplished through the use of dedicated low-flow sampling devices. Bailers and portable pumps are not recommended because they cause mixing of the standing water column within the well (Robin and Gilham, 1987). This mixing action requires the removal of the traditional large purge volumes before sampling. Introducing any device into the well prior to sampling causes a surging effect that may increase turbidity and interfere with the normal flow of water through the well screen. This disturbance may remain in effect for as long as 24 to 48 hours (Kearl *et al.*, 1992).

For monitoring wells with dedicated bladder pumps equipped with check values that hold stagnant water in the discharge tubing between sampling events, the discharge tubing shall be purged prior to commencing micropurge activities to ensure that fresh formation water is sampled following the completion of micropurging. The discharge tube purge volume will be determined using the following equation:

Discharge Tube Volume (milliliters) = DTP * V_F
Where: DTP = Depth to the top of the pump to the nearest 0.1 foot
V_F = Volume Factor as follows:
10 = 1/4-inch diameter tubing
22 = 3/8-inch diameter tubing
39 = 1/2-inch diameter tubing

If discharge tube purging is required, the purge should be conducted at a rate equal to the well yield to avoid drawing stagnant well column water into the pump (*i.e.*, between 100 and 500 milliliters per minute). During the discharge tubing purge, the flow rate and the depth to groundwater should be monitored on regular intervals (every 3 to 5 minutes) to verify that the purge activities are not removing stagnant water from the water column in the monitoring well.

After completing the discharge tubing purge, if required, water quality parameters (pH, temperature, conductivity) will be monitored during the micropurge consistent with EPA guidance on micropurging. The stabilization of these parameters (generally 10% for three consecutive readings) indicates when the discharge water is representative of formation water and samples can be collected for analysis. Measurements of turbidity may also be collected for the purpose of evaluating the purging technique. Water quality measurements will be collected on approximate 3- to 5-minute intervals and will be recorded on a Field Log or in the Field Book to document purge stabilization.

In addition to the water quality parameters, the flow rate may be monitored on regular intervals during the micropurge to verify that the micropurge activities are not removing stagnant water from the water column in the monitoring wells. In general, purge rates when using micropurge sampling procedures should not exceed 500 milliliters per minute. Any measurements taken should be recorded on a Field Log or in the Field Book to document steady-state flow conditions during the purge. The purge water will be managed in accordance with Dominion standard practices.

On rare occasions, the yield of a monitoring well will be insufficient to keep up with the micropurge. In cases where the yield of the monitoring well is less than 50 milliliters per minute as documented by the recorded flow rate and continually decreasing head level as the well is purged, the required samples may be collected prior to stabilization of the water column provided the water quality parameters have stabilized within the required 10% range.

In the event that dedicated pumping equipment malfunctions during a sampling event, non-dedicated equipment may be used to micropurge the affected well(s) provided the pump can be decontaminated prior to use in each well. The pump and associated discharge hoses must be decontaminated using a non-phosphate-based detergent and water mixture followed by a deionized water rinse to avoid cross-contamination between monitoring wells.

6.4 Sample Collection

Once the water quality data indicate that the micropurge activities have been completed, required samples should be collected directly from the discharge hose on the pump into laboratory-provided, pre-preserved sample containers selected for the required parameters or compatible parameters. Samples collected for the compliance program will not be filtered in the field or at the laboratory. Sample collection should be performed at the same rate (or lower) that was used during the micropurge. Following collection, samples will be placed in a cooler on ice under chain-of-custody control. Samples will be kept at no more than 6°C from collection to laboratory delivery.

Anticipated sample container, minimum volume, chemical preservative, and holding times for each analysis type are provided in Table 5. These may change depending on laboratory requirements. Sample preservation methods will be used to retard biological action, retard hydrolysis, and reduce sorption effects. These methods include chemical addition, refrigeration, and protection from light.

6.5 Sample Documentation

Chain-of-custody control is critical for documenting the integrity of the samples following collection, during transport to the laboratory, and at the laboratory. Consequently, the label for each sample container shall be completed to document the sample collection activities.

The chain-of-custody form should be signed by the sampling personnel and the receiving agent, with the date and time of transfer noted. In the event that the samples are being shipped to a laboratory, the signature of the receiving agent is not required; however, it is recommended that the tracking number for the shipping label should be recorded on the chain-of-custody form. After completing the chain-of-custody form, it should be maintained with the samples.

6.6 Sample Seals

It is recommended that the shipping container be sealed to ensure that the samples have not been disturbed during transport to the laboratory. If sample seals are used, the tape should be labeled with instructions to notify the shipper if the seal is broken prior to receipt at the laboratory.

6.7 Sample Event Documentation

The sampling event field notes should document the field activities such that they along with the chain-of-custody form(s) are sufficient to allow for reconstruction of the sampling event along by a third party.

6.8 Field Quality Assurance/Quality Control Procedures

Trip blanks, equipment blanks, and field blanks provide QA/QC measures for the monitoring program. The QA/QC measures are discussed in the following sections.

6.8.1 Trip Blanks

Trip blanks are a required part of the field sampling QA/QC program only whenever analytical parameters include volatile organic compounds (VOCs). Trip blanks are used to detect contamination that may be introduced in the field (either atmospheric or from sampling equipment), in transit (to or from the sampling site), or in the bottle preparation, sample log-in, or sample storage stages at the laboratory.

Trip blanks are samples of organic-free water (*i.e.*, distilled) prepared at the laboratory. The blanks remain with the sample bottles while in transit to the site, during sampling, and during the return trip to the laboratory. Trip blank sample bottles must not be opened at any time during this process. Upon return to the laboratory, trip blanks will be analyzed for VOCs using the same procedures and methods that are used for the collected field samples.

Trip blank results will be reported in the laboratory results as separate samples, using the designation TB-(#) as their sample point designation. One trip blank should be analyzed for each sample group requiring shipment with VOC samples.

6.8.2 Field Blanks

Field blanks may also be collected as part of the field sampling QA/QC program. The purpose of the field blank is to detect any contamination that might be introduced into the groundwater samples through the air or through sampling activities. For sampling programs involving VOCs, at least one field blank is recommended to be collected and analyzed for the same parameters as those for which groundwater samples are analyzed.

Field blanks must be prepared in the field (at the sampling site) using laboratory-supplied bottles and deionized or laboratory reagent-quality water. Each field blank is prepared by pouring the deionized water into the sample bottles at the location of one of the wells in the sampling program. Preservatives are added to specific sample bottles as required. The well at which the field blank is prepared must be identified on the Field Log along with any observations that may help explain anomalous results (*e.g.*, prevailing wind direction, up-wind potential sources of contamination). Once a field blank is collected, it is handled and shipped in the same manner as the rest of the samples.

Field blank results will be reported in the laboratory results as separate samples, using the designation FB-(well #) as their sample point designation.

6.8.3 Equipment Blanks

For wells that must be sampled with non-dedicated equipment, decontamination procedures consist of rinsing the equipment once with deionized or laboratory reagent-quality water, brushing the equipment using laboratory-quality soap, and triple rinsing the equipment with deionized or laboratory reagent-quality water. One equipment blank may be collected during each sampling event and analyzed for the same parameters as those for which groundwater samples are analyzed. Equipment blanks are collected by pouring deionized or laboratory reagent-quality water into or over the sampling device (*e.g.*, the water level indicator), and then filling a set of sample bottles.

If the analytes for the equipment blank would normally be filtered, this water should be placed into a pre-filtration bottle and subsequently filtered. Whether or not it is filtered, this water is placed into the equipment blank bottles, and the proper preservative added (as required).

Equipment blank results will be reported in the laboratory results as separate samples, using the designation EB-(Well #) as their sample point designation.

6.9 Laboratory Quality Control Procedures

The quality assurance program for the selected Virginia Environmental Laboratory Accreditation Program (VELAP)-accredited analytical laboratory will be documented in their Quality Assurance Program Plan (QAPP). This document describes mechanisms employed by the VELAP-accredited laboratory to ensure that reported data meet or exceed applicable EPA and State requirements. The QAPP describes the laboratory's experience, its organizational structure, and procedures in place to ensure quality of the analytical data. The QAPP outlines the sampling, analysis, and reporting procedures used by the laboratory. The laboratory is responsible for the implementation of and adherence to the QA/QC requirements outlined in the QAPP. A copy of the laboratory's QAPP will be available to the DEQ or Facility personnel upon request.

Audits are an important component of the quality assurance program at the laboratory. Audits are conducted by the laboratory. Internal system and performance audits are conducted periodically to ensure adherence by all laboratory departments to the QAPP. External audits are conducted by accrediting agencies or states. These reports are transmitted to department managers for review and response. Corrective measures must be taken for any finding or deficiency found in an audit.

Data Quality Reviews (DQRs), or equivalent, are requests submitted to the laboratory to formally review results that differ from historical results, or that exceed certain permit requirements or quality control criteria. The laboratory prepares a formal written response to DQRs explaining discrepancies. The DQR is the first line of investigation following any anomalous result.

6.9.1 Laboratory Documentation

Upon receipt of the samples at the laboratory, the following activities are recommended:

- The date, time of sample collection, and analysis to be performed will be provided to the VELAP-accredited laboratory.
- The samples will be examined upon receipt to ensure collection in EPA-approved containers for the requested analysis. The sample collection data and time will also be reviewed to ensure the EPA-required sample holding time has not expired or will not expire before the analysis can be performed.
- The information concerning transportation mode and manner will be reported on the form. Samples must be transported on ice or under refrigeration, and the inside temperature of the cooler recorded upon opening.
- The pH of each sample as well as the sample appearance will be recorded if required by the analytical method. Also, preservative adjustments, filtration, and sample splitting must also occur as required prior to distribution. Sample adjustments will be fully documented.

During analysis of the samples, it is recommended that the laboratory agent maintain the integrity of the samples as follows:

- During the sample analysis period, the samples will remain refrigerated.
- If at any point during the analysis process, the results are considered technically inaccurate, the analysis must be performed again if holding times have not been exceeded.

Documentation activities should be completed with permanent ink in a legible manner with mistakes crossed out with a single line.

6.9.2 Laboratory Analyses

Analytical procedures will be performed in accordance with EPA *Test Methods for Evaluating Solid Waste - Physical/Chemical Methods, SW-846,* as updated and other EPA-approved methods. The modified Detection Monitoring Program and modified Assessment Monitoring Program constituents, along with recommended test methods and PQLs, are listed in Tables 3 and 4. Laboratory analytical results for groundwater compliance samples will be reported on a total sample basis.

Alternate methods may be used if they have the same or lower PQL. Methods with higher PQLs will be considered if the concentration of the parameter is such that an alternate test method with a higher PQL will provide the same result.

6.9.3 Limits of Quantitation (LOQs)

Laboratory-specific LOQs will be used as the reporting limits for quantified detections of required monitoring constituents. Laboratory LOQs should be reported with the sample results.

6.9.4 Limits of Detection (LODs)

Laboratory-specific LODs will be used as the reporting limits for estimated detections of required monitoring constituents. Constituents detected at concentrations above the LOD but below the LOQ will be reported as estimated with a qualifying "J" flag on the laboratory certificates of analysis. It is noted that estimated detections are considered statistically significant and cannot trigger the Corrective Action Program. Laboratory LODs should be reported with the sample results.

6.9.5 Method Blanks

Laboratory method blanks are used during the analytical process to detect any laboratory-introduced contamination that may occur during analysis. A minimum of one method blank should be analyzed by the laboratory per sample batch.

6.9.6 Matrix Spike and Matrix Spike Duplicate Samples

A matrix spike/matrix spike duplicate sample will be run with every sample batch. The relative percent difference between the spike and the spike duplicate sample should be less than 20 percent. Higher values may indicate matrix interference.

7.0 DATA EVALUATION

Statistical analysis of the data will be completed as discussed in the following subsections. These criteria represent a conservative approach to groundwater analysis and incorporate appropriate statistical and other evaluation methodologies.

7.1 Groundwater Data Evaluation

This section outlines the inter-well statistical evaluation methodologies that may be used to detect a release from the Facility by comparing downgradient well results to background.

During background sample collection, it will be necessary to examine the data for outliers, anomalies, and trends that might be an indication of a sampling or analytical error. Outliers and anomalies are inconsistently large or small values that can occur due to sampling, laboratory, transportation, or transcription errors, or even by chance alone. Significant trends indicate a source of systematic error, or an actual contamination occurrence, that must be evaluated and corrected before valid inter-well statistical evaluations can be implemented. The inclusion of such values in the historical database used for temporal water quality evaluations or in the Facility's upgradient database for inter-well statistical evaluations could cause misinterpretation of the data set, and result in high false positive (*i.e.*, an indication of a release when none exists) and/or false negative (*i.e.*, falsely concluding there is no release in the presence of an actual release) conclusions.

To prevent the inclusion of anomalous data in the inter-well database, background monitoring results will be evaluated during background development for any new wells constructed, once those well(s) have at least four measurements for a given constituent using time vs. concentration graphs. Parameter concentrations that appear anomalous (*i.e.*, that are 5 times or greater than the previous results) may be verified during the next sample collection event or after a reasonable period of time to ensure sample independence (*e.g.*, 3 months). If the anomalous result is not verified, the outlier will be removed from the database to maintain the accuracy of the evaluation method. Any detected systematic trends or verified outliers in the background database will be evaluated and reported to the DEQ in a timely manner.

7.1.1 Correcting for Linear Trends

If a data series exhibits a linear trend, the sample will exhibit temporal dependence when tested via the sample autocorrelation function (see Section 14.2.3 of the Unified Guidance; EPA, 2009), the rank von Neumann ratio (see Section 14.2.4 of the Unified Guidance; EPA, 2009), or similar procedure. These data can be de-trended, much like the data in the previous example were de-seasonalized. Typically, the easiest way to de-trend observations with a linear trend is to compute a linear regression on the data (see Section 17.3.1 of the Unified Guidance; EPA, 2009) and then use the regression *residuals* instead of the original measurements in subsequent statistical analysis.

7.2 Statistical Methodology

In accordance with CCR Final Rule §257.93(f)(6) as adopted in the VSWMR, the owner or operator of the CCR unit must obtain a certification from a qualified professional engineer stating that the selected statistical method is appropriate for evaluating the groundwater monitoring data for the CCR management area. The certification will include a narrative description of the statistical method selected to evaluate the groundwater monitoring data. As adopted in the VSWMR, this certification is subject to the recordkeeping requirements specified in §257.105(h), the notification requirements specified in §257.106(h), and the internet requirements specified in §257.107(h).

The statistical test used to evaluate the groundwater monitoring data will be the prediction interval method as allowed by the VSWMR and the CCR Final Rule, unless this test is inappropriate with the background data. If one or more alternative statistical tests are used, Dominion will ensure that an adequate number of independent samples for the statistical method are collected within the compliance period such that the level of significance for individual well comparison will be no less than 0.01 and no less than 0.05 for multiple comparisons for any statistical test. Possible alternate statistical test methods are:

1. A parametric analysis of variance (ANOVA) followed by multiple comparisons procedures to identify statistically significant evidence of contamination. The method will include estimating and testing the contrasts between each compliance well's mean and the background mean levels for each constituent;
2. An analysis of variance (ANOVA) based on ranks followed by multiple comparisons procedures to identify significant evidence of contamination. The method will include estimating and testing the contrasts between each compliance well's median and the background median levels for each constituent;
3. 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;
4. A control chart approach that gives control limits for each constituent; or
5. Another statistical test method that meets the performance standards specified by the DEQ. A justification for the alternate test method will be submitted for approval by the DEQ.

The statistical analysis chosen to evaluate the groundwater data will meet the following performance standards and will be consistent with the DEQ's *Data Analysis for Solid Waste Facilities* (March 2008):

1. The statistical method used to evaluate groundwater monitoring data shall be appropriate for the distribution of monitoring parameters or constituents. If the distribution is shown by the owner or operator to be inappropriate for a normal theory test, then the data should be transformed or a distribution-free theory test should be used. If the distributions for the constituents differ, more than one statistical method may be needed.
2. If an individual well comparison procedure is used to compare an individual compliance well constituent concentration with background constituent concentrations or a GPS, the test shall be done at a Type I error level no less than 0.01 for each testing period. If a multiple comparisons procedure is used, the Type I experiment-wise error rate for each testing period shall be no less

than 0.05; however, the Type I error of no less than 0.01 for individual well comparisons must be maintained. This performance standard does not apply to tolerance intervals, predictions intervals, or control charts.

3. If a control chart approach is used to evaluate groundwater monitoring data, the specific type of control chart and its associated parameter values shall be protective of human health and the environment. The parameters shall be determined after considering the number of samples in the background database, the data distribution, and the range of the concentration for each constituent of concern.
4. If a tolerance interval or a prediction interval is used to evaluate groundwater monitoring data, the levels of confidence and, for tolerance intervals, the percentage of the population that the interval must contain, shall be protective of human health and the environment. These parameters shall be determined after considering the number of samples in the background database, the data distribution, and the range of the concentrations for each constituent of concern.
5. The statistical method shall account for data below the LOD with one or more statistical procedures that shall be at least as effective as any other approach in this section for evaluating groundwater data. Any PQL that is used in the statistical method shall be the lowest concentration level that can be reliably achieved within specified limits of precision and accuracy during routine laboratory operating conditions that are available to the Facility.
6. If necessary, the statistical method shall include procedures to control or correct for seasonal and spatial variability as well as temporal correlation in the data.

7.2.1 Reporting of Low and Zero Values

Chemical constituents that are not present above the detection limit of the analytical procedure are reported as NOT DETECTED (ND), or less than the LOD, rather than as zero or not present, and the laboratory's LOD is provided on the analytical report. There is a variety of ways to deal with data that include values below detection. General guidelines that will be used to handle the data when less than 100 percent of the data are detected are summarized in Table 6.

However, procedures referenced above may be modified as discussed in Chapter 2 of *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance*, March 2009, and as agreed on with the DEQ on a case-by-case basis.

7.2.2 Normality Testing

The original data must be tested for normality using the Shapiro Wilk Test of Normality (either single group or multiple group version) for sample size up to 50, and the Shapiro-Francia Test of Normality for sample size more than 50, or other acceptable test methods. If an alternative test method is proposed for evaluating the normality of data, the Facility operator will provide adequate supporting information demonstrating that the alternative method has a similar level of power to detect deviations from the normal distribution as the Shapiro-Wilks and Shapiro-Francia test methods, as appropriate. The following guidelines are used for decisions in normality testing:

1. If the original data show that the data are not normally distributed, then the data must be natural log-transformed and tested for normality using the above methods.

2. If the original or the natural log-transformed data confirm that the data are normally distributed, then a normal distribution test must be applied.
3. If neither the original nor the natural log-transformed data fit a normal distribution, then a distribution-free test must be applied.

7.2.3 Missing Data Values

Missing data values may result in an incomplete measure of environmental variability and an increased likelihood of falsely detecting contamination. If data are missing, there is a danger that the full extent of contamination may not be characterized. Therefore, resampling will occur within 30 days to replace the missing data unless an alternative schedule is otherwise approved by DEQ.

7.2.4 Outliers

An outlier is a value that is much different from most other values in a data set for a given groundwater chemical constituent. The reasons for outliers may include:

- Sampling errors or field contamination;
- Analytical errors or laboratory contamination;
- Recording or transcription errors;
- Faulty sample preparation or preservation, or shelf-life exceedance; or
- Extreme, but accurately detected environmental conditions (*e.g.*, spills, migration from the Facility).

Formal testing for outliers should be done only if an observation seems particularly high (by orders of magnitude) compared to the rest of the data set. If a sample value is suspect, one should run the outlier test described below, from EPA's *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Interim Final Guidance*. It should be cautioned, however, that this outlier test assumes that the rest of the data values, except for the suspect observation, are normally distributed. Since log-normally distributed measurements often contain one or more values that appear high relative to the rest, it is recommended that the outlier test be run on the logarithms of the data instead of the original observations. That way, one can avoid classifying a high log-normal measurement as an outlier just because the test assumptions were violated.

The procedure for evaluating data for the presence of outliers is as follows. Let the sample of data be denoted by $X_1 \ldots X_n$. For specificity, assume that the data have been ordered and that the largest observation, denoted by X_n, is suspected of being an outlier. Generally, inspection of the data suggests values that do not appear to belong to the data set. For example, if the largest observation is an order of magnitude larger than the other observations, it would be suspect.

Step 1. Calculate the mean, *0*, and the standard deviation, S, of the data including all observations.

Step 2. Form the statistic, T_n:

$$T_n = (X_n - \bar{X}) / S$$

Note that T_n is the difference between the largest observation and the sample mean, divided by the sample standard deviation.

Step 3. Compare the statistic T_n to the critical value given the sample size, n, in Table 8, Appendix B of EPA's statistical analysis document mentioned above. If the T_n statistic exceeds the critical value from the table, this is evidence that the suspect observation, X_n, is a statistical outlier.

If the test designates an observation as a statistical outlier, the source of the abnormal measurement should be investigated. Valid reasons for the outlier value may include contaminated sampling equipment, laboratory contamination of the sample, errors in transcription of the data values, or the value may be a true, but extreme data point. Once a specific reason for the outlier is documented, the data point should be excluded from any further statistical analysis. If a plausible reason cannot be found, the sample should be treated as a true but extreme value and should be excluded from the current data evaluation round (*i.e.*, should not be used to calculate background concentrations). The value should be maintained in the Facility's database, however, with the database re-evaluated during the next data evaluation round.

7.3 Verification Procedure

Once groundwater analysis results have been collected, checked for QA/QC consistency, and determined to be above the appropriate statistical level, the results must be verified in accordance with the objectives of the VSWMR for groundwater monitoring. Verification re-sampling is an integral part of the statistical methodology described by EPA's *Addendum to Interim Final Guidance Document - Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities* (July, 1992). Without verification re-sampling, much larger statistical limits would be required to achieve site-wide false positive rates of 5% or less. Furthermore, the resulting false negative rate would be greatly increased. Verification sampling should generally be performed for each constituent when it is initially determined to be present above its statistical limit. Consistent with the VSWMR, verification samples if collected must be obtained within the 30-day statistically significant increase determination period defined in 9VAC20-81-250.A.4.h.(2)

7.4 Comparison to Groundwater Protection Standards

Following the establishment of GPS under the modified Assessment Monitoring Program, detected constituents will be statistically compared to the approved GPS using one of the methods discussed below.

If the GPS for a constituent is derived from the Facility background concentration, then the groundwater monitoring data must be compared directly to the GPS using a value-to-value comparison. If the established GPS is derived from a MCL (or other reference standard concentration), then the groundwater monitoring data may be compared to the GPS statistically and/or using a value-to-value procedure.

Based on the above criteria, groundwater monitoring data will initially be compared to established GPS via a value-to-value comparison. If a GPS is exceeded during the value-to-value comparison for any parameter, a verification sample may be collected. The results from the verification sample will be compared to the GPS via a value-to-value comparison. If the comparison indicates a GPS exceedance, the source of the GPS will be determined. If the GPS is derived from a MCL, two additional groundwater samples for the suspect constituent(s) may be collected to facilitate a statistical comparison to the GPS. It is noted that verification sampling and/or additional sampling required to perform a statistical evaluation must occur within the same compliance monitoring period that the original samples were collected. The compliance monitoring period begins on the day of sampling and expires 6 months later, or the date of the next compliance sampling event, whichever occurs first.

To perform a statistical comparison, a minimum of four samples must be collected within the compliance monitoring period. Once data have been received for the four samples, then the lower confidence interval can be calculated and compared to the GPS. The lower limit should be calculated initially by using a 95% confidence level. If the lower limit exceeds the GPS, the DEQ may be contacted regarding the use of a confidence level greater than 95%.

8.0 HYDROGEOLOGIC ASSESSMENT

After each sampling event, groundwater surface elevations will be evaluated to determine whether the requirements for locating the monitoring wells continue to be satisfied and the rate and direction of groundwater flow will be determined. Groundwater elevations in monitoring wells must be measured within a period of time short enough to avoid temporal variations in groundwater flow which could preclude accurate determination of groundwater flow rate and direction.

The rate and direction of groundwater flow will be determined each time groundwater is sampled by comparing the groundwater surface elevations among the monitoring wells, and at least annually, constructing a groundwater surface contour map. The groundwater flow rate shall be determined using the following equation:

$$V_{gw} = K\, i \left({}^{1}/_{n_e} \right)$$

Where:

V_{gw} = Groundwater velocity
K = Hydraulic conductivity
i = Hydraulic gradient
n_e = Effective porosity

If the evaluation shows that the groundwater monitoring system does not satisfy the requirements of the VSWMR, the monitoring system will be modified to comply with those regulations after obtaining approval from the DEQ. The operator will request the appropriate permit amendment action related to any revisions of the monitoring well network deemed necessary due to a change in groundwater flow pattern or functionality of any monitoring well. Proposed revisions will be submitted to the DEQ within 30 days of determining that the system does not satisfy the requirements of the VSWMR; the modifications may include a change in the number, location, or depth of the monitoring wells.

9.0 REFERENCES

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g:\projects\dominion\chesterfield power stn\1532-864 uap and lap groundwater\uap groundwater monitoring plan\2016-04 submittal - rtc deq ltr 2016-02-26\2016-04-14 cps uap updated gwmp pn 619.docx

TABLES

TABLE 1

Summary of Existing Slug Test Results
Chesterfield Power Station Upper Ash Pond

Well Identification	Well Location	Test Type	Screened Interval (feet Mean Sea Level)	Analyst	Date	Results (feet per day)	Results (centimeter per second)
B-19	Lower Ash Pond	Falling Head Slug Test	14.0 to 4.0	Dames & Moore	1983	0.2835	1.00E-04
		Falling Head Slug Test		URS	9/12/2006	0.1941	6.85E-05
		Rising Head Slug Test		URS	9/12/2006	0.1941	6.85E-05
B-21	Lower Ash Pond	Falling Head Slug Test	14.0 to 4.0	Dames & Moore	1983	1.4173	5.00E-04
B-41A	Lower Ash Pond	Falling Head Slug Test Rising Head Slug Test	7.0 to -13.0	URS	9/12/2006	0.2501	8.82E-05
B-42A	Lower Ash Pond	Falling Head Slug Test Rising Head Slug Test	1.8 to -8.2	URS	9/12/2006	1.116	3.94E-04
MW-2	Oil Storage Tanks	Falling Head Slug Test	6.3 to -8.7	ENSAT	2/25/1993	0.7776	2.74E-04
DM-2	Off-Site (upgradient)	Slug Test	-9.1 to -19.1	Dames & Moore	1983	500	1.76E-01
DM-3	Off-Site (upgradient)	Slug Test	-68 to -78	Dames & Moore	1983	0.2835	1.00E-04
DM-5	Upper Ash Pond	Slug Test	-5.4 to -15.4	Dames & Moore	1983	283.5	1.00E-01
DM-6	Upper Ash Pond	Slug Test	-73.7 to -83.7	Dames & Moore	1983	0.5669	2.00E-04
DM-7	Upper Ash Pond	Slug Test	-39.8 to -44.8	Dames & Moore	1983	5.669	2.00E-03
DM-11	Off-Site (upgradient)	Slug Test	2.0 to -8.0	Dames & Moore	1983	500	1.76E-01
				Maximum Observed Value:		500	1.76E-01
				Minimum Observed Value:		0.19	6.85E-05
				Geometric Average :		2.6	9.06E-04

TABLE 2

Summary of Existing Well Construction Information
Chesterfield Power Station Upper Ash Pond

Well Identification	Easting (feet)	Northing (feet)	Top of Casing Elevation (ft AMSL)	Ground Surface Elevation (ft AMSL)	Boring Depth (ft bgs)	Well Depth (ft bgs)	Screened Interval (ft MSL)	Slot Size (inch)	Well Construction
B-19 (decommissioned)	3,661,024.5833	11,809,663.7735	21.57	18.8	15	14.8	9.0 to 4.0	0.010	PVC
B-19R	3,661,024.5833	11,809,670.7735	--	--	23.6	20.0		0.010	2-inch ID PVC
B-40A	3,660,535.6911	11,808,691.4695	18.48	14.8	15	15	9.8 to -0.2	0.010	2-inch ID PVC
B-42A	3,662,112.8341	11,809,574.8210	5.78	6.0	--	--	--	0.010	PVC
B-30A	3,661,350.4642	11,811,410.3441	13.73	14.0	--	--	--	0.010	PVC
B-31	3,660,340.7409	11,812,582.9038	12.37	11.1	--	--	--	0.010	PVC
B-32	3,659,332.2474	11,810,654.2646	13.5	12.2	--	--	--	0.010	PVC
B-50	3,662,818.0367	11,807,890.9803	25.55	22.6	30	30	2.6 to -7.4	0.010	2-inch ID PVC
B-51	3,663,191.7148	11,807,348.2085	37.49	34.7	36	36	8.7 to -1.3	0.010	2-inch ID PVC
B-52	3,663,461.1817	11,807,694.8032	33.78	31.0	35	35	6.0 to -4.0	0.010	2-inch ID PVC
DM-1	3,662,142.3170	11,813,554.8136	37.87	36.0	136	43	4.2 to -5.8	0.020	4-inch ID PVC
MW-DM2 (DM-2)	--	--	--	5.6	30.5	--	--	--	--
DM-3	--	--	--	5.7	105.5	--	--	--	--
MW-DM5 (DM-5)	3,659,281.2256	11,811,697.0718	10.59	8.8	50.5	25	-5.4 to -15.4	0.020	4-inch ID PVC
MW-DM6 (DM-6)	3,659,263.3758	11,811,690.7894	11.07	8.4	150	92.5	-73.7 to -83.7	0.020	2-inch ID PVC
MW-DM7 (DM-7)	3,659,263.3107	11,811,709.5081	10.90	8.6	56	54	-39.8 to -44.8	0.020	2-inch ID PVC
DM-8/8A	--	--	--	22.0	100.5	--	--	--	--
DM-9	--	--	--	19.5	101.0	--	--	--	--
DM-10	--	--	--	14.0	95.8	--	--	--	--
MW-DM11 (DM-11)	--	--	--	19.0	21	--	--	--	--

Notes:
Coordinates in State Plane (NAD83)
AMSL = Above mean sea level
ft bgs = feet below ground surface
ID = Inside diameter
PVC = poly vinyl chloride

TABLE 3

Constituents for Modified Detection Monitoring Program

Chesterfield Power Station - Upper Ash Pond

PARAMETER	CLASS	CAS RN	TYPICAL METHOD	TYPICAL LOQ/PQL (ug/L)
CCR Appendix III to Part 257				
Boron	metal	7440-42-8	6010C	50
Calcium	metal	7440-70-2	6010C	5,000
Chloride	anion	16887-00-6	300.0	5,000
Fluoride	anion	16984-48-8	300.0	200
pH	field parameter	NA	SM4500-H	NA
Sulfate	anion	18785-72-3	300.0	5,000
Total Dissolved Solids (TDS)	dissolved cations and anions	Total	SM2540C	50,000
Virginia Water Control Board Water Quality Pollutants				
Ammonia	water quality	7664-41-7	350.1	1,000
Manganese	metal	Total	6010C	25
Virginia Solid Waste Management Regulation Table 3.1 Column A Constituents				
Antimony	metal	Total	6010C	20
Arsenic	metal	Total	6010C	7
Barium	metal	Total	6010C	1
Beryllium	metal	Total	6010C	5
Cadmium	metal	Total	6010C	1
Chromium	metal	Total	6010C	2
Cobalt	metal	Total	6010C	5
Copper	metal	Total	6010C	5
Lead	metal	Total	6010C	10
Nickel	metal	Total	6010C	10
Selenium	metal	Total	6010C	10
Silver	metal	Total	6010C	3
Thallium	metal	Total	6010C	20
Vanadium	metal	Total	6010C	5
Zinc	metal	Total	6010C	2

Notes:

- Class: General type of compound
- CAS RN: Chemical Abstracts Service Registry Number. Where 'Total' is entered, all species that contain the element are included.
- Method: Analytical Method from EPA SW-846 Methods for Evaluating Solid Waste. Samples will be analyzed using the version of each method that is current at the time of sampling.
- LOQ: Limit of Quantitation.
- Acceptable alternatives to the analytical methods listed above include current SW-846 Methods with EQLs equal to or lower than the one specified and other laboratory methods as approved by the Virginia Department of Environmental Quality.

TABLE 4

Constituents for Modified Assessment Monitoring Program

Chesterfield Power Station - Upper Ash Pond

PARAMETER	CLASS	CAS RN	TYPICAL METHOD	TYPICAL LOQ/PQL (ug/L)
CCR Appendix III to Part 257				
Boron	metal	7440-42-8	6010C	50
Calcium	metal	7440-70-2	6010C	5,000
Chloride	anion	16887-00-6	300.0	5,000
Fluoride	anion	16984-48-8	300.0	200
pH	field parameter	NA	SM4500-H	NA
Sulfate	anion	18785-72-3	300.0	5,000
Total Dissolved Solids (TDS)	dissolved cations and anions	Total	SM2540C	50,000
CCR Appendix IV to Part 257				
Antimony	metal	Total	6010C	20
Arsenic	metal	Total	6020A	7
Barium	metal	Total	6020A	1
Beryllium	metal	Total	6010C	5
Cadmium	metal	Total	6010C	1
Chromium	metal	Total	6020A	2
Cobalt	metal	Total	6020A	5
Fluoride	metal	Total	300.0	300
Lead	metal	Total	6010C	10
Lithium	metal	Total	200.7	20
Mercury	metal	Total	7470	2

TABLE 4

Constituents for Modified Assessment Monitoring Program

Chesterfield Power Station - Upper Ash Pond

PARAMETER	CLASS	CAS RN	TYPICAL METHOD	TYPICAL LOQ/PQL (ug/L)
Molybdenum	metal	Total	6010C	10

TABLE 4

Constituents for Modified Assessment Monitoring Program

Chesterfield Power Station - Upper Ash Pond

PARAMETER	CLASS	CAS RN	TYPICAL METHOD	TYPICAL LOQ/PQL (ug/L)
Selenium	metal	Total	6010C	10
Thallium	metal	Total	6010C	20
Radium 226 and 228 combined	radionuclide	(226) - 13982-63-3 (228) - 15262-20-1	903.1 Modified	1.00 pCi/L
Pertinent Virginia Solid Waste Management Regulation Table 3.1 Column B Constituents				
Copper	metal	Total	6010C	5
Nickel	metal	Total	6010C	10
Silver	metal	Total	6010C	3
Tin	metal	Total	6010C	10
Thallium	metal	Total	6010C	20
Vanadium	metal	Total	6010C	5
Tin	metal	Total	6010C	10
Zinc	metal	Total	6010C	2
Sulfide	anion	18496-25-8	9030	100
Cyanide	water quality	57-12-5	9010B	5
Pertinent Virginia Water Control Board Water Quality Pollutants				
Ammonia	water quality	7664-41-7	350.1	1,000
Manganese	metal	7439-96-5	6010C	25

TABLE 4

Constituents for Modified Assessment Monitoring Program

Chesterfield Power Station - Upper Ash Pond

PARAMETER	CLASS	CAS RN	TYPICAL METHOD	TYPICAL LOQ/PQL (ug/L)

Notes:

- Class: General type of compound
- CAS RN: Chemical Abstracts Service Registry Number. Where 'Total' is entered, all species that contain the element are included.
- Method: Analytical Method from EPA SW-846 Methods for Evaluating Solid Waste. Samples will be analyzed using the version of each method that is current at the time of sampling.
- LOQ: Limit of Quantitation
- PQL: Practical Quantitation Limit
- ug/L: micrograms per liter
- NA: Not Available
- pCi/L: picocuries per liter
- Acceptable alternatives to the analytical methods listed above include current SW-846 Methods with PQLs equal to or lower than the one specified and other laboratory methods as approved by the Virginia Department of Environmental Quality.

TABLE 5

Summary of Sample Container Information and Hold Times
Chesterfield Power Station Upper Ash Pond

Parameter	Container & Volume	Preservative	Maximum Holding Time
pH	Flow-through cell or plastic, 500 mL	None	15 minutes (field analysis)
Specific Conductance	Flow-through cell or plastic, 500 mL	None	15 minutes (field analysis)
Temperature	Flow-through cell or plastic, 500 mL	None	15 minutes (field analysis)
Mercury (total)	Plastic; 250 mL	HNO_3 to pH<2	28 days
Metals (total) except mercury	Plastic, 250 mL	HNO_3 to pH<2	6 months
Ammonia as Nitrogen	Plastic, 500 mL	H_2SO_4 to pH<2	28 days
Cyanide	Plastic, 250 mL	NaOH	14 days
Sulfide	Plastic, 250 mL	NaOH	7 days
Total Dissolved Solids (TDS)	Plastic, 200 mL	None	7 days
Fluoride, Chloride, Sulfate	Plastic, 250 mL	None	28 days
Radium 226/228	Plastic, 1/2 gallon (2 L)	Preserved upon receipt at laboratory	6 months

Notes:

mL= milliliter

VOA = Volatile Organic Analysis

L= Liter

HNO_3 = Nitric Acid

HCL = Hydrochloric Acid

H_2SO_4 = Sulfuric Acid

TABLE 6

Summary of Statistical Methods for Databases with Censored Data

Chesterfield Power Station Upper Ash Pond

Percentage of Non-Detects in the Database	Statistical Analysis Method
Less than 25%	Replace NDs with LOD or LOQ then proceed with parametric procedures: Tolerance Limits, Prediction Limits, or Control Charts
25 to 50%	Use Cohen's or Aitchison's adjustment, then proceed with: Tolerance Limits, Prediction Limits, Confidence Intervals, or Control Charts
More than 50%	Proceed with Nonparametric Methods: Tolerance Limits, Prediction Limits, Wilcoxin-Rank Sum Test, or Test of Proportions

Notes:

ND = Not detect above laboratory detection limit

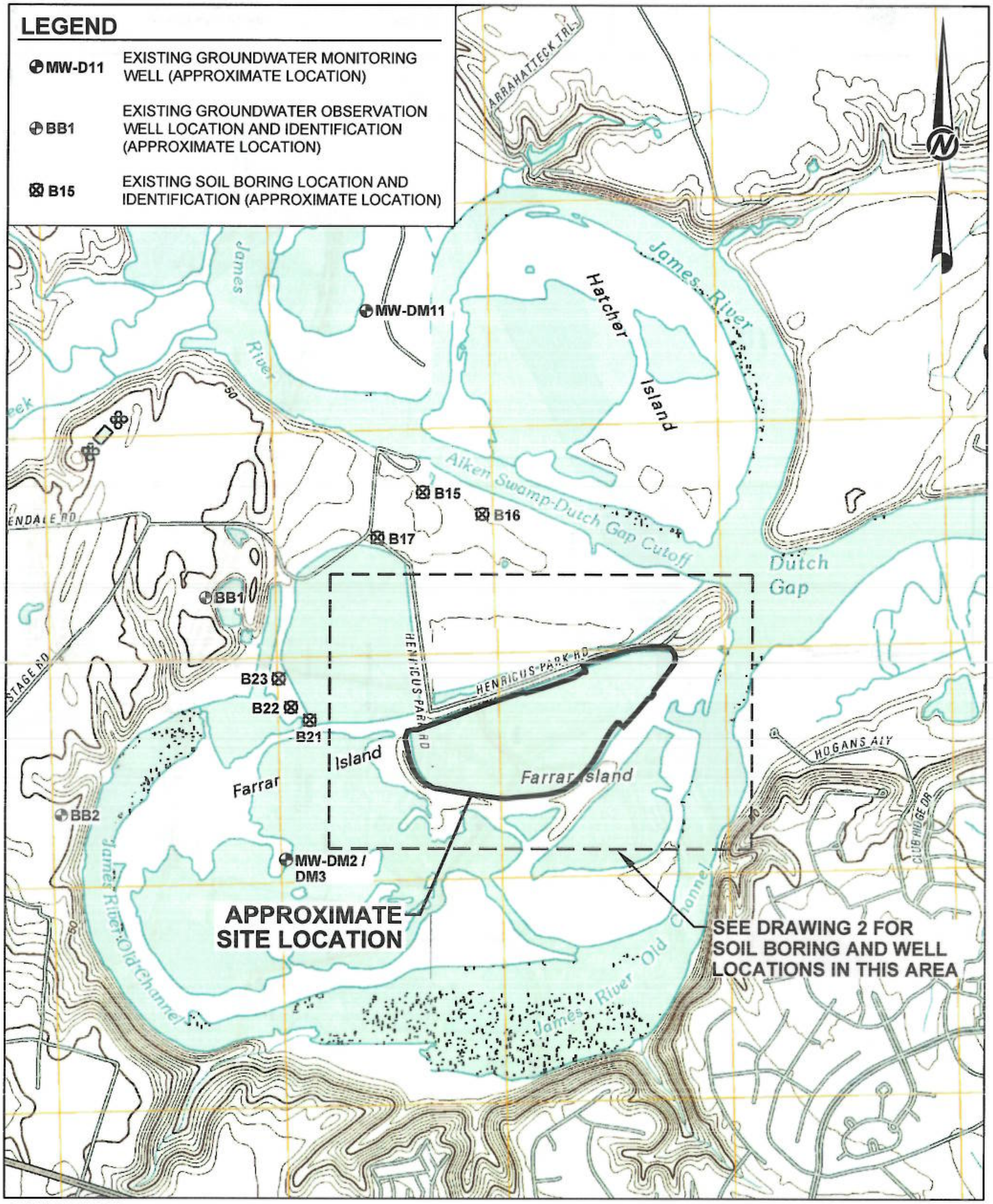
LOD = Limit of Detection

LOQ = Limit of Quantitation

DRAWINGS

LEGEND

MW-D11	EXISTING GROUNDWATER MONITORING WELL (APPROXIMATE LOCATION)
BB1	EXISTING GROUNDWATER OBSERVATION WELL LOCATION AND IDENTIFICATION (APPROXIMATE LOCATION)
B15	EXISTING SOIL BORING LOCATION AND IDENTIFICATION (APPROXIMATE LOCATION)



SOURCE NOTE

Site Location Map consists o 7.5-minute USGS topographic uadrangles named Dutch Gap, Drewr s Blu Chester and Hopewell, all dated 2010.

Golder Associates, Richmond, Virginia	DATE 12/29/15	TITLE	
	DESIGN MGW	**SITE LOCATION MAP**	
	CADD BPG		
PROJECT No. 15-32864	CHECK		
SCALE AS SHOWN — REV. 0	REVIEW	DOMINION - CHESTERFIELD POWER STATION UPPER ASH POND	DRAWING 1

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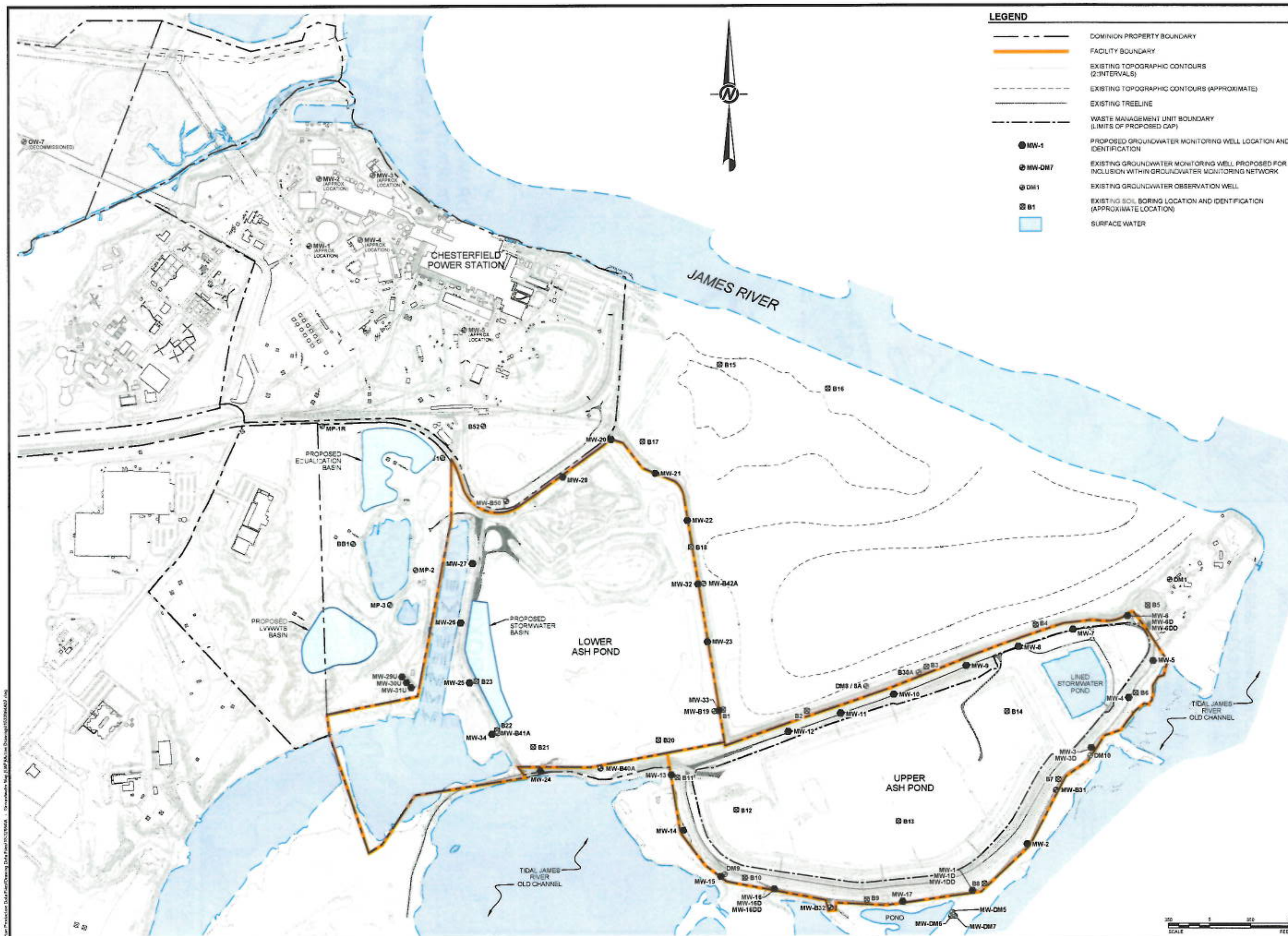


LEGEND

(dash-dot line)	DOMINION PROPERTY BOUNDARY
(orange line)	FACILITY BOUNDARY
(light line)	EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
(dashed line)	EXISTING TOPOGRAPHIC CONTOURS (APPROXIMATE)
(line)	EXISTING TREELINE
(dash-dot line)	WASTE MANAGEMENT UNIT BOUNDARY (LIMITS OF PROPOSED CAP)
MW-1	PROPOSED GROUNDWATER MONITORING WELL LOCATION AND IDENTIFICATION
MW-DM7	EXISTING GROUNDWATER MONITORING WELL PROPOSED FOR INCLUSION WITHIN GROUNDWATER MONITORING NETWORK
DM1	EXISTING GROUNDWATER OBSERVATION WELL
B1	EXISTING SOIL BORING LOCATION AND IDENTIFICATION (APPROXIMATE LOCATION)
(blue fill)	SURFACE WATER

Golder Associates
Richmond, Virginia

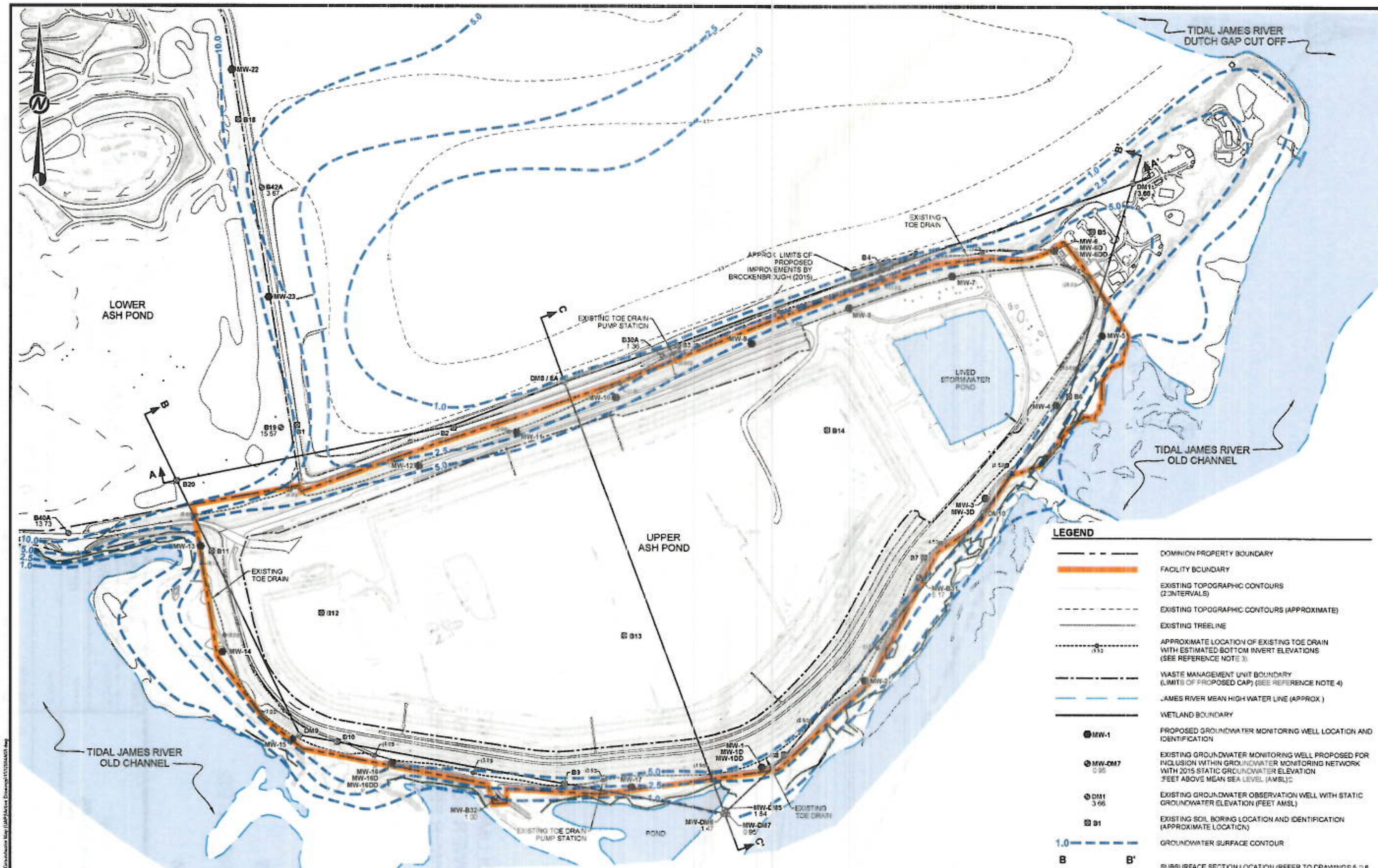
REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
3	[illegible]	MGW	RESPONSE TO COMMENTS	BPG	MGW	MGW
2	[illegible]	MGW	MONITORING NETWORK REVISIONS	BPG	MGW	MGW
1	[illegible]	MGW	WELL LOCATION REVISION	BPG	MGW	MGW

PROJECT
DOMINION
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VA

TITLE
UPPER ASH POND
GROUNDWATER
MONITORING PLAN

PROJECT No.			15-52864
FILE No.			1532864A02
REV.	0	SCALE	AS SHOWN
DESIGN	MGW		03/24/16
CADD	BPG		03/24/16
CHECK			
REVIEW			

DRAWING 2



LEGEND

- DOMINION PROPERTY BOUNDARY
- FACILITY BOUNDARY
- EXISTING TOPOGRAPHIC CONTOURS (2' INTERVALS)
- EXISTING TOPOGRAPHIC CONTOURS (APPROXIMATE)
- EXISTING TREELINE
- APPROXIMATE LOCATION OF EXISTING TOE DRAIN WITH ESTIMATED BOTTOM INVERT ELEVATIONS (SEE REFERENCE NOTE 3)
- WASTE MANAGEMENT UNIT BOUNDARY (LIMITS OF PROPOSED CAP) (SEE REFERENCE NOTE 4)
- JAMES RIVER MEAN HIGH WATER LINE (APPROX.)
- WETLAND BOUNDARY
- MW-1 — PROPOSED GROUNDWATER MONITORING WELL LOCATION AND IDENTIFICATION
- MW-DM7 0.95 — EXISTING GROUNDWATER MONITORING WELL PROPOSED FOR INCLUSION WITHIN GROUNDWATER MONITORING NETWORK WITH 2015 STATIC GROUNDWATER ELEVATION (FEET ABOVE MEAN SEA LEVEL (AMSL))
- DM11 3.66 — EXISTING GROUNDWATER OBSERVATION WELL WITH STATIC GROUNDWATER ELEVATION (FEET AMSL)
- B1 — EXISTING SOIL BORING LOCATION AND IDENTIFICATION (APPROXIMATE LOCATION)
- 1.0 — GROUNDWATER SURFACE CONTOUR
- B — B' — SUBSURFACE SECTION LOCATION (REFER TO DRAWINGS 5 & 6 FOR SUBSURFACE SECTIONS)
- UGE — EXISTING UNDERGROUND ELECTRIC LINE
- WL — EXISTING UNDERGROUND WATER LINE
- G — EXISTING UNDERGROUND GAS LINE
- C — EXISTING UNDERGROUND COMMUNICATIONS LINE
- EXISTING UNDERGROUND STORMWATER PIPE
- EXISTING UNDERGROUND PIPE SLEEVE
- EXISTING UNKNOWN UNDERGROUND LINE

REFERENCE

1. EXISTING TOPOGRAPHY AND OTHER MISCELLANEOUS SITE FEATURES TAKEN FROM AERIAL SURVEY COMPILED BY TUCK MAPPING SOLUTIONS (BASED ON AERIAL PHOTOGRAPH DATED OCTOBER 8, 2014)
2. WETLANDS DELINEATED BY GOLDER ASSOCIATES IN MARCH 2015
3. EXISTING TOE DRAIN TAKEN FROM DRAWINGS 5 AND 6 FROM "ASH DISPOSAL POND, SITE EXCAVATION PLAN," BY J.K. TIMMONS & ASSOCIATES INC., DATED 5/18/83. THE LOCATION OF THE EXISTING TOE DRAIN SHALL BE CONSIDERED APPROXIMATE.
4. LIMITS OF PROPOSED CAP TAKEN FROM DRAWING SET TITLED "CHESTERFIELD UPPER ASH POND CLOSURE PLAN PROJECT - PRELIMINARY 90% DRAFT," BY GAI CONSULTANTS, DATED JUNE 4, 2015.
5. SUBSURFACE SECTION LOCATIONS AND APPROXIMATE SOIL BORING LOCATIONS TAKEN FROM FIGURES INCLUDED IN REPORT TITLED, "WATER QUALITY IMPACT EVALUATION FROM PROPOSED ASH TAILINGS IMPOUNDMENT AT VEPCO'S CHESTERFIELD POWER STATION," PREPARED BY DAMES & MOORE, DATED JULY 15, 1983.
6. LOCATIONS OF EXISTING UNDERGROUND ELECTRIC LINES, UNDERGROUND WATER LINES, UNDERGROUND GAS LINES, UNDERGROUND COMMUNICATIONS LINES, UNDERGROUND STORM SEWER, UNDERGROUND PIPE SLEEVES, AND OTHER MISC. UNKNOWN UNDERGROUND LINES TAKEN FROM AUTOCAD FILE TITLED, "UTILITIES UPDATE 83-88 DATUM 05-05-16.DWG," PROVIDED BY DOMINION.

REV	DATE	DES	REVISION DESCRIPTION	CADD	CHK	RVW
	05/26/16	MGW	WELL LOCATION REVISION	EPG	MGW	MGW
	05/18/16	MGW	MONITORING NETWORK REVISIONS	EPG	MGW	MGW
	03/17/16	MGW	RESPONSE TO COMMENTS	EPG	MGW	MGW

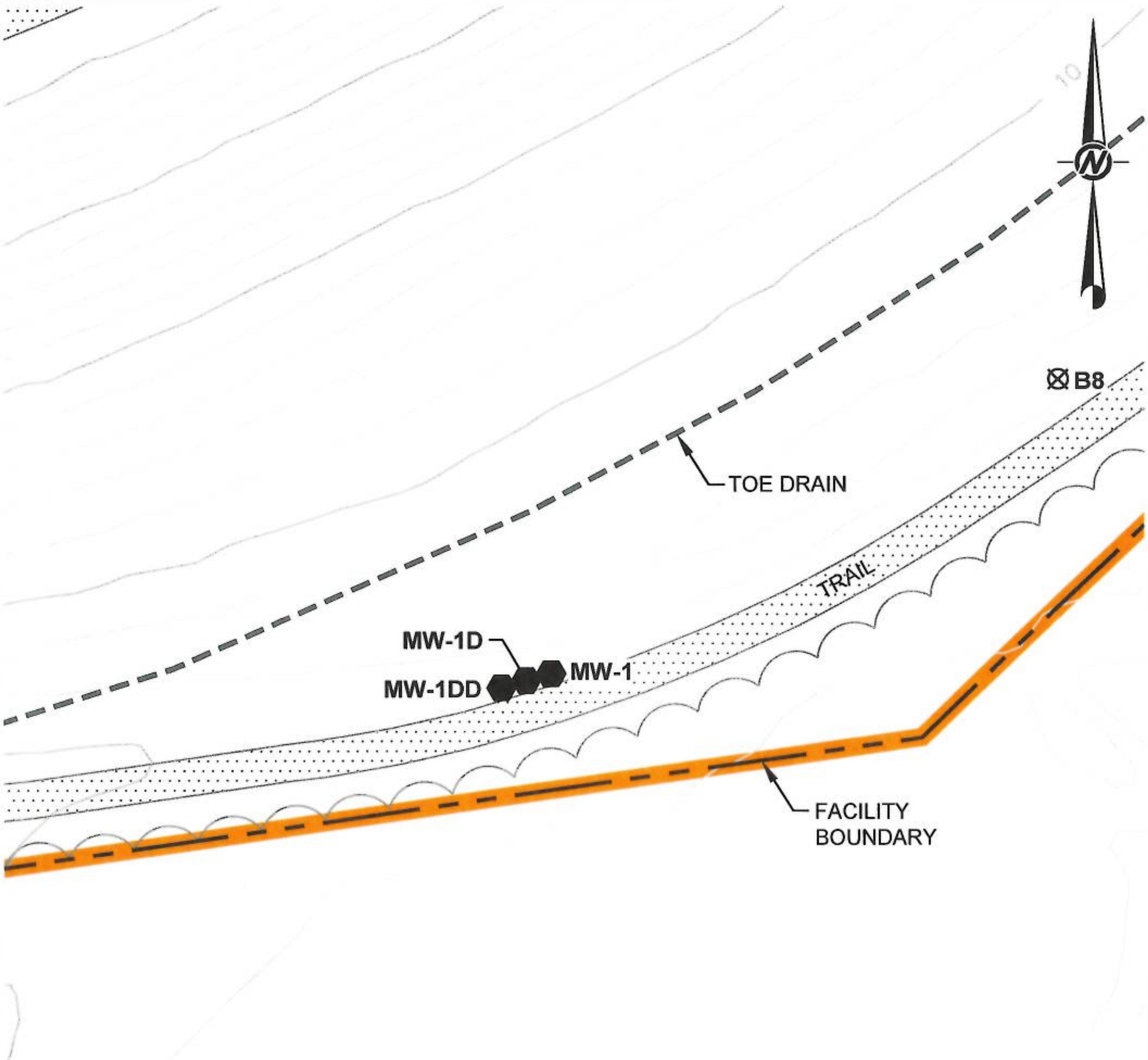
Golder Associates
Richmond, Virginia

PROJECT
DOMINION
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VA

TITLE
UPPER ASH POND
COLUMBIA AQUIFER
WATER TABLE MAP

PROJECT No.			15-32864
FILE No.			1532864A03
REV.	0	SCALE	AS SHOWN
DESIGN	MGW		12/09/15
CADD	EPG		12/29/15
CHECK	MKB		01/21/16
REVIEW	JRD		01/21/16

DRAWING 3



MW-1: COLUMBIA A□UIFER
MW-1D: LOWER SEMI-CONFINED A□UIFER
MW-1DD: LOWER FRACTURED BEDROCK / SAPROLITE

MW-1 COORDINATES:
N 3,659,478.61
E 11,811,871.86

MW-1D COORDINATES:
N 3,659,477.31
E 11,811,867.03

MW-1DD COORDINATES:
N 3,659,475.88
E 11,811,862.24

30 0 30
SCALE FEET

Golder Associates, Richmond, Virginia	DATE 05/26/16	TITLE
	DESIGN MGW	MW-1, MW-1D & MW-1DD PLAN DETAIL
	CADD BPG	
PROJECT No. 15-32864	CHECK	
SCALE AS SHOWN REV. 0	REVIEW	CHESTERFIELD POWER STATION - UAP / DRAWING 3A

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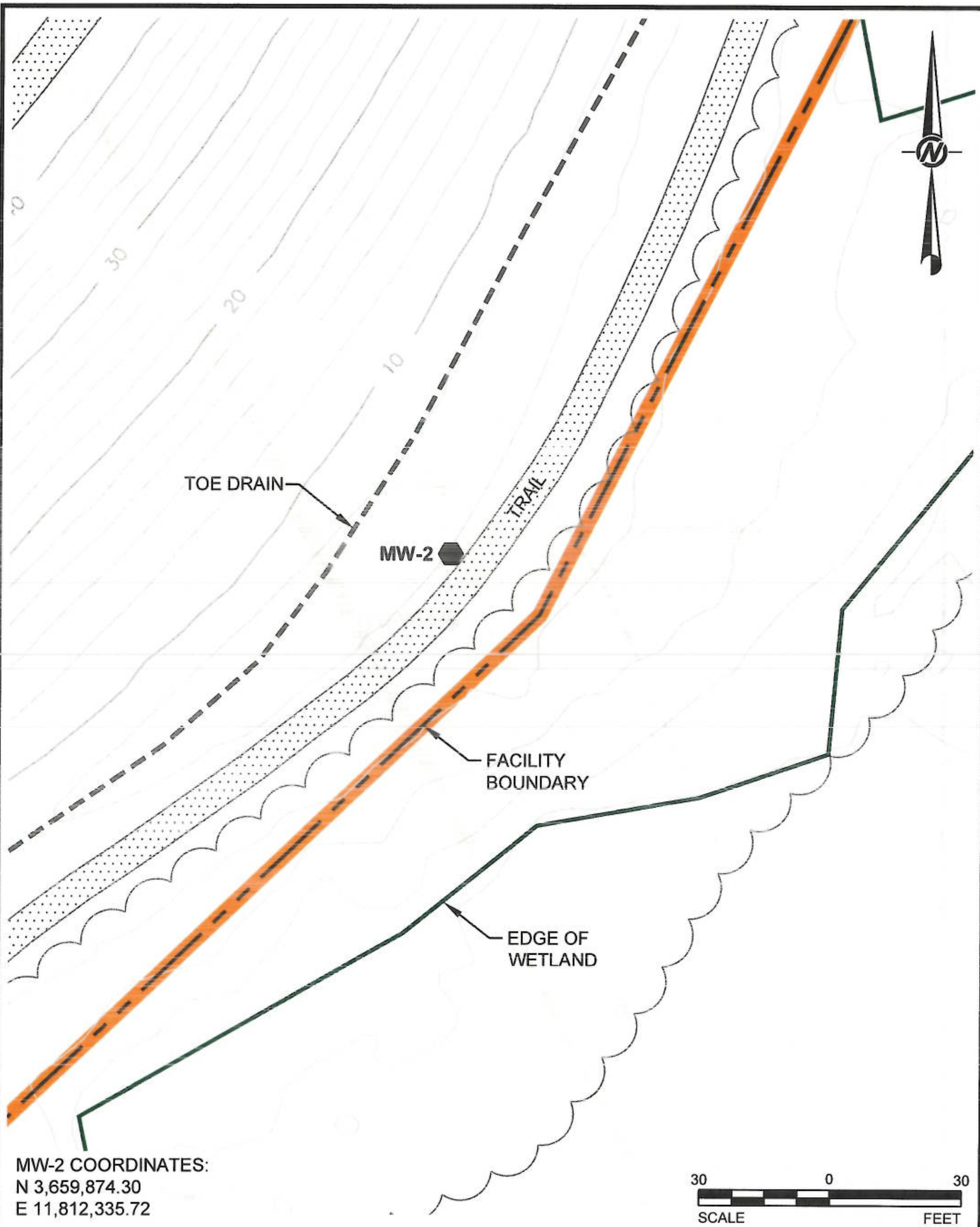

Golder Associates, Richmond, Virginia			DATE	05/26/16	TITLE
			DESIGN	MGW	**MW-2 PLAN DETAIL**
			CADD	BPG	
PROJECT No.	15-32864		CHECK		
SCALE	AS SHOWN	REV. 0	REVIEW		**CHESTERFIELD POWER STATION - UAP** / DRAWING 3B

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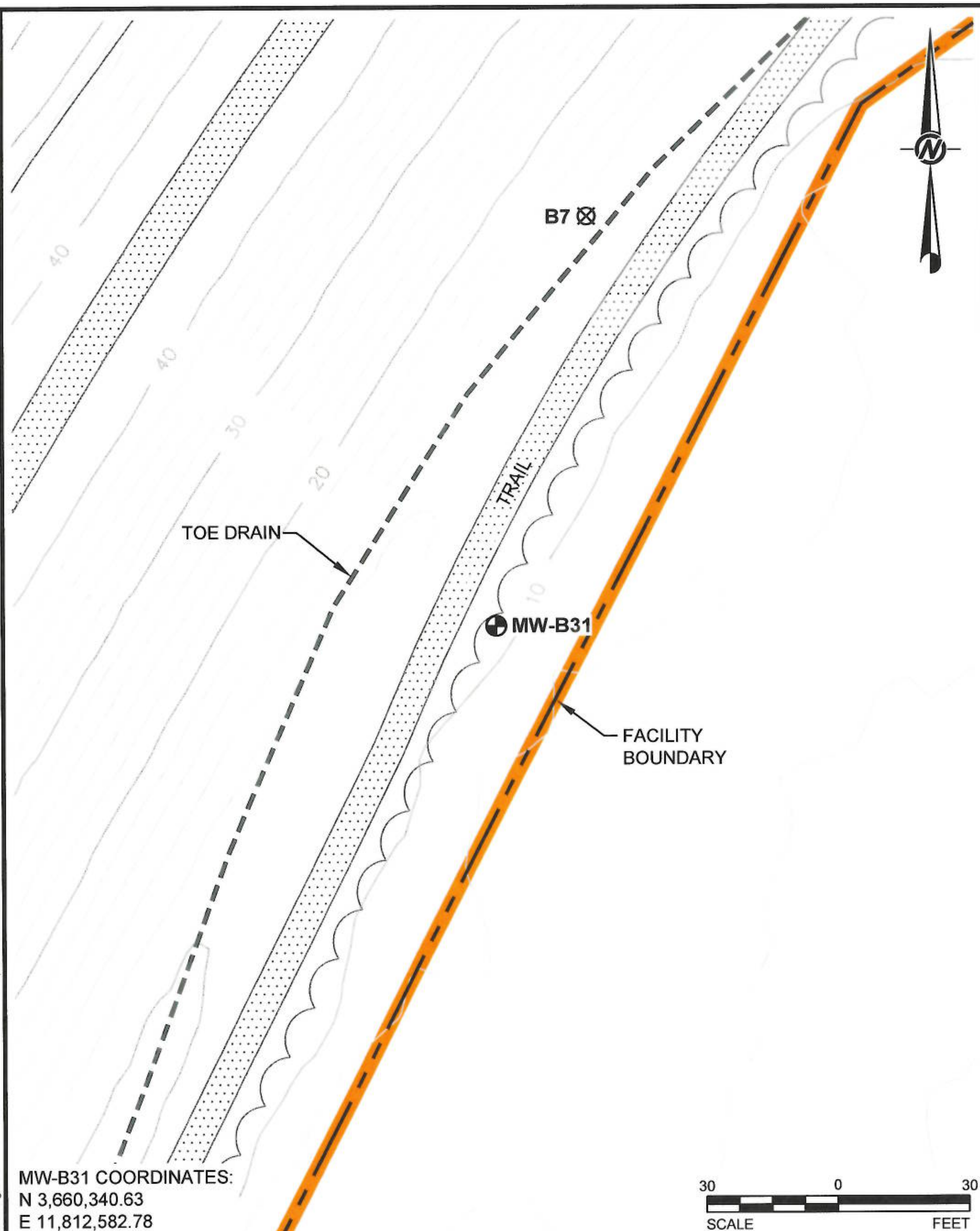

MW-B31 COORDINATES:
N 3,660,340.63
E 11,812,582.78

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Golder Associates, Richmond, Virginia	DATE 05/26/16	TITLE	
	DESIGN MGW	**MW-B31 PLAN DETAIL**	
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PROJECT No. 15-32864	CHECK		
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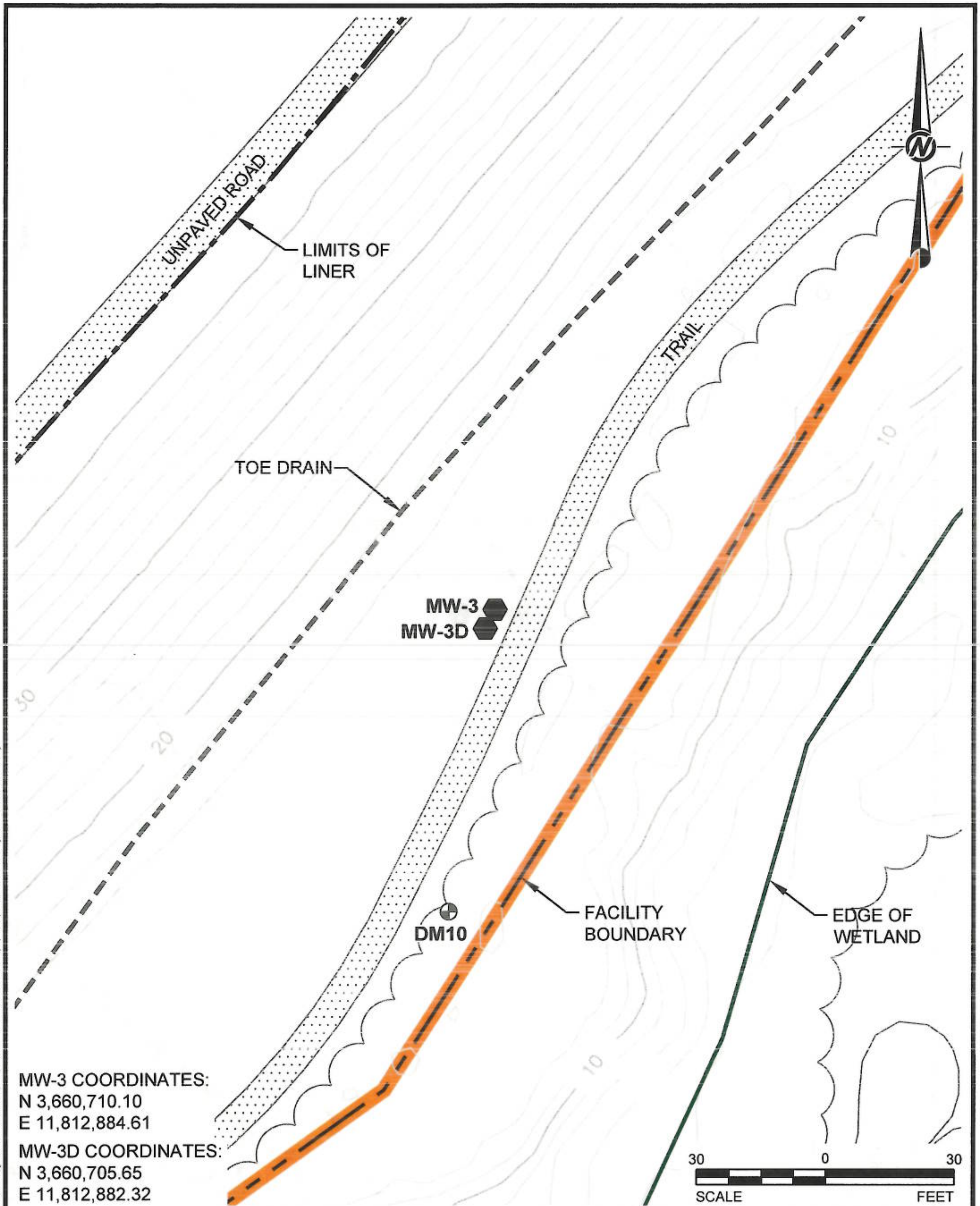

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SCALE AS SHOWN REV. 0	REVIEW	CHESTERFIELD POWER STATION - UAP	DRAWING 3D

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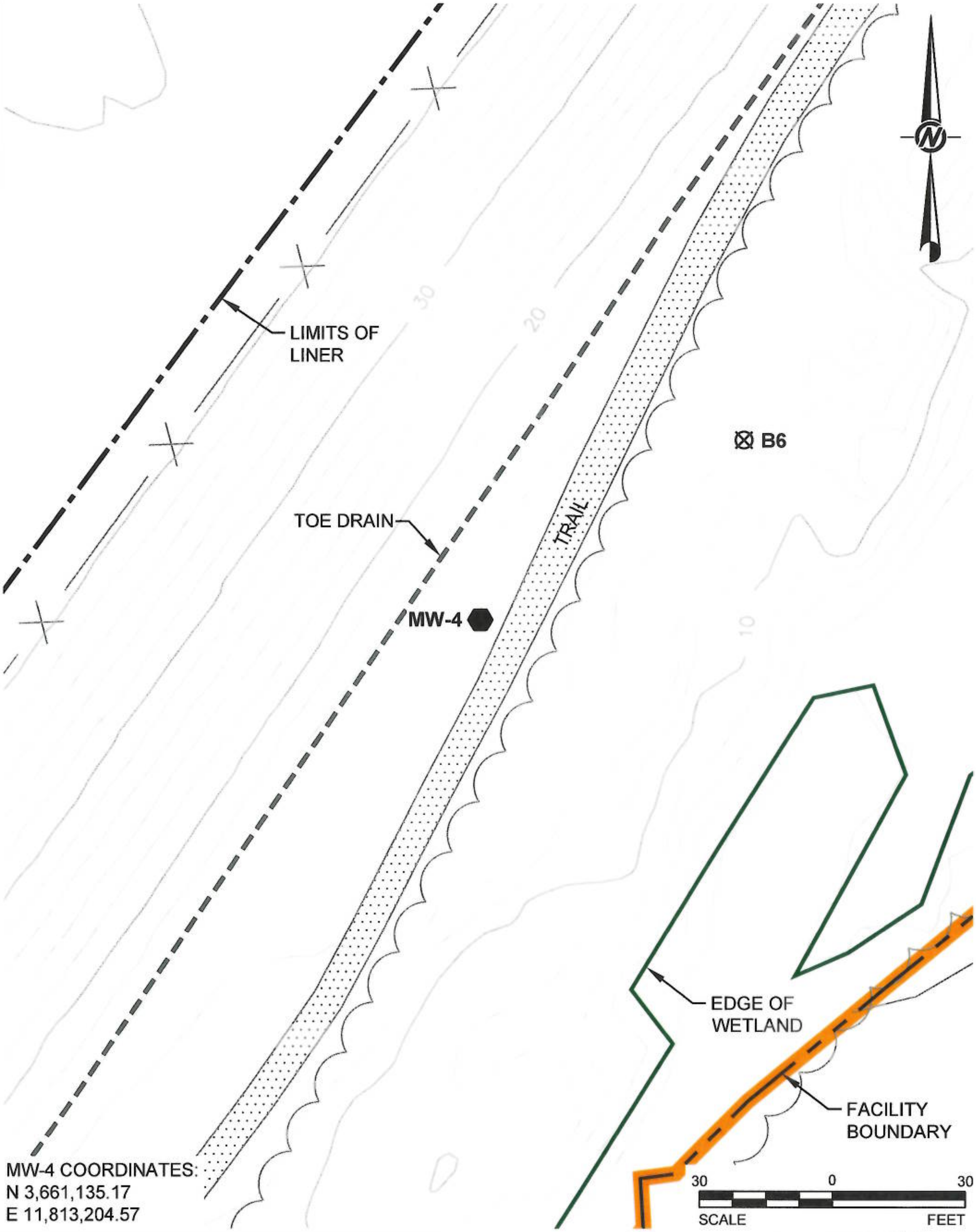

MW-4 COORDINATES:
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E 11,813,204.57

Golder Associates, Richmond, Virginia		DATE 05/26/16	TITLE	
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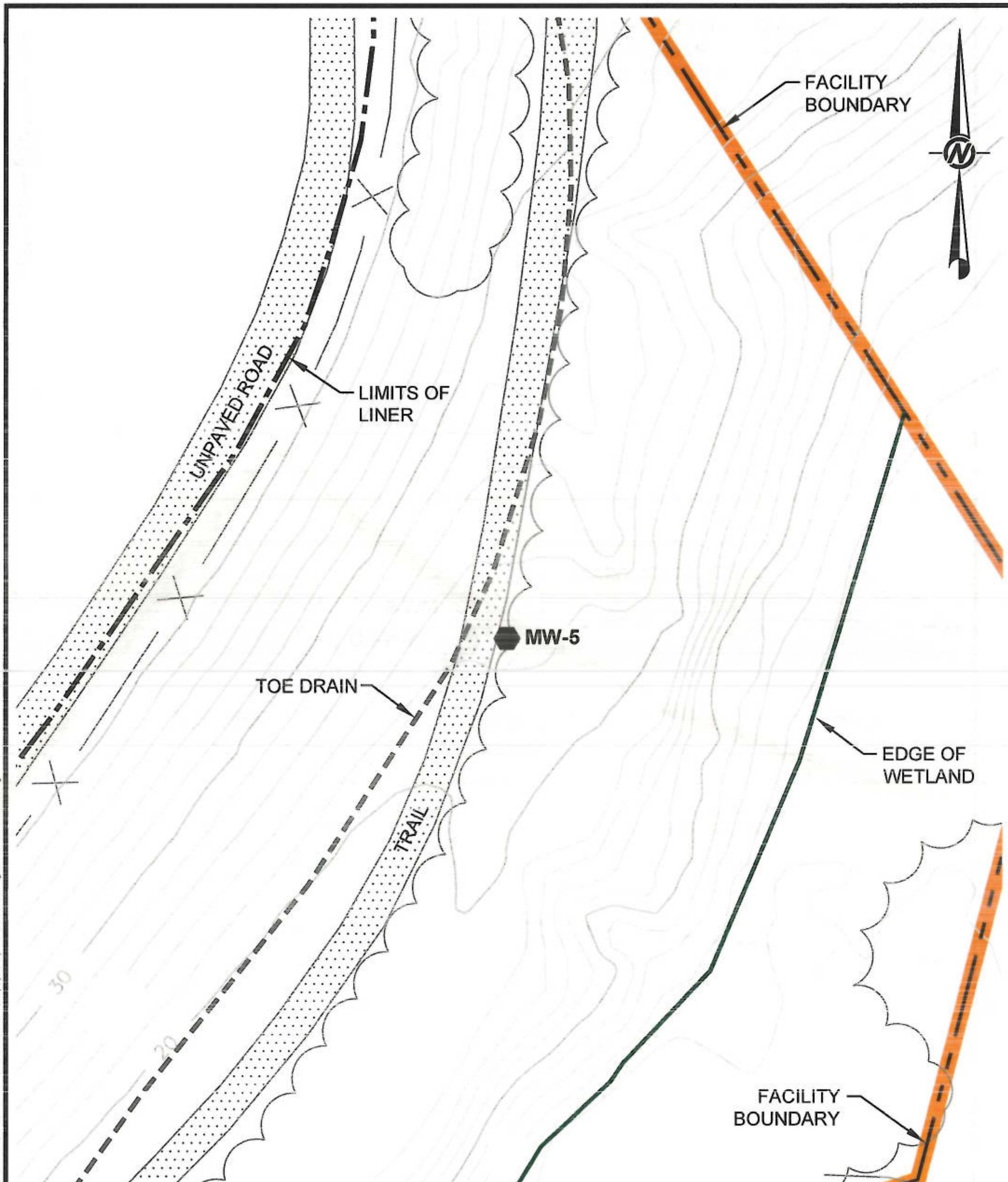

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E 11,813,413.75

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Golder Associates, Richmond, Virginia	DATE 05/26/16	TITLE	
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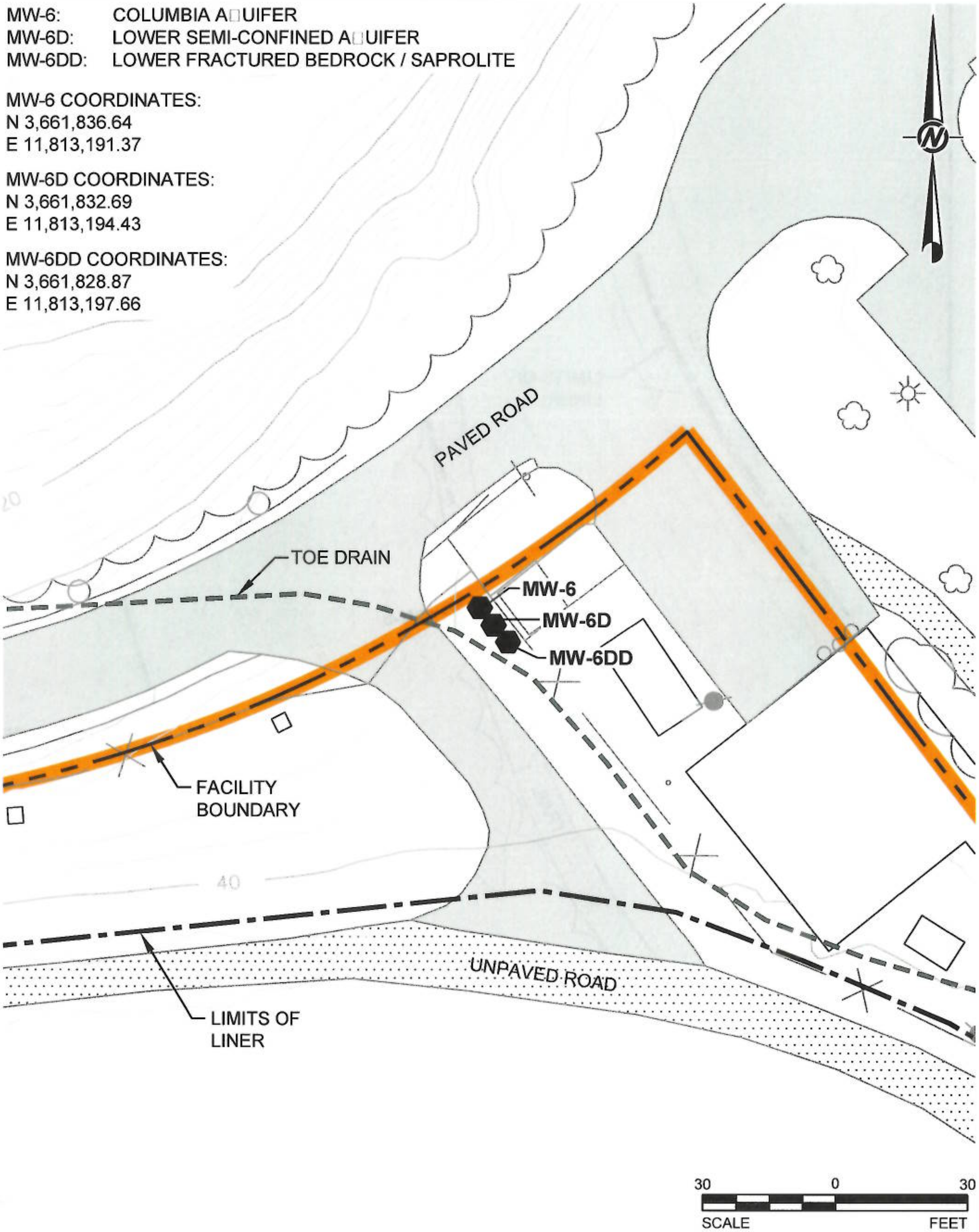
SCALE AS SHOWN / REV. 0	REVIEW	CHESTERFIELD POWER STATION - UAP	DRAWING 3F



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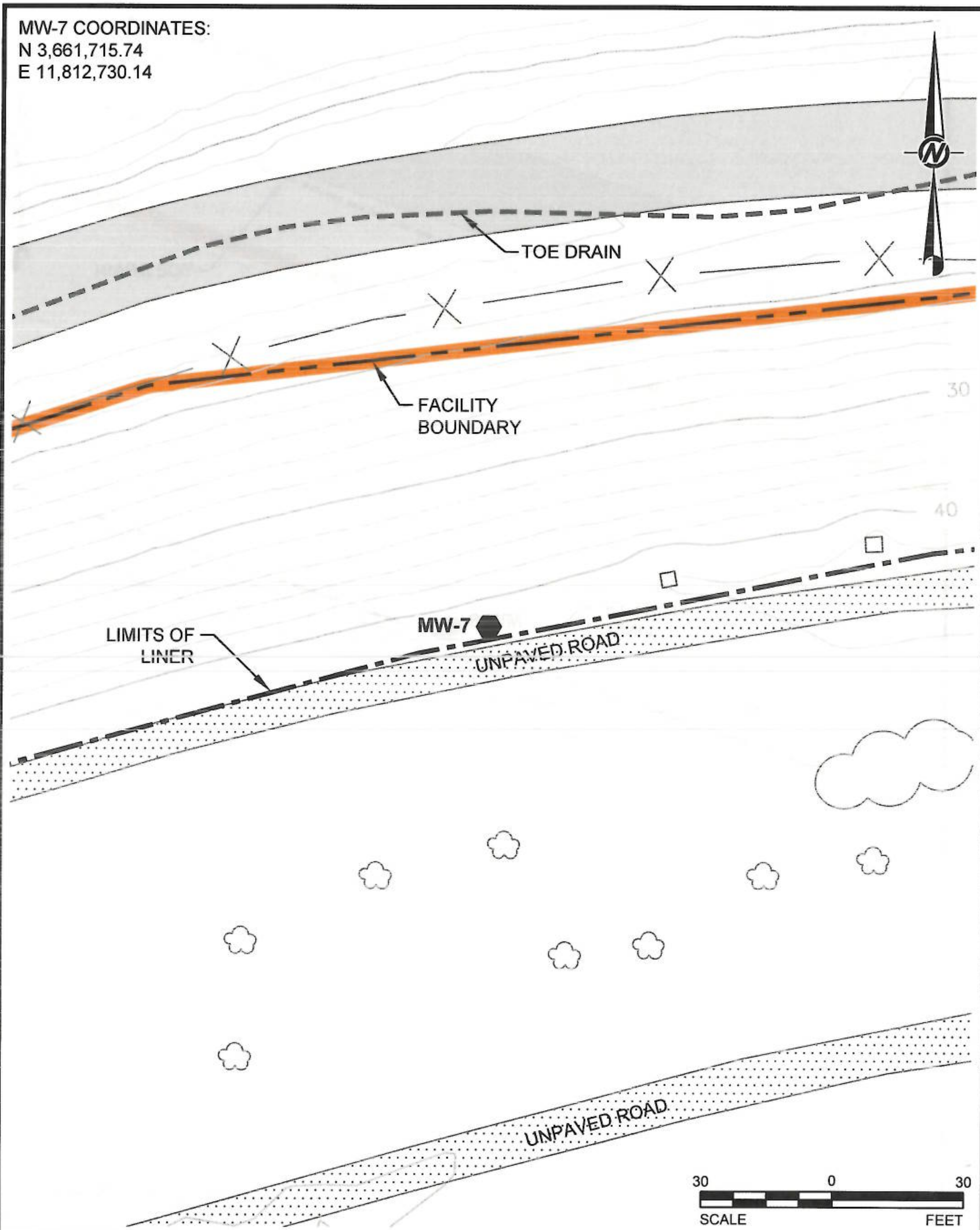

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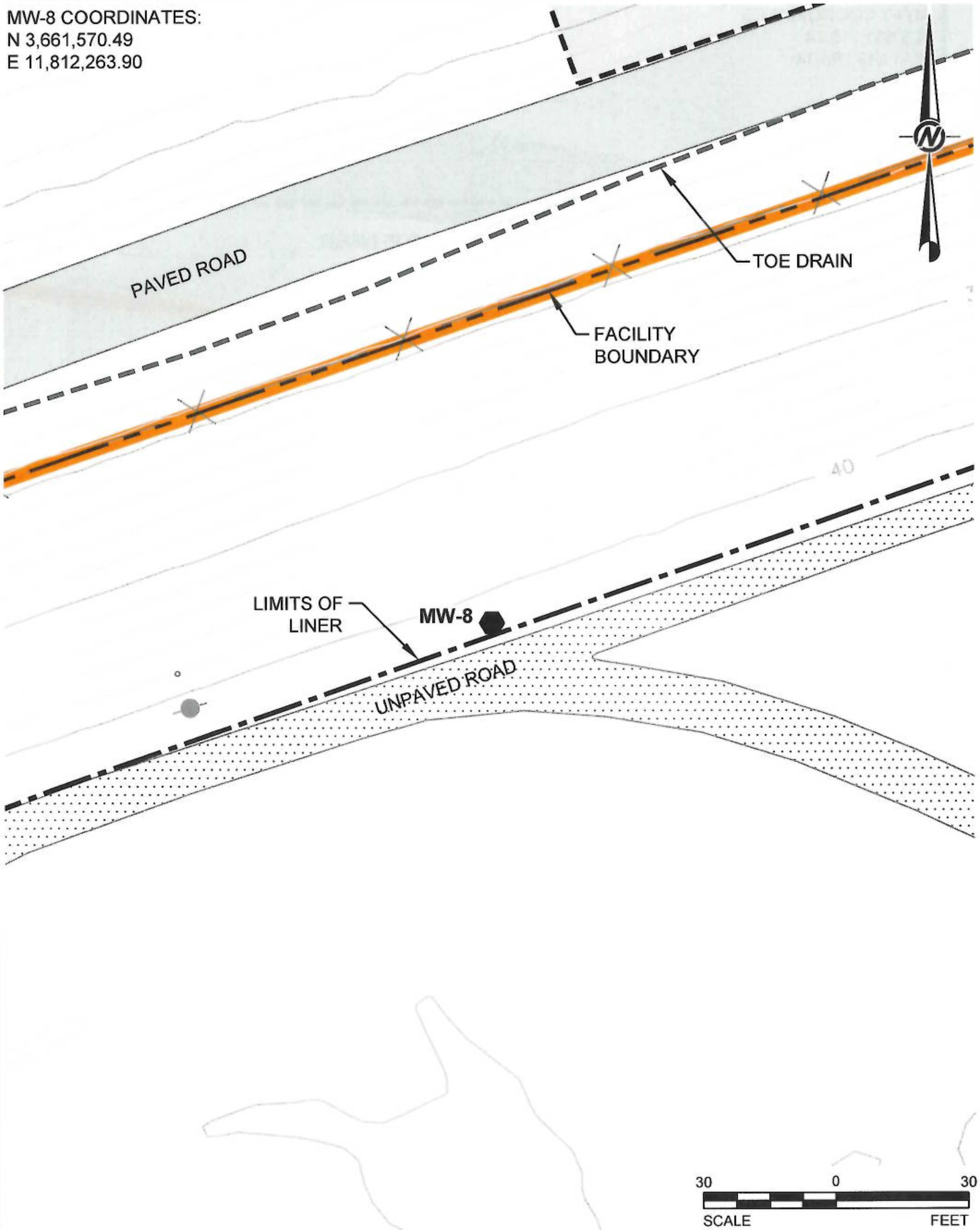

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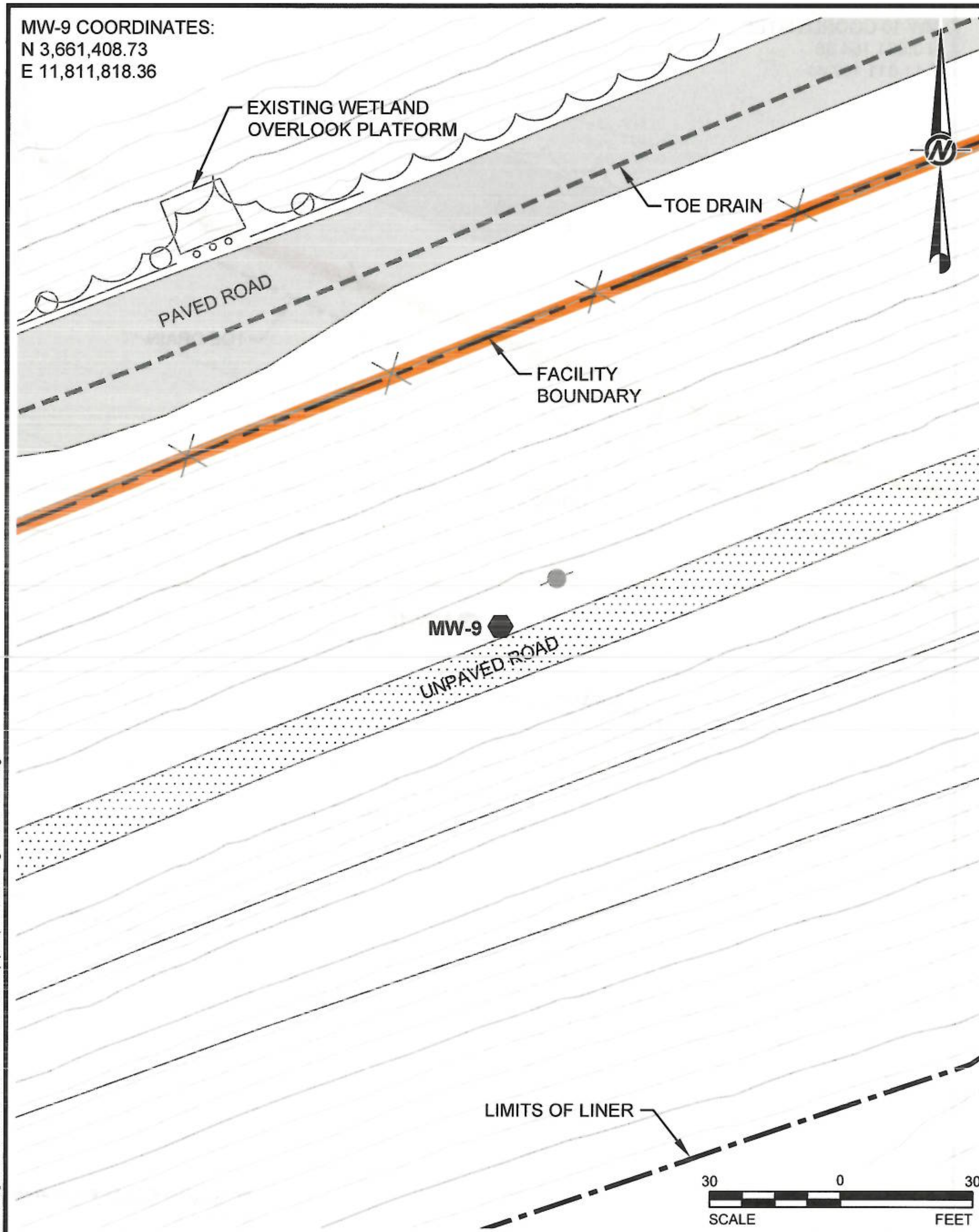

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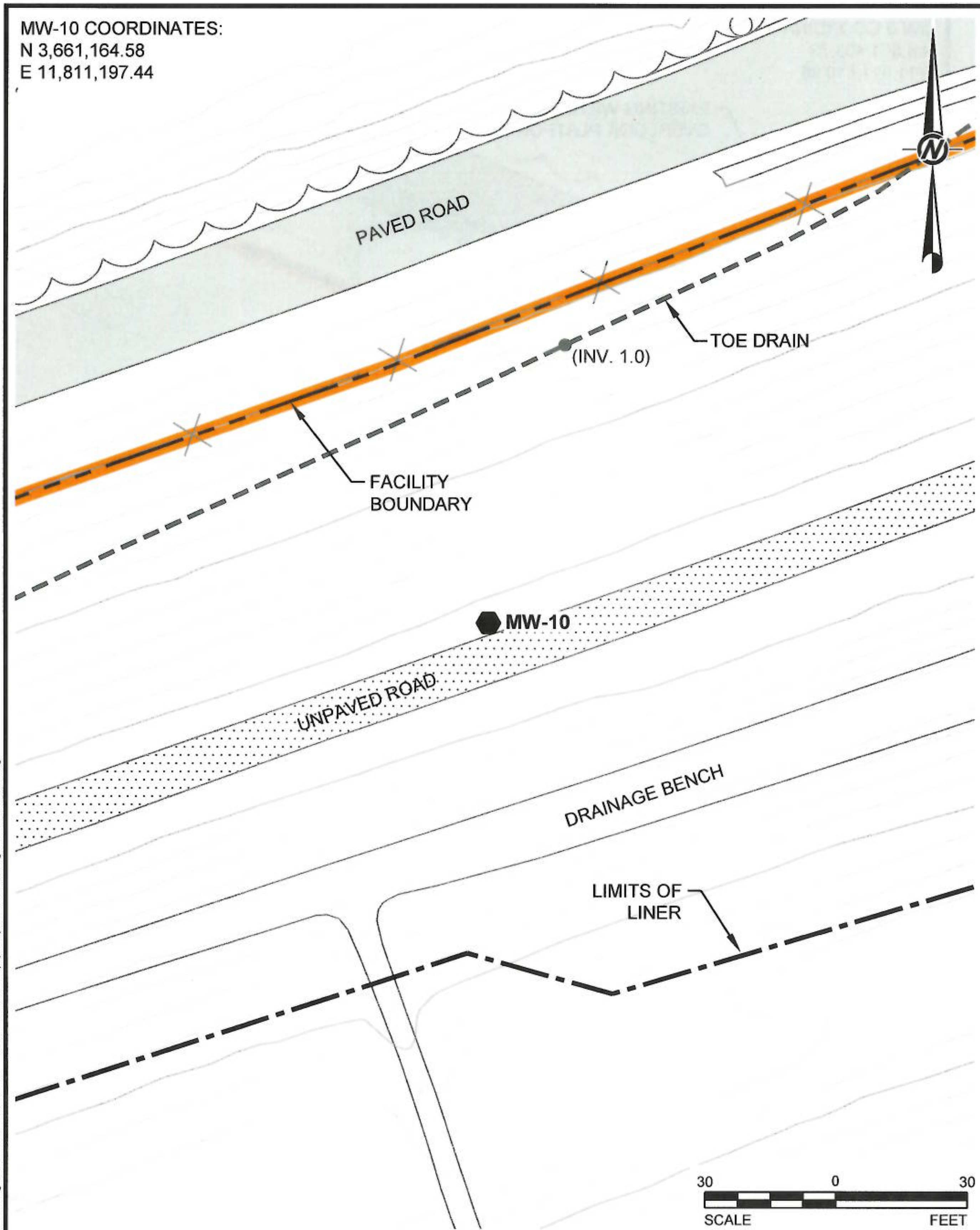

Golder Associates
Richmond, Virginia

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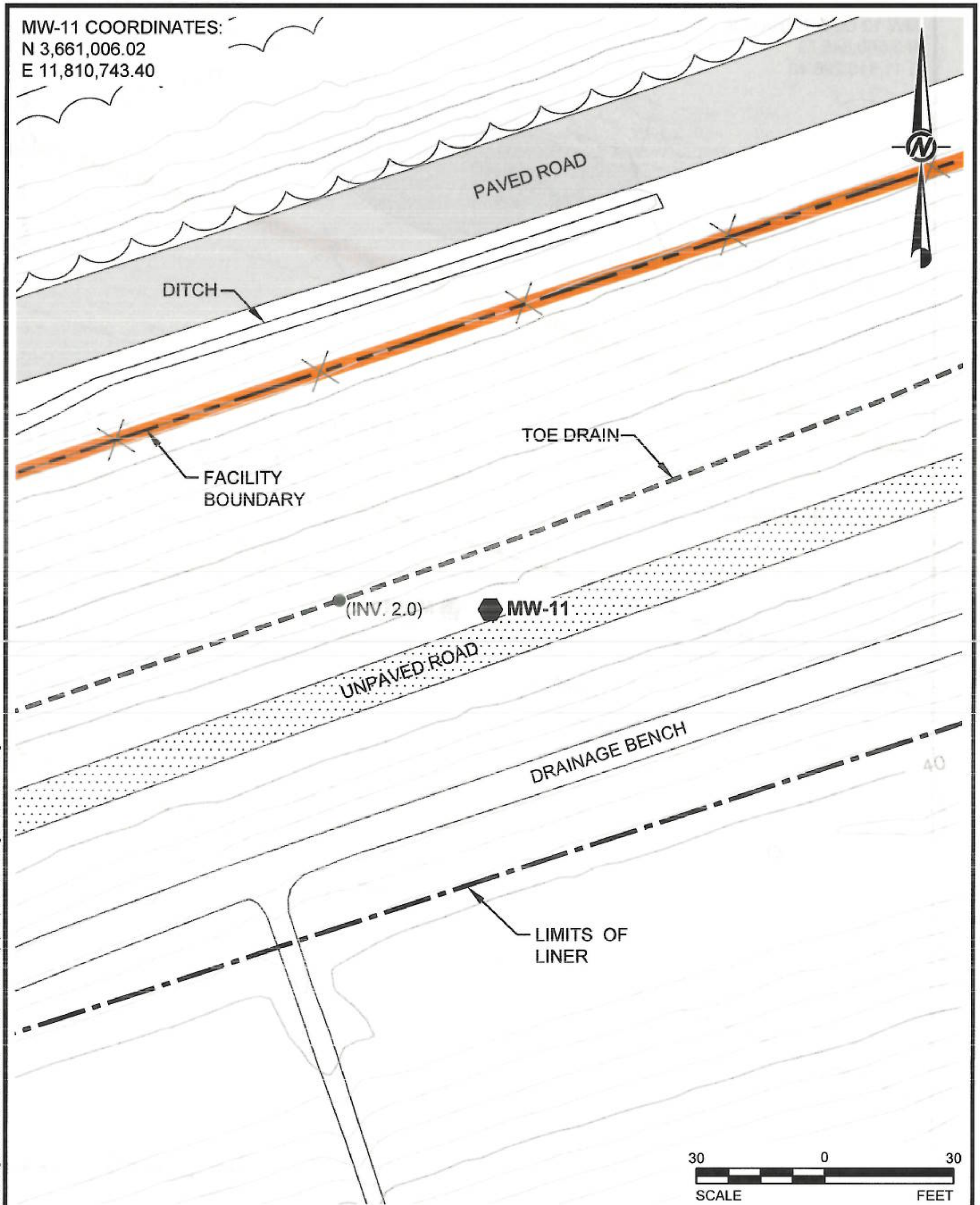

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Golder Associates
Richmond, Virginia

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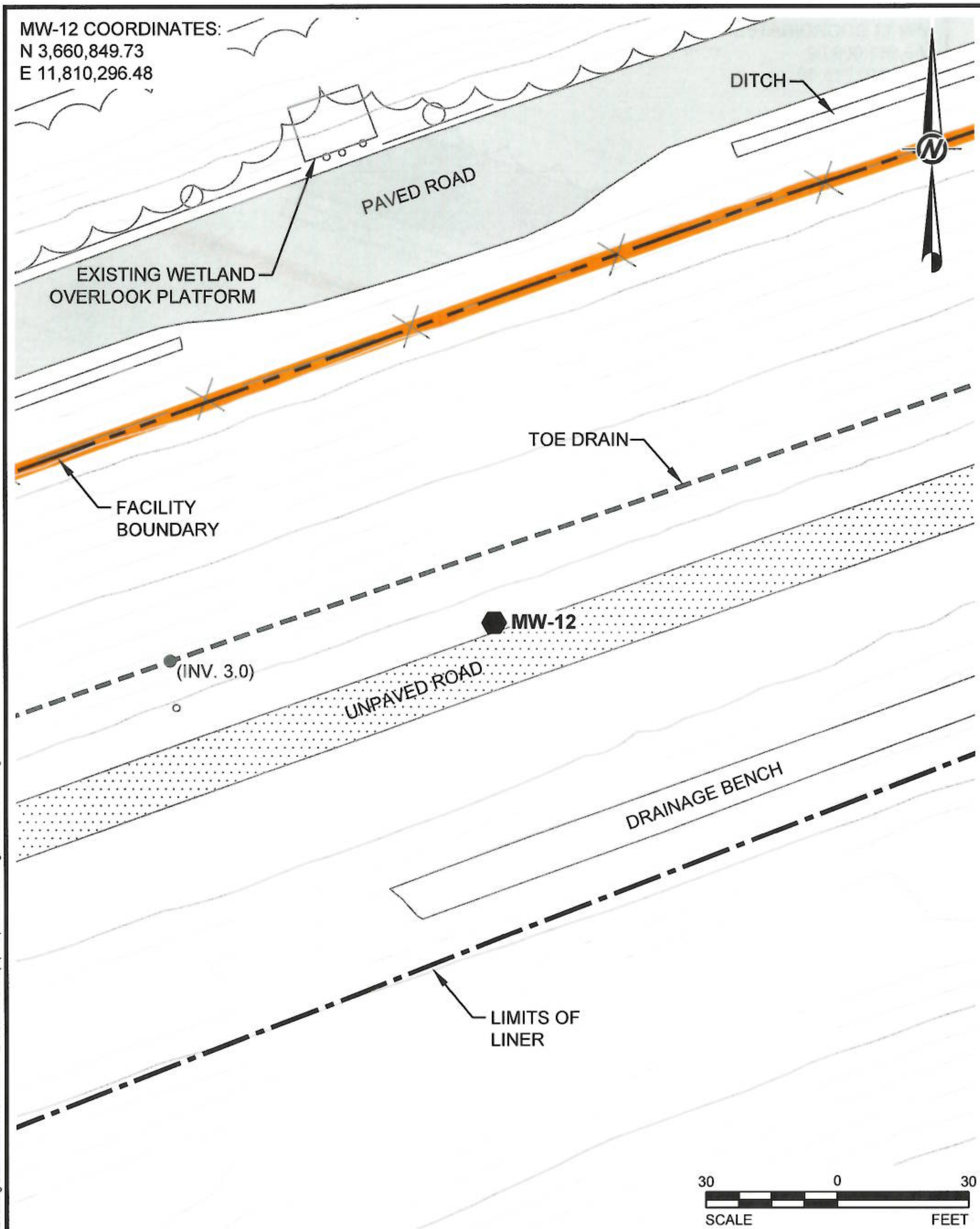

Golder Associates
Richmond, Virginia

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SCALE AS SHOWN / REV. 0	REVIEW	CHESTERFIELD POWER STATION - UAP	DRAWING 3M

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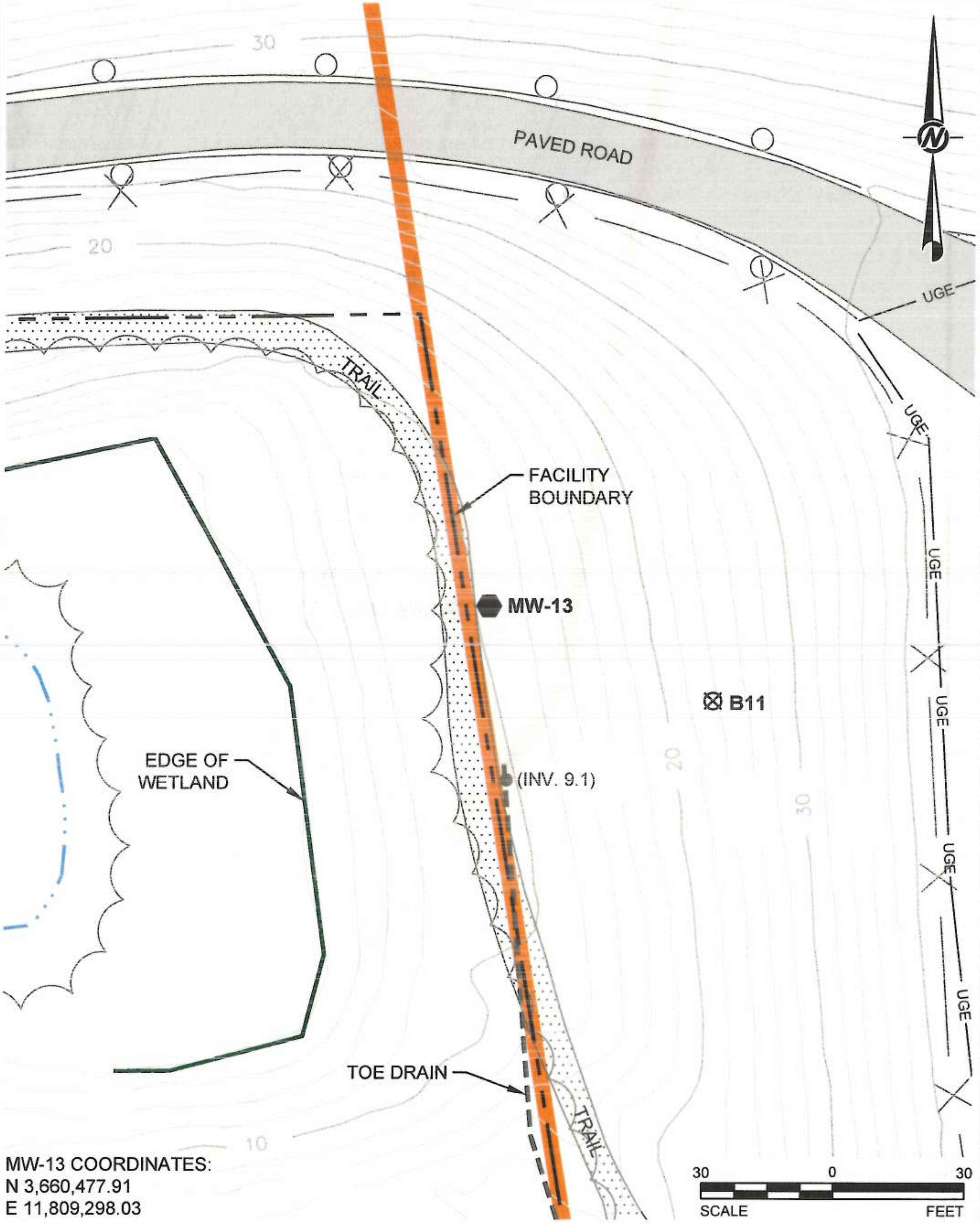

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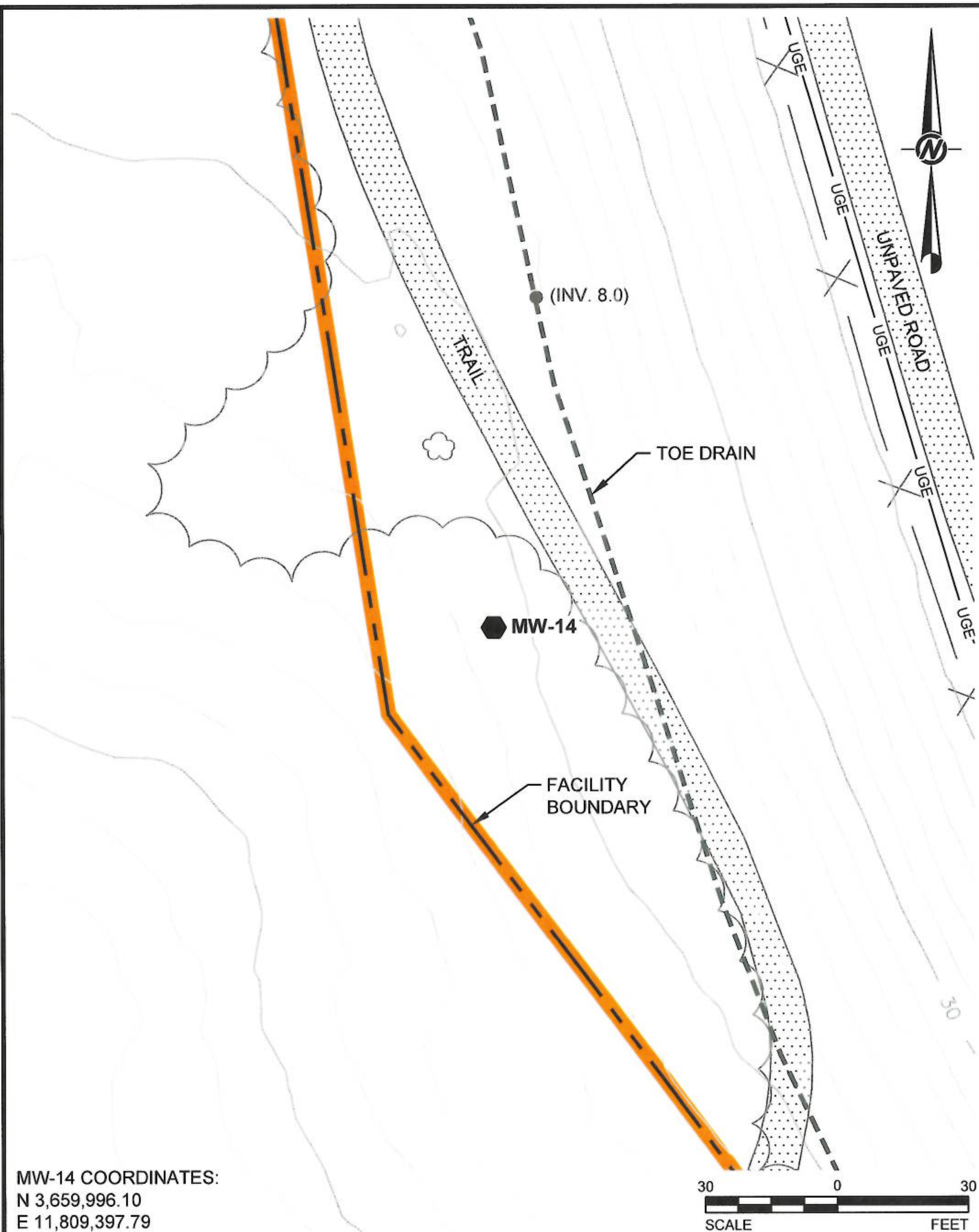

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Golder Associates
Richmond, Virginia

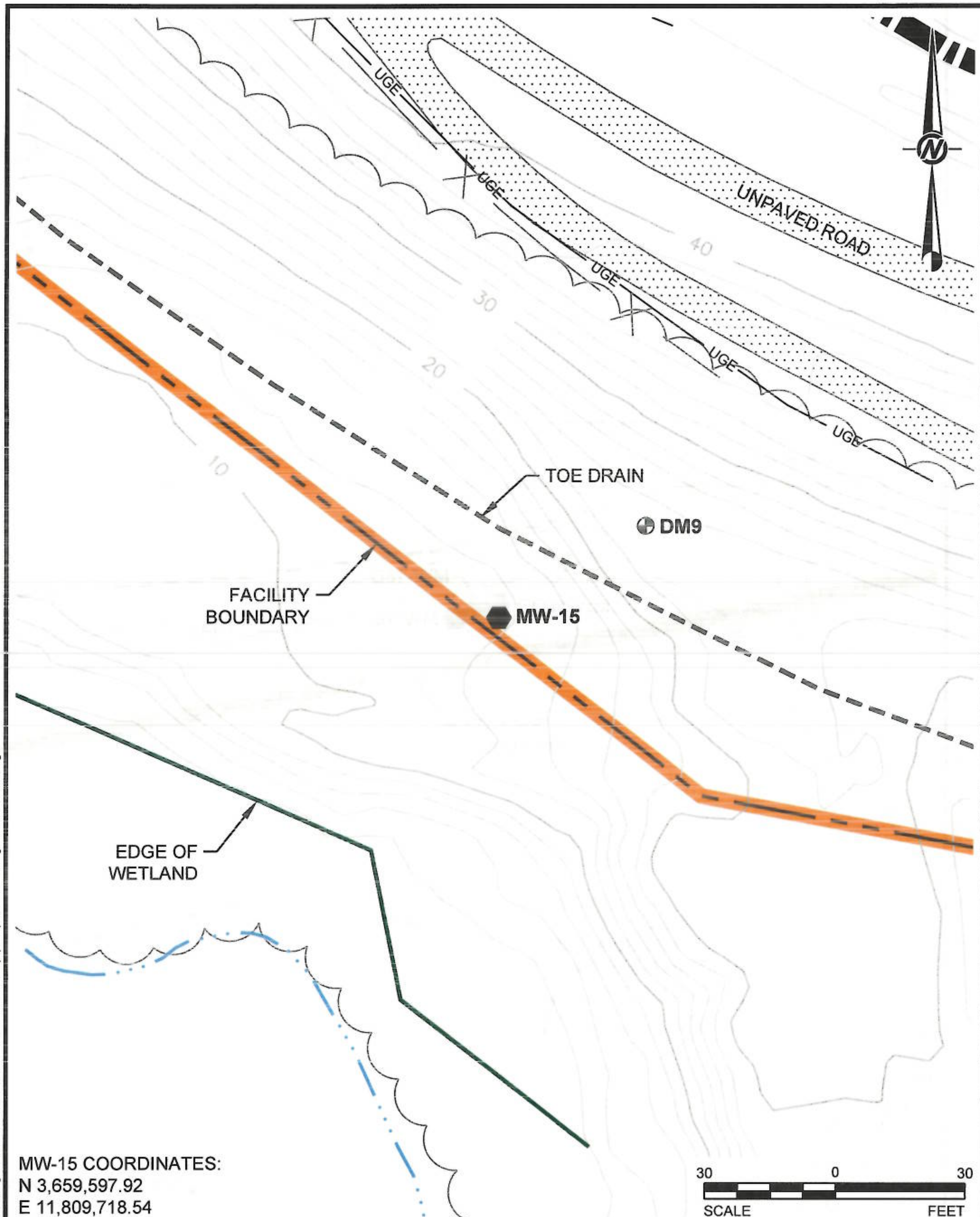
PROJECT No.	15-32864	DATE	05/26/16
SCALE	AS SHOWN	DESIGN	MGW
REV.	0	CADD	BPG
		CHECK	
		REVIEW	

TITLE

MW-14 PLAN DETAIL

CHESTERFIELD POWER STATION - UAP

DRAWING 3O



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PROJECT No. 15-32864	CHECK			
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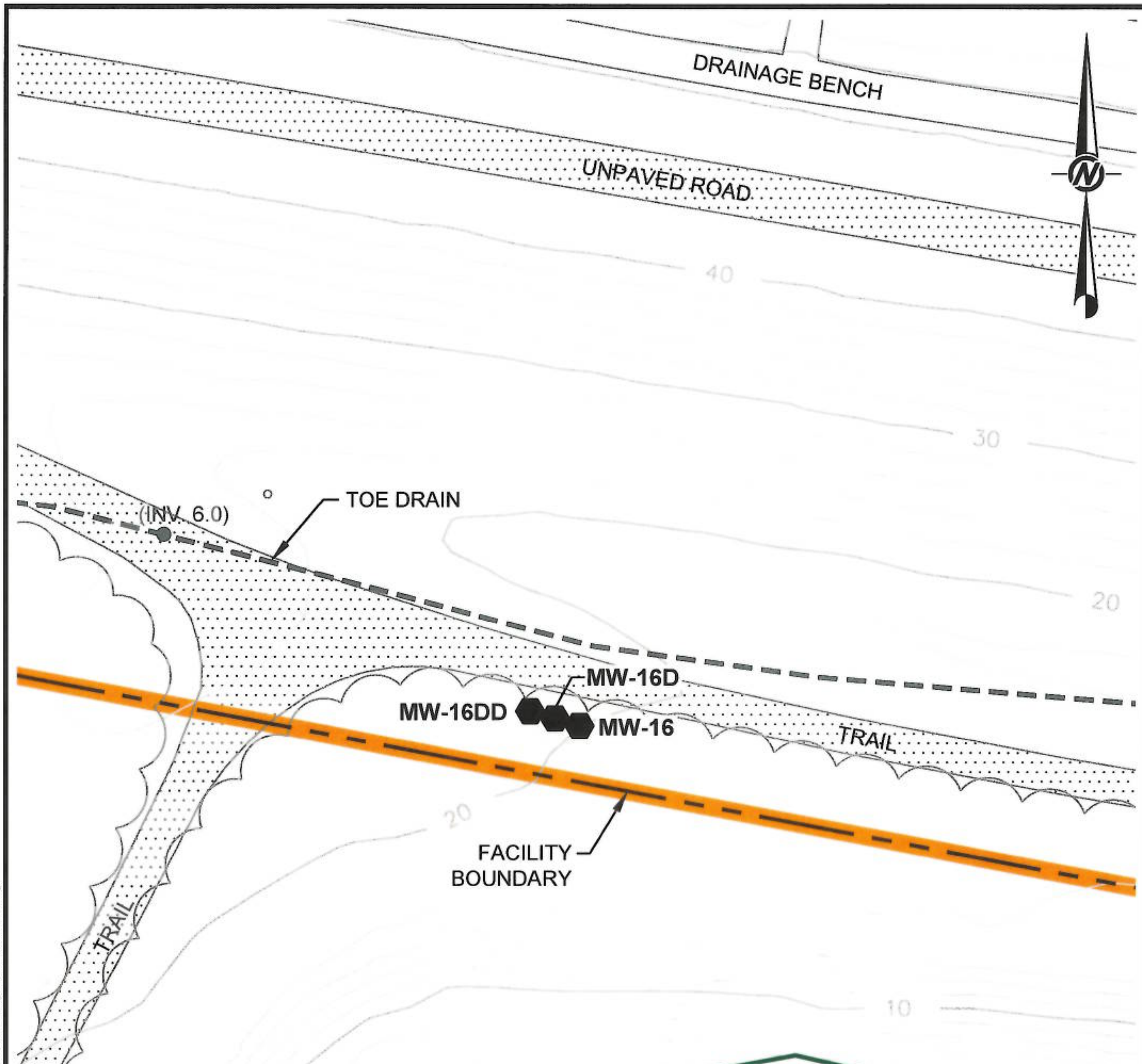

MW-16: COLUMBIA A□UIFER
MW-16D: LOWER SEMI-CONFINED A□UIFER
MW-16DD: LOWER FRACTURED BEDROCK / SAPROLITE

MW-16 COORDINATES:
N 3,659,489.64
E 11,810,179.88

MW-16D COORDINATES:
N 3,659,491.12
E 11,810,175.11

MW-16DD COORDINATES:
N 3,659,492.52
E 11,810,170.30

Golder Associates
Richmond, Virginia

DATE	05/26/16	TITLE	
DESIGN	MGW	**MW-16, MW-16D & MW-16DD PLAN DETAIL**	
CADD	BPG		
PROJECT No. 15-32864	CHECK		
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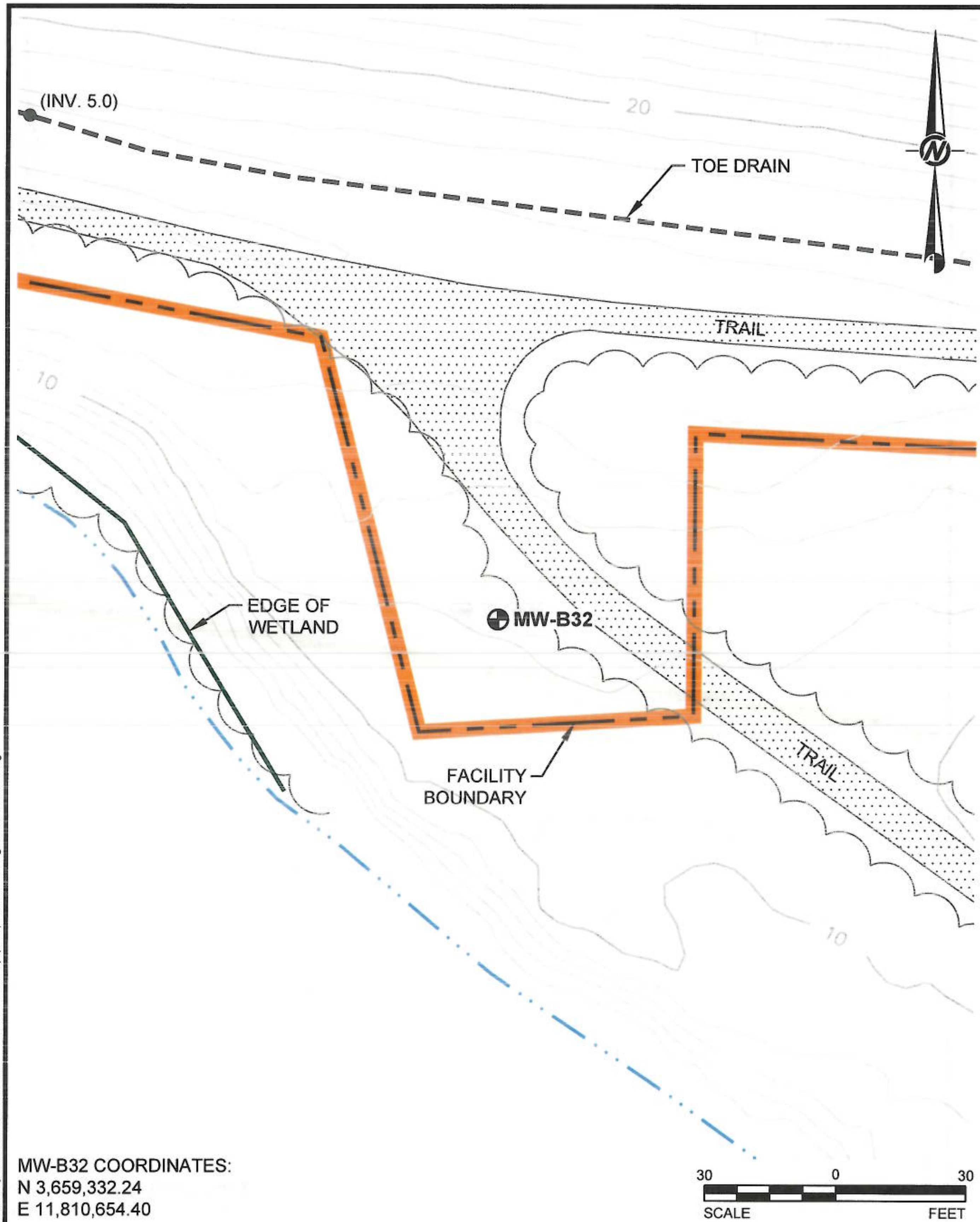

Golder Associates
Richmond, Virginia

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SCALE AS SHOWN · REV. 0	REVIEW	CHESTERFIELD POWER STATION - UAP	DRAWING 3R

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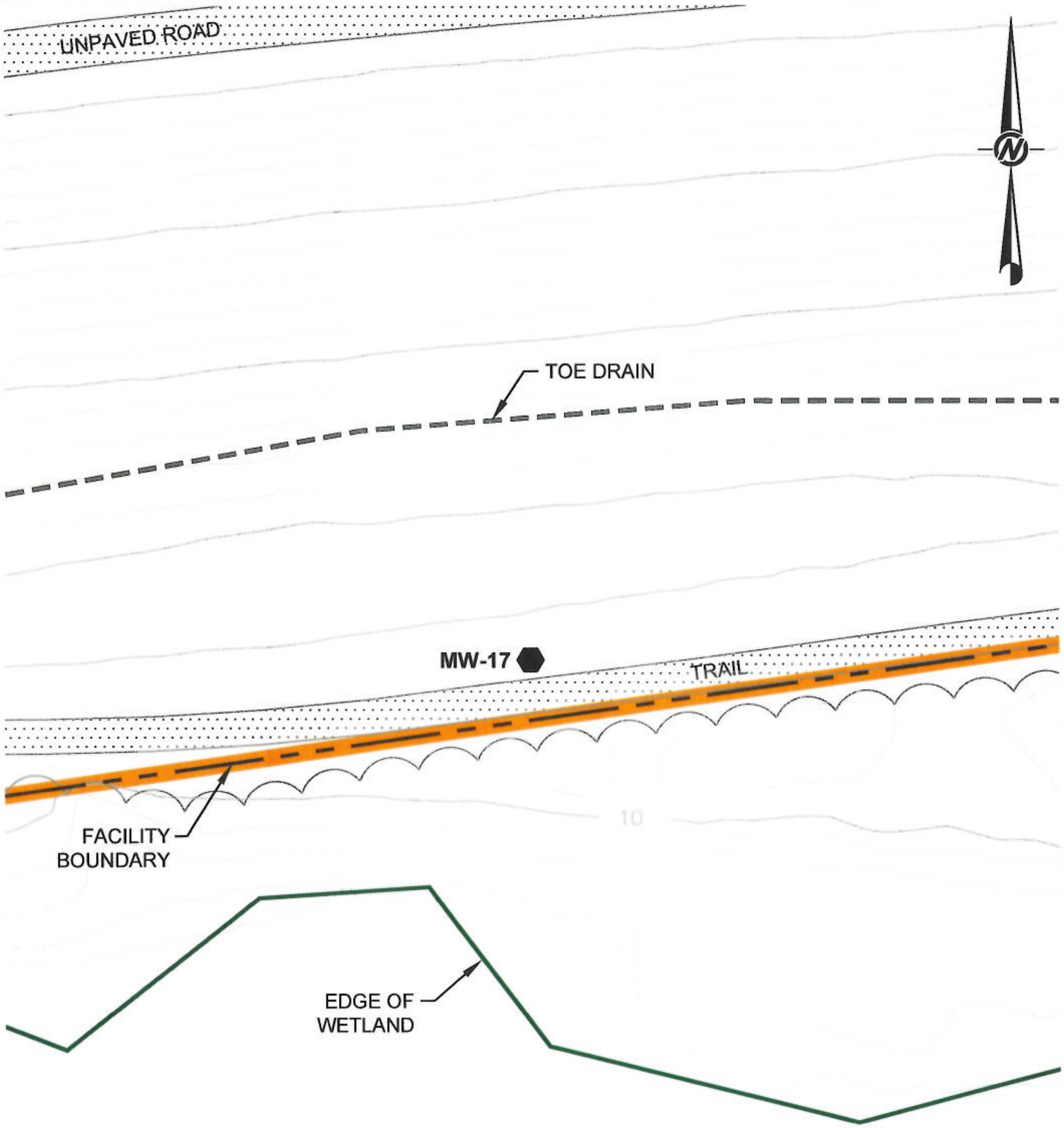

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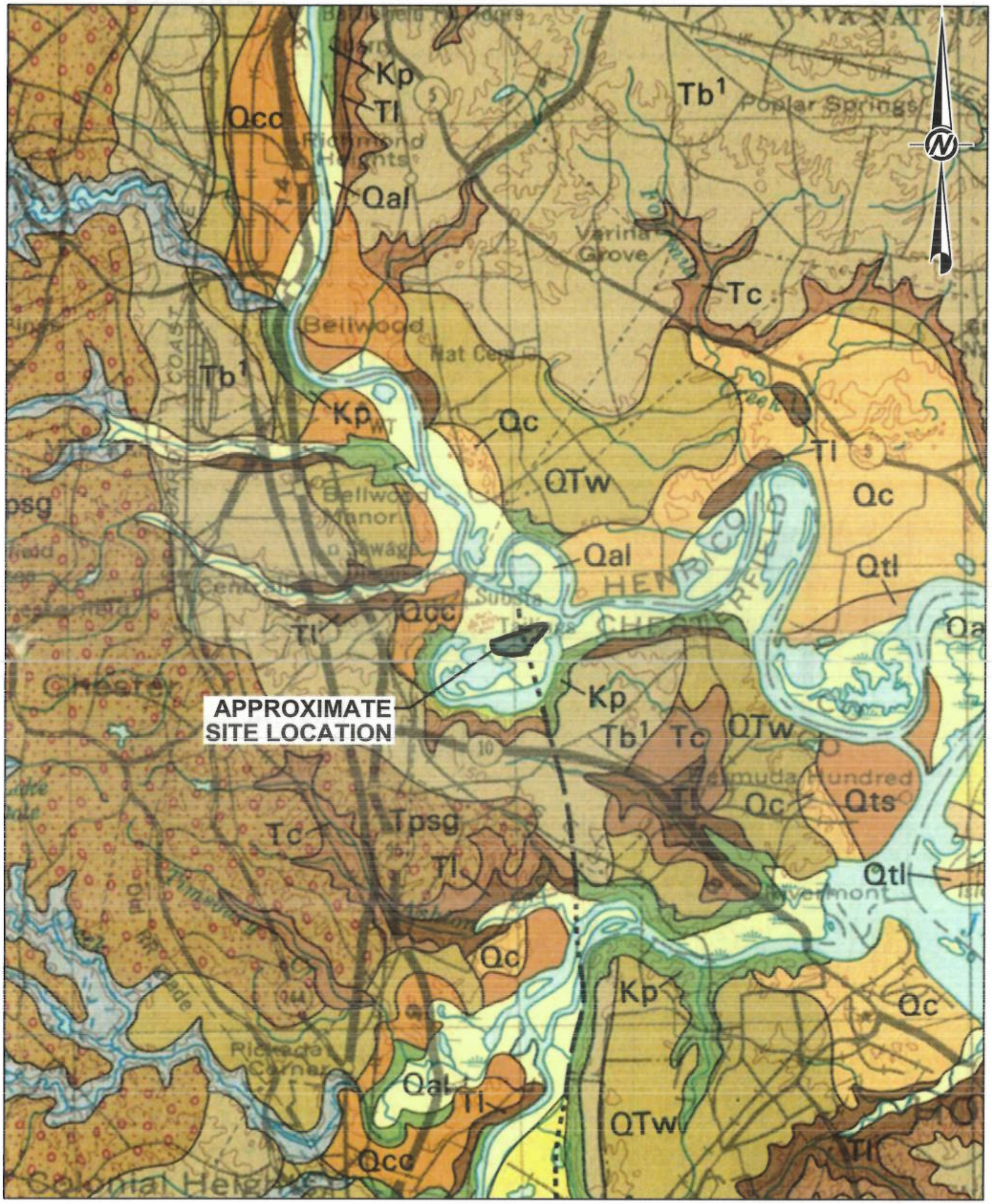
SCALE AS SHOWN / REV. 0	REVIEW		CHESTERFIELD POWER STATION - UAP	DRAWING 3S

G:\Plan Production Data Files\Drawing Data Files\15-32864\A - Groundwater Map (UAP)\Active Drawings\1532864A03.dwg



SOURCE NOTE

Geologic Map, 1989, R.B. Mi on, C.R. Ber uist, Jr., W.L. Newell, and G.H. Johnson

10000 0 10000

SCALE FEET

Golder Associates, Richmond, Virginia	DATE 12/29/15	TITLE	
	DESIGN MGW	**GEOLOGIC MAP**	
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PROJECT No. 15-32864	CHECK		
SCALE AS SHOWN / REV. 0	REVIEW	DOMINION - CHESTERFIELD POWER STATION UPPER ASH POND	DRAWING 4

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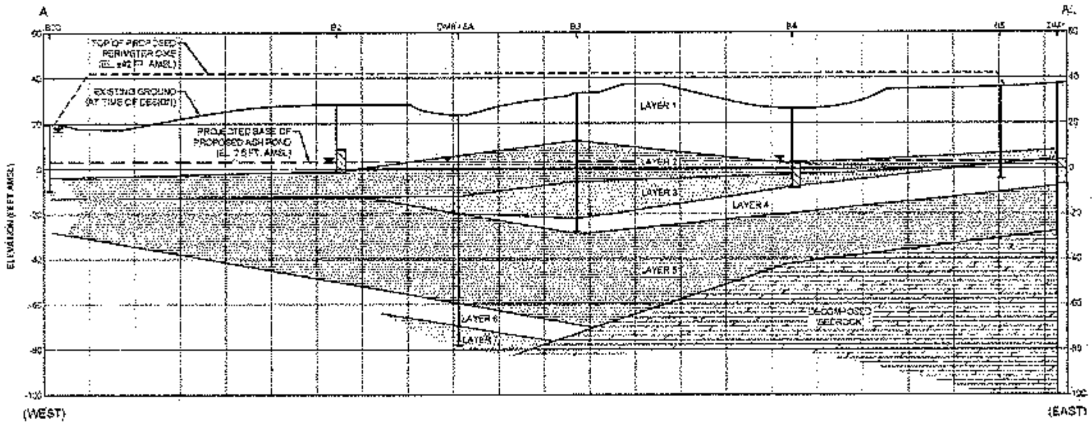
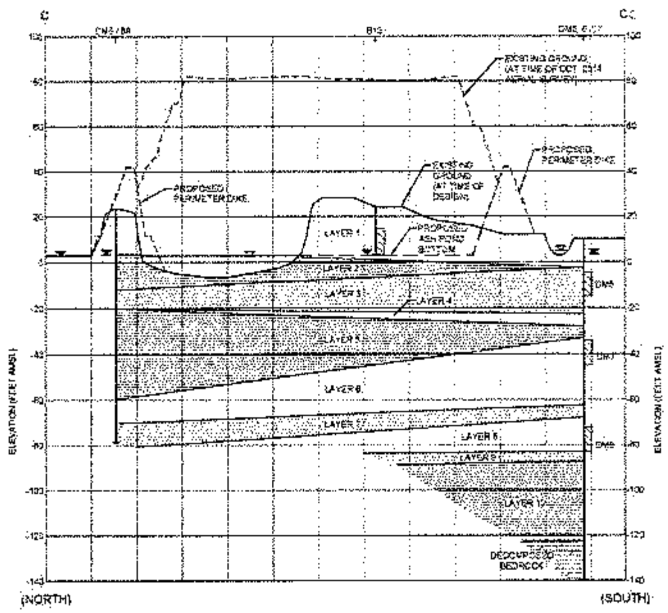


SUBSURFACE SECTION A-A'



SUBSURFACE SECTION C-C'

LEGEND

- FREE WATER SURFACE
- GROUNDWATER LEVEL
- LOCATION AND DEPTH OF BORING
- WELL SCREEN LOCATION
- SOIL LAYERS HAVING A VERY HIGH PERMEABILITY
- SOIL LAYERS HAVING A VERY LOW PERMEABILITY
- DECOMPOSED ROCK LAYER HAVING A VERY LOW PERMEABILITY

SOIL LAYER DESCRIPTIONS

LAYER 1	GENERALLY SILTY SAND, MEDIUM DENSE
LAYER 2	GENERALLY CLAYEY SILT WITH ORGANICS, SOFT TO MEDIUM STIFF
LAYER 3	GENERALLY CLEAN SAND OR SILTY SAND AND GRAVEL, MEDIUM TO VERY DENSE
LAYER 4	GENERALLY SILTY OR CLAYEY SAND WITH CLAY LENSES, DENSE TO VERY DENSE
LAYER 5	GENERALLY SILTY CLAY, HARD
LAYER 5A	GENERALLY CLAYEY SILT, VERY STIFF
LAYER 6	GENERALLY SILTY SAND WITH CLAY LENSES, VERY DENSE
LAYER 7	GENERALLY CLEAN SAND OR SILTY SAND AND GRAVEL, VERY DENSE
LAYER 8	GENERALLY SILTY OR CLAYEY SAND, VERY DENSE
LAYER 9	GENERALLY GRAVEL, VERY DENSE
LAYER 10	GENERALLY SILTY CLAY, HARD
DECOMPOSED BEDROCK	GRANITIC ROCK WEATHERED TO PREDOMINATELY SILT AND CLAY SIZE PARTICLES, SOFT

REFERENCE

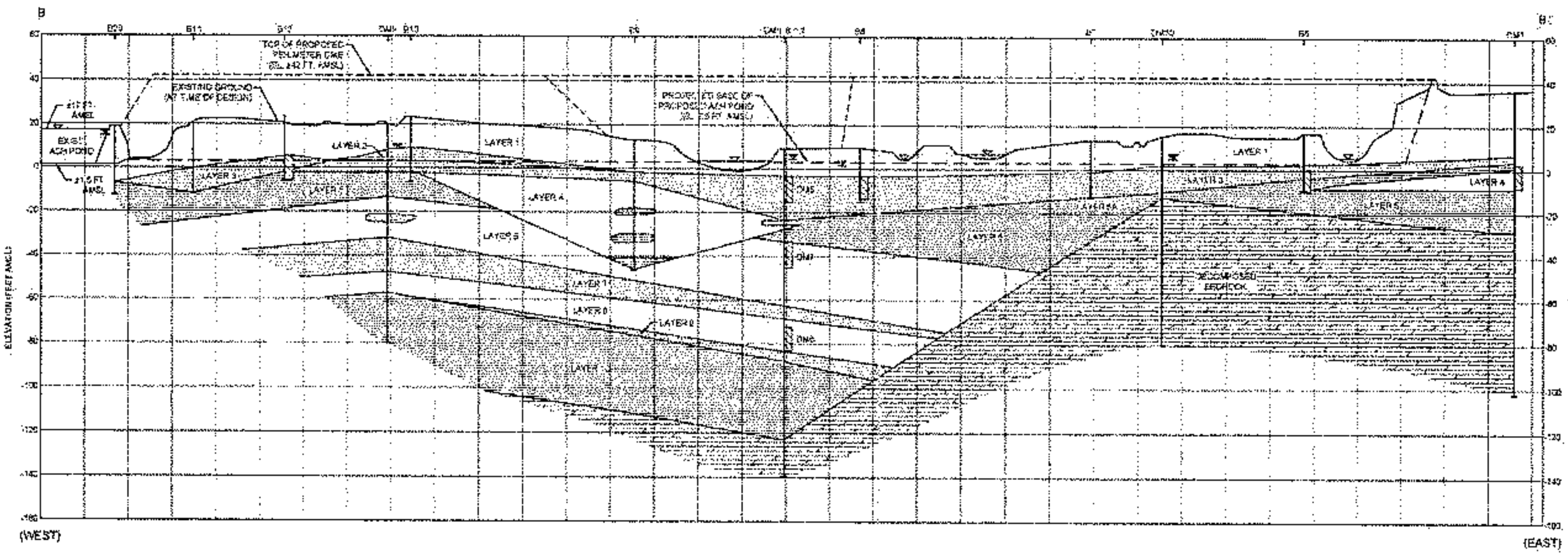
1. SUBSURFACE SECTIONS REPRODUCED FROM FIGURES INCLUDED IN REPORT TITLED "WATER QUALITY IMPACT EVALUATION FROM PROPOSED ASH TAILINGS IMPOUNDMENT AT VEPCO'S CHESTERFIELD POWER STATION," PREPARED BY DAMES & MOORE, DATED JULY 15, 1983.

Golder Associates
Richmond, Virginia

DOMINION
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VA

SUBSURFACE
SECTIONS A-A' AND C-C'

DRAWING 5



SUBSURFACE SECTION B-B'

LEGEND

- FREE WATER SURFACE
- GROUNDWATER LEVEL
- LOCATION AND DEPTH OF BORING
- WELL SCREEN LOCATION
- SOIL LAYERS HAVING A VERY HIGH PERMEABILITY
- SOIL LAYERS HAVING A VERY LOW PERMEABILITY
- DECOMPOSED ROCK LAYER HAVING A VERY LOW PERMEABILITY

SOIL LAYER DESCRIPTIONS

LAYER 1	GENERALLY SILTY SAND, MEDIUM DENSE
LAYER 2	GENERALLY CLAYEY SILT WITH ORGANICS, SOFT TO MEDIUM STIFF
LAYER 3	GENERALLY CLEAN SAND OR SILTY SAND AND GRAVEL, MEDIUM TO VERY DENSE
LAYER 4	GENERALLY SILTY OR CLAYEY SAND WITH CLAY LENSES, DENSE TO VERY DENSE
LAYER 5	GENERALLY SILTY CLAY, HARD
LAYER 5A	GENERALLY CLAYEY SILT, VERY STIFF
LAYER 6	GENERALLY SILTY SAND WITH CLAY LENSES, VERY DENSE
LAYER 7	GENERALLY CLEAN SAND OR SILTY SAND AND GRAVEL, VERY DENSE
LAYER 8	GENERALLY SILTY OR CLAYEY SAND, VERY DENSE
LAYER 9	GENERALLY GRAVEL, VERY DENSE
LAYER 10	GENERALLY SILTY CLAY, HARD
DECOMPOSED BEDROCK	GRANITIC ROCK WEATHERED TO PREDOMINATELY SILT AND CLAY SIZE PARTICLES, SOFT

REFERENCE

1. SUBSURFACE SECTIONS REPRODUCED FROM FIGURES INCLUDED IN REPORT TITLED "WATER QUALITY IMPACT EVALUATION FROM PROPOSED ASH TAILINGS IMPOUNDMENT AT VEPCO'S CHESTERFIELD POWER STATION" PREPARED BY DAMES & MOORE, DATED JULY 15, 1983.

Golder Associates
Richmond, Virginia

DOMINION
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VA

SUBSURFACE SECTION

DRAWING 6

APPENDIX I

GROUNDWATER MONITORING WELL CONSTRUCTION SPECIFICATIONS
WELL DEVELOPMENT GUIDANCE
WELL DECOMMISSIONING GUIDANCE, AND
FIGURE 1 – MONITORING WELL DETAILS

GROUNDWATER MONITORING WELL CONSTRUCTION SPECIFICATIONS

1.0 DRILLING

1.1 Nominal Boring Diameter

In all cases where the diameter of the well pipe will be 2 inches, the minimum nominal borehole diameter of borings advanced through soil materials will be 6 inches in order to help ensure that the minimum width of the annulus around the well pipe will be 2 inches.

1.2 Drilling Methods

Boring should be advanced with drilling technology appropriate for the subsurface conditions at the site.

1.3 Cuttings

Drilling will be performed in a manner that minimizes the spreading of soil cuttings. Disposition of cuttings upon project completion will be the responsibility of Owner/Operator or the Owner/Operator's designated representative. Cuttings will be disposed of in accordance with the DEQ's Investigative Derived Waste Disposal Policy.

2.0 SOIL SAMPLING

2.1 Cuttings

During borehole drilling, the driller will attempt to sample the soil cuttings by providing samples of the cuttings at intervals specified by the Owner/Operator or the Owner/Operator's representative. The driller will keep cuttings clear of the borehole.

2.3 Sample Disposition

Disposition of sample material upon completion of the project will be the responsibility of the Owner/Operator or the Owner/Operator's designated representative.

3.0 WELL CONSTRUCTION

3.1 Well Pipe and Screen

Each monitoring well will be constructed of pre-cleaned Schedule 40 PVC pipe having an inner diameter of 2 inches.

The base of each well will terminate with a screen 10 feet in length unless otherwise requested by the client or regulatory agency or dictated by geologic conditions. Screens will be factory-slotted. Slots will be 0.01 inch in width.

The driller will wear clean surgical-type gloves whenever handling PVC well pipe, and the pipe will be maintained in a clean manner.

In order to provide a clean cut, a PVC pipe cutter will be used whenever it is necessary to shorten sections of the PVC well pipe; a hacksaw will not be used.

3.3 Sand Pack

Filter sand will be a clean sand of proper size in relation to the screen slots to prevent its passage into the well, with no fraction coarser than 0.25-inch nominal diameter.

Filter sand will be placed in the annulus around the well riser and to a point approximately 2 feet above the top of the screen. A tremie pipe will be used as feasible.

3.4 Bentonite Seal

The annulus around the well pipe will be sealed with a layer of bentonite pellets, to be placed directly above the sand filter pack. The minimum thickness of the bentonite layer will be approximately two feet. The bentonite pellets should ideally be allowed 24 hours for hydration prior to continuing with well construction. A tremie pipe will be used as feasible

3.5 Grout

Following hydration of the bentonite seal, each boring will be sealed with a Portland Type I bentonite/cement slurry, using the tremie pipe method or a bentonite slurry grout if required by the project.

Bentonite content in the cement slurry will be 2 to 5 percent by weight to help reduce shrinkage.

3.6 Surface Completion

The driller will be prepared for either manhole or stickup surface completions.

In the case of manhole installations, suitable surface completion will consist of capped PVC riser and steel manhole.

The PVC riser will be provided with a lockable, watertight, expansion cap. The driller will provide a lock for each cap. All locks will be keyed identically and all keys relinquished to the owner.

The manhole will be placed in a manner that permits surface water to runoff and drain away from the manhole cover.

In the case of stickup installations, suitable surface completion will consist of a concrete apron, capped PVC well riser, and outer protective casing. The apron will be constructed in such a manner that surface water will not return to it.

The concrete apron will have the following minimum dimensions: 3 feet x 3 feet x 3.5 inches, and will be centered with respects to the riser. A form will be used in constructing the apron. The form will be centered with respect to the PVC riser. The upper surface of the apron will be graded to provide drainage away from the PVC riser. A spike will be set into the pad for surveying purposes.

The inner PVC riser (well pipe) will extend to an approximate height of 1.75 feet above the top of the concrete pad. A vent hole having a diameter of 0.25 inches will be drilled through the PVC riser at a point 2 inches below its top. Shavings generated by drilling the PVC riser will be prevented from falling into the well. The PVC riser will be provided with a slip on PVC cap.

The outer protective casing will be constructed of steel pipe having a diameter, or diagonal, of not less than 8 inches. The top of the outer protective casing, when uncovered, will be placed at a point between 0.5-inch above the top of the PVC well pipe and 0.5-inch below the top of the PVC pipe. A drain hole having a diameter of 0.5-inch will be drilled through the outer protective casing near the top of the concrete apron. Shavings generated by drilling the steel casing will be prevented from falling into the well. The casing will be marked for surveying purposes.

The outer protective casing will be lockable. The driller will provide a lock for each protective casing cap. All locks will be keyed identically.

4.0 SURVEYING

A licensed surveyor will survey well elevation. Survey point(s) will include:

- concrete pad (marked with a spike);
- outer protective steel casing, when open (engraved mark);
- inner PVC well pipe (engraved mark);
- ground surface (not marked);
- well location to within ± 0.5 foot in horizontal plane;
- ground surface elevation to within ± 0.01 foot;

- surveyor's pin elevation on concrete apron within $\pm$ 0.01 foot;
- top of monitoring well casing elevation to within $\pm$ 0.01 foot; and,
- top of protective steel casing elevation to within $\pm$ 0.01 foot.

5.0 WELL DEVELOPMENT AND INSPECTION

The driller will develop each well until sediment free water with stabilized field constituents (i.e., temperature, pH and specific conductance) is obtained.

Development will be conducted using a surge block followed by pumping or bailing. The surge block may be used as a means of assessing the integrity of the well screen and riser.

In the event a pump is employed, the design of the pump will be such that any groundwater that has come into contact with air is not allowed to drain back into the well. Air surging will not be used.

All well development equipment (bailers, pumps, surge blocks) and any additional equipment that contacts subsurface formations will be decontaminated prior to on site use, between consecutive on site uses, and/or between consecutive well installations, as directed by Owner/Operator or Owner/Operator's designated representative.

6.0 ANCILLARY REQUIREMENTS

6.1 Extraneous Material

The driller will take all reasonable care to ensure that each boring is free from all materials other than those required for well construction. Materials required for well construction is here defined to include polyvinyl chloride (PVC), sand, bentonite, Portland cement and natural soil materials. All other materials accidentally or purposely placed in the hole will be removed by driller prior to well completion.

6.2 Decontamination

All drilling equipment (drill steel, bits, casing materials) and any additional equipment, that contacts subsurface formations will be decontaminated prior to on site use, between consecutive on site uses, and/or between consecutive well installations, as directed by Owner/Operator or Owner/Operator's designated representative.

Appropriate decontamination procedure will consist of steam cleaning with potable water and biodegradable detergent (e.g., Liquinox) approved by Owner/Operator or Owner/Operator's designated representative. Steam cleaning will be conducted in a manner that minimizes over-spray and runoff.

6.3 Disposition of Waste Water

If drilling fluids are used or monitoring wells constructed in an area of suspected contamination, well development wastewater will be placed in 55-gallon drums at the well site and subsequently transported to a publicly operated treatment works (POTW) or the sites leachate collection system for disposal.

6.4 Site Safety Plan

The driller is responsible for maintaining the personal safety of his employees while on site. The driller will keep a fire extinguisher (in good working condition) and first aid kit at the site at all times during which his employees occupy the site.

The driller will be responsible for providing any personal protective equipment that might be required by state and federal occupational safety and health agencies, including, but not necessarily limited to, hard hats, hearing protection and steel-toed boots, for all personnel employed by the driller.

6.5 Cleanup

The driller will be responsible for removing all refuse from each well site. Such refuse typically includes, but is not limited to, PVC pipe wrappers, sand bags, bentonite bags, cement bags, beverage containers, food wrappers and other forms of litter. Smoking on site will not be permitted.

The driller will be responsible for providing the following information to the Owner/Operator's designated representative after well installation has been performed:

- date and time of construction;
- drilling method and fluid used (if applicable);
- boring diameter;
- well pipe (inner casing) specifications;
- well depth (+/-0.01 ft.);
- drilling/lithologic logs;
- specifications for other casing materials (if applicable);
- screen specifications;
- well pipe/screen joint type;
- filter pack specifications (material, size);
- filter pack volume and calculations;
- filter pack placement methods;

- bentonite seal specifications;
- bentonite seal volume;
- bentonite seal placement method;
- grout specifications;
- grout volume;
- grout placement method;
- surface completion specifications; and
- well development procedure

7.0 WELL CONSTRUCTION AND SOIL BORING LOGS

In accordance with 9VAC-20-81-250-A.3.g of the Virginia Solid Waste Management Regulations or other applicable regulations, certified copies of well construction and soil boring logs will be forwarded to the DEQ following completion of well construction activities.

g:\projects\dominion\chesterfield power stn\1532-864 uap and lap groundwater\uap groundwater monitoring plan\2016-04 submittal - rtc deq ltr 2016-02-26\appendices\appendix iia monitoring well construction specifications - golder vswmr amendment 7 update.docx

WELL DEVELOPMENT PROCEDURES

- Record the static water level in the well.
- If a pump is present in the well, remove the pump from the well and measure the total depth of the well.
- Calculate saturated volume of the well and filter pack.
- Using a disposable bailer, collect a water sample from the top of the water column and record field measurements of water quality parameters (Water Quality Parameters (WQP): turbidity, pH, temperature, and specific conductance).
- Surge the well with the teflon surge block or large diameter weighted bailer for three to five minutes.
- Remove the surging device and purge the well with a pneumatic well development pump at a rate that is greater than the natural recharge rate of the well.
- Containerize all purge water for disposal at the location designated by the site.
- Record measurements of WQP on development logs following the removal of each consecutive well and filter pack volume.
- Continue purging until the turbidity level stabilizes or is reduced to less than 5 NTU, then repeat surging with surge block. Surging and purging are to be continued for a minimum of 4 hours, or until turbidity levels following a surging event are less than 10 NTU.
- If the well purges dry, record the rate of recharge and continue purging and surging activities after the well has recovered. Reduce the purge rate to slightly less than the natural recharge rate of the well.
- All non-disposable equipment that will be placed inside of the well during the development process will be decontaminated prior to each day's use using a phosphate-free detergent followed by a deionized water rinse.
- Purge water should be disposed of in a manner that is consistent with the Virginia Department of Environmental Quality's Investigative Derived Waste Disposal Policy.

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WELL DECOMMISSIONING PROCEDURES

1.0 STANDARD OVERVIEW

This Standard represents recommended procedures for decommissioning monitoring wells at solid waste facilities. All wells (monitor wells, water supply wells, etc.) and piezometers not actively being used for their intended purpose and with no future plan for utilization should be decommissioned. Wells and piezometers represent potential conduits for cross-contamination through annulus transfer, improper construction, corrosion, accidents and vandalism. Proper decommissioning eliminates the potential for cross-contamination. In addition to the threat of cross-contamination, improperly decommissioned wells can pose a threat to the integrity of future baseliners. In expansion areas over unconsolidated material, unless the well casing is removed and replaced with a flexible grout, the casing can damage the baseliner in the event of differential settlement or subsidence. The weight of the overlying waste mass often causes a limited amount of subsidence, especially in fine-grained deposits. Since future expansions can occur in areas not currently foreseen, all unused wells within the vicinity of a solid waste disposal facility should be abandoned in accordance with this Standard.

The following well decommissioning procedures are designed to ensure that well materials (including cement grout) will not cause damage to liner materials in the event of subsidence and to minimize the potential for contaminant migration through annular materials. Where regulatory requirements conflict with the procedures described herein, approval should be sought to adhere to this Standard. The procedures described in this Standard generally meet or exceed most regulatory requirements. Possible reasons for variation to this Standard include, but are not limited to, unusual site hydrogeologic conditions, deep wells (>100 feet), multiple cased monitor wells or larger diameter wells (>4"), driven casing wells and State-specific well decommissioning requirements that differ from this Standard.

The goal of well decommissioning is to remove <u>all</u> borehole components including the existing grout and gravel pack and replace the borehole contents with a suitable grout mixture. Removal of all borehole components is best accomplished by overdrilling the well using an auger of a diameter 1.25 times that of the original borehole coupled with a centering device.

This standard was developed in consideration of the following reference materials:

- ASTM D 5299-99, 2005. Standard Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities. ASTM 1993 Annual Book of Standards, vol. 04.08, pp. 1318-1333.
- AWWA/ANSI A100-06, 2006. AWWA Standard for Water Wells, American Water Works Association, Denver Colorado. Appendix G.
- Lutenegger, A.J. and DeGroot, D.J. 1993, Hydrologic properties of contaminant transport barriers as borehole sealants. Hydraulic conductivity and Waste Contaminant Transport in Soils, ASTM STP 1142, D.E. Daniel and S.J. Trautwein, eds., ASTM Philadelphia, Pennsylvania.
- NWWA, 1975 (National Water Well Association Committee on Water Well Standards, 1975) Manual of Water Well Construction Practices, EPA –570/9-75-001. Office of Water Supply, Washington D.C.
- Smith, S.A., 1994, Well & Borehole Sealing, S.A. Smith Consulting Services, Ada, Ohio with Wisconsin Water Well Association for Groundwater publishing Co., Dublin, Ohio, 69p.

2.0 SURVEY CONTROL

Unless detailed survey information exists, each well shall be surveyed for both horizontal and vertical control, prior to decommissioning. The location of the well shall be surveyed to the nearest 0.5 feet. The ground surface elevation and top of well casing shall also be surveyed to the nearest 0.1 feet and 0.1 feet, respectively, relative to mean sea level. A State-licensed surveyor shall perform surveying.

3.0 GROUT SPECIFICATIONS

The following are specifications for three grout mixtures commonly used in well decommissioning and referenced throughout this Standard:

1. Neat cement grout - a mixture in the proportion of 94 pounds of Portland cement and not more than six gallons of water. Used to decommission wells completed in competent bedrock formations.
2. Neat Bentonite grout - a mixture in the proportion of 94 pounds of Portland cement and not more than six gallons of water, with bentonite up to five percent by weight of cement (between 3 and 4.7 pounds of bentonite per 94 pounds of Portland cement). Used to decommission wells completed in competent bedrock formations.
3. High solids bentonite grout - a mixture of water and a minimum of 30 percent by weight of bentonite (see discussion below), with no additives (minimum of 2.5 pounds of bentonite per gallon of water). Used to decommission wells completed in unconsolidated materials and competent rock, where appropriate.

Typically, a high solids grout can be prepared using granular bentonite and pumped at a relatively low-viscosity state if done quickly (within 15 minutes). This is due to the slower hydration of the granular bentonite as compared to powdered bentonite. However, if these timeframes cannot be achieved or if it is desirable to have a slower "set," an alternative is to use what has been termed the "Ohio mix". The "Ohio mix" involves preparing a low-solids bentonite grout slurry (30 to 50lbs/100 gallons of water) using API 200-mesh bentonite (e.g., Natural Gel, Gold Seal), into which 125 lb. of granular bentonite (8 to 20-mesh) is added and mixed (stirred). The hydrated bentonite in the slurry delays hydration of the granular bentonite without the addition of polymers or other agents. The result is a high solids bentonite grout at a viscosity that is feasible to pump with reasonable working time (Eidil et al. 1992 from Smith, 1994).

3.1 Cement

The cement shall be Portland Cement® Type 1 in accordance with ASTM C150, Type 1 or API-10A, Class A.

3.2 Water

Water shall be obtained from an approved source. Water used for down-hole purposes shall have a Total Dissolved Solids (TDS) concentration of less than 500 mg/L (Smith, 1994) and be certified free from contaminants, or sampled for volatile organic compounds by EPA method 8260.

3.3 Bentonite

Bentonite shall be an additive free granular sodium bentonite (Benseal, Enviroplug, PDS Granular, Volclay Crumbles or equivalent) generally 8 to 20 mesh particle size. Use of granular bentonite *in lieu* of powdered bentonite allows the placement of a high-solids grout with relatively low viscosity, if mixing and pumping are done quickly. If following the "Ohio mix" discussed above, additive free API 200-mesh bentonite is used for the initial slurry (e.g., Natural Gel, Gold Seal) into which granular bentonite (8 to 20 mesh) is added and mixed.

3.4 Grouting Equipment

Grout mixers shall be paddle or blade type capable of thoroughly mixing grout. All grouting lines (i.e., hoses, pipes, drill rods, etc.) shall have an inside diameter of at least 0.50 inches to prevent clogging. Grout pumps shall be of a positive displacement or progressive cavity type (Moyno) capable of delivering a minimum pressure of 20 psi. Venturi mixing and centrifugal pumps are less desirable alternatives due to clay particle shearing and clogging problems, respectively.

4.0 DECOMMISSIONING PROCEDURES

Decommissioning procedures must be tailored to each well type and geologic environment. The broad range of suitable decommissioning methods for different situations is covered in detail in ASTM D5299-99 and the above referenced standards and literature. The purpose of this standard is to establish minimum requirements for the most common well construction types at our facilities. For landfill facilities, the most common type of well installation consists of single cased wells installed in unconsolidated material at relatively shallow depths (i.e., < 100 feet). The procedures described herein can be used to decommission two-inch or four-inch diameter single cased PVC or steel wells installed at depths generally less than 100 feet. Other less common well types requiring specialized procedures and materials include large diameter wells, multiple cased wells and driven casing wells.

The goal of decommissioning is to completely remove all well materials either through overdrilling or pulling of the well or casing. Once all well materials have been removed, the resulting borehole can be properly sealed with a suitable grout mixture.

In general, a high solids bentonite grout mixture (30% by weight) is preferred for most well decommissioning projects. State regulations often stipulate that for wells installed in bedrock, non-flexible grout mixtures must be used, such as neat cement grout or neat bentonite grout. Non-flexible grout mixtures more closely match the physical characteristics of competent bedrock. For all wells or portions of wells completed in unconsolidated material a high solids bentonite grout as defined above is the requisite grouting material. For wells of portions of wells completed in competent bedrock grouting materials can be either of the three grout types specified above with preference given to high solids bentonite grout.

The following are specific decommissioning procedures. These steps shall generally be completed in the order listed below.

1. Ensure that adequate survey control exists for each well and obtain a copy of the original well construction log.
2. Well decommissioning drilling equipment, augers, water level marker, and other tools must be decontaminated before being brought to the site.
3. The depth of the well shall be measured and compared to the anticipated well depth to determine if any obstructions are in the well. If the well is obstructed, the obstruction will be removed prior to sealing the well, if possible.
4. Expected grout volume calculations shall be completed using the depth information derived from Steps 1 and 3. The expected volume shall be recorded for reconciliation with the final grout volumes used.
5. Remove the protective casing. Position the drill rig directly over the well and attach a chain to the outer protective casing. Pull directly upward on the protective casing. Often for shallow wells this procedure will also pull up the inner-casing and annular materials. If this occurs, continue to pull all well materials out, as practicable.

6. Remove the well casing and associated annular materials. Typically, removal is accomplished through overdrilling using a Hollow Stem Auger (HSA) drill rig equipped with an auger bit that exceeds the diameter of the original bit (1.25 times the original auger diameter) used to construct the well. The key to successful overdrilling is insuring the auger bit remains centered on the well for the duration of overdrilling. For wells constructed of PVC, either employ a pilot bit to insure centering is maintained or place A-rod (steel rod) throughout the length of the well to act as a guide during overdrilling. A pilot bit consists of an elongate pointed pin with a maximum diameter slightly less than that of the inner well casing. For wells constructed of steel materials, the steel casing itself can be used to maintain centering during overdrilling. Essentially, an auger is selected with an inner diameter slightly larger than the diameter of the steel casing. During overdrilling the auger follows the steel casing to the target depth. Centering must be assured through use of one of the above-described centering methods. The overdrilling shall progress slowly to insure that the drilling operation remains centered over the well/boring. Once the base of the well is reached the auger or drilling equipment shall be left in place, to prevent cave in of materials, while proceeding to Step 6.

   For unconsolidated wells installed using driven casing or equivalent methods (i.e., no annular materials), it may be possible to pull the outer casing or well *in lieu* of overdrilling. If this procedure is used, grouting must be completed concurrently with the pulling of casing with grout level maintained within 5 feet of ground surface while the casing is pulled. The grout shall be introduced into the well from the base using a tremie line through the innermost casing (with the base of the well removed). The grout mixtures and procedures shall be as described in Step 6.

   Driven casing wells completed entirely in competent bedrock may be decommissioned without removing the casing by tremie grouting according to the procedures described in Step 6.

7. Upon removal of the casing, well screen and annular materials, the resulting boring shall be tremie grouted. The grout shall be a high solids bentonite grout as defined above. Essentially, the grout mixture shall contain as high a bentonite content as can be reasonably pumped (30% bentonite by weight). For wells installed in competent bedrock state regulations often mandate use of a neat cement grout mixture. It is preferable in cases where the borehole intersects both competent bedrock and unconsolidated materials that the unconsolidated interval shall be abandoned using a high solids bentonite grout. Grout shall be mixed to a uniform consistency. The grout shall be pumped into the boring through a tremie pipe placed at the bottom of the boring. The auger flights shall be left in place until the tremie line is situated at the bottom of the boring. Grouting shall proceed in a continuous and expeditious manner by concurrently pulling the auger flights and pumping grout until the grout level is within two feet of the ground surface. Both the bottom of the tremie pipe and the base of the auger flights must remain submerged in grout while the well is grouted.

   After the grout has settled for 24 hours, the borehole must be checked for grout settlement, and if necessary, topped off with the appropriate grout mixture. The final level of the grout shall be within two feet of the ground surface. The top two feet of the borehole shall be abandoned by adding and compacting native soils.

8. Equipment used for well decommissioning shall be cleaned and decontaminated between decommissioning locations.

9. Upon completion of decommissioning activities, well decommissioning materials and equipment will be removed from the site and the site will be restored. Over-drilled well materials and cuttings shall be properly disposed.

10. After the well has been decommissioned, a record must be prepared. The record must contain the following information, at a minimum:
    - Name and address of property owner;
    - Name, license or registration number of the contractor doing the work, name of the driller performing the work, and the signature of the representative;
    - Date work was completed;
    - Survey information including the county, township, range, section, and three quartiles, and the street address or fire number of the well or boring (for unincorporated areas);
    - A description of the geological material penetrated by the well (i.e., copy of the original boring log);
    - The original well or boring depth, and current well or boring depth;
    - The approximate date of construction;
    - The grout or sealing materials, type, quantities, and intervals;
    - The casing type, diameter, and depth, if present;
    - The screen or open hole depth interval, if present;
    - A description of any obstruction, if present;
    - A description of any deviations from the above procedures, or other unusual conditions encountered or actions taken; and
    - A statement as to whether or not all well materials were removed and if not a detailed explanation of the type of materials left in place and their approximate elevation, type, condition, etc.
11. Copies of the decommissioning record are to be forwarded to the site and the State agency if required.

4.1 Failure to remove all well materials

If for any reason the above decommissioning procedures fail to remove all well casing and screen materials, the well shall be permanently marked with a steel post and attached name plate containing the well identification. The name plate and/or site records shall contain, at a minimum, the following:

- Well Identification;
- Date of installation;
- Date of decommissioning;
- Survey coordinates; and
- Approximate elevation interval of in place well materials.

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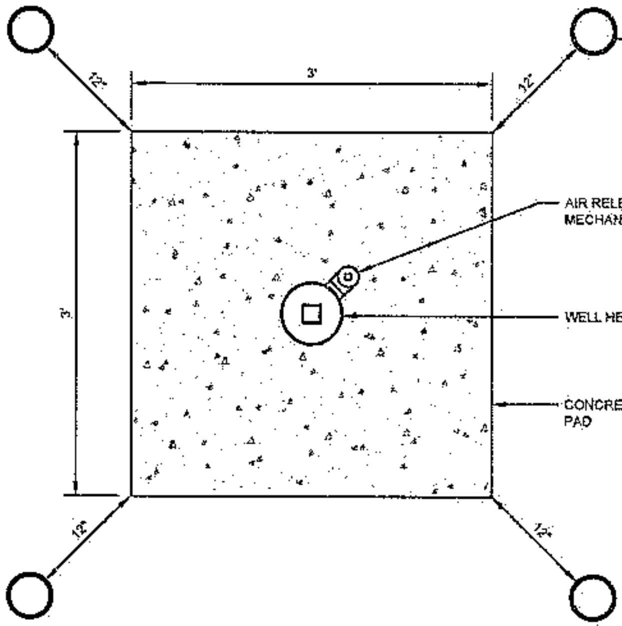
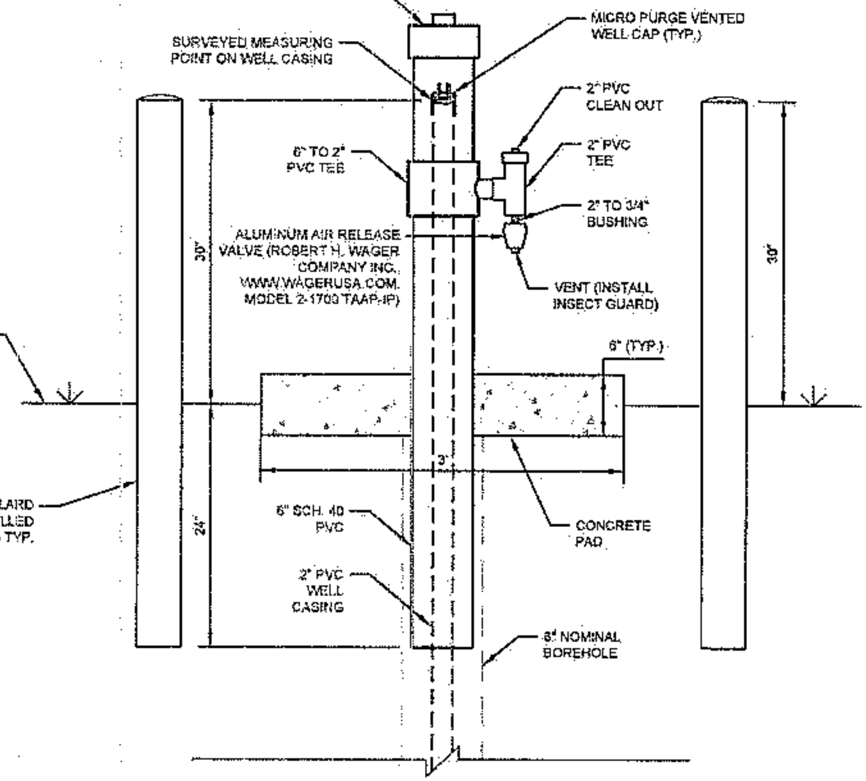


PLAN VIEW

SCALE: 1" = 1'

NOTE: PROTECTIVE BOLLARDS TO BE INSTALLED AS NEEDED BASED ON SITE CONDITIONS TO PROTECT WELLHEAD INTEGRITY (AS DETERMINED BY DOMINION).



CROSS-SECTION VIEW

SCALE: 1" = 1'

Golder Associates
Richmond, Virginia

PROJECT

DOMINION
CHESTERFIELD POWER STATION
CHESTERFIELD COUNTY, VA

TITLE

MONITORING WELL DETAILS

PROJECT No.			15-32684
FILE No.			1532684A05
REV. 0		SCALE	AS SHOWN
DESIGN	MGW		06/29/16
CADD	BPG		06/29/16
CHECK			
REVIEW			

FIGURE 1

Golder Associates

WELL CONDITION SUMMARY

DATE:________

Project Name____________________ Project No./Task No.____________________

Personnel ____________________ Page______ of ______

Well ID	Protective Casing	Well Casing	Label	Lock	Pad Condition	Depth of Well (Feet)	General Turbidity	Comments/ Observations*
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	
	☐ OK ☐ Damaged	☐ OK ☐ Damaged	☐ OK ☐ Inadequate	☐ Yes ☐ No	☐ OK ☐ Damaged		☐ Clear ☐ Turbid	

* Note ponding water, weep holes, condition of surrounding area, including any disturbance of the ground since last inspection, evidence of contamination.

Signature:______________________________ Date:______________________________

WELL INSPECTION REPORT

Golder Associates

FACILITY INFORMATION

Owner: ______________________ **Permit No.** ______________________

Location: ______________________ **Project No.** ______________________

INSPECTION

Inspection Date: ______________________ **Inspector Name:** ______________________

Time: ______________________ **Weather Conditions:** ______________________

MONITORING WELL CONDITIONS

Well ID: ______________________

Lock Condition: ______________________

Protective Casing Condition: ______________________

Pad Condition: ______________________

Pump Type: ______________________

Pump Serial No.: ______________________

Pump Condition: ______________________

Tubing Condition: ______________________

Sediment Accumulation in Well (describe): ______________________

Depth to Water (feet): ______________________

Depth to Bottom (feet): ______________________

Comments: ______________________

____

Signature: ______________________ **Date:** ______________________

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APPENDIX II

MONITORING WELL CONSTRUCTION LOGS

BORING DM-1

SURFACE ELEVATION: +37.2
LOCATION: See Figure 2

LABORATORY TEST DATA

Depth (feet)	Other tests	Triaxial compression (ksf) $\frac{\sigma_1-\sigma_3}{2}$	Triaxial compression (ksf) σ_3	Atterberg limits: Liquid limit (%)	Atterberg limits: Plasticity index (%)	Moisture content (%)	Dry density (pcf)
35	SA/HA					23.1	
40	pH					50.6	
50	ATT R&D CEC			51		35.1	82.5
55	R&D					37.4	68.2
65	R&D					18.3	99.2
75	R&D					23.3	94.5
80	R&D					24.3	104.1

LOG

Depth (feet)	Depth (meters)	Blow count	Symbols	Description
0	0		ML	ORGANIC MAT AND TOPSOIL (0 TO 0.4 FEET) RED-BROWN CLAYEY SILT WITH A LITTLE FINE SAND AND A TRACE OF ORGANICS AND FINE GRAVEL (VERY STIFF)
5	1.5	12	ML	
10	3	23	ML	GRADING WITH SOME FINE SAND
15	4.5	18	SM	RED-BROWN FINE SAND WITH SOME SILT (MEDIUM DENSE)
20	6	50/6" 60/6"	SM	GRADING TO GRAY-BROWN FINE TO MEDIUM SAND WITH A TRACE OF SILT
25	7.5	19	SM	
30	9	30	SP/SC	WHITE AND ORANGE-BROWN FINE TO COARSE SAND WITH A TRACE OF CLAY (MEDIUM DENSE TO DENSE)
			MH	BLACK CLAYEY SILT WITH A LITTLE YELLOW TO TAN STRINGERS OF FINE TO COARSE SAND WITH OCCASIONAL FINE TO COARSE GRAVEL (VERY STIFF)
35	10.5	40	SM	YELLOW-ORANGE TO LIGHT TAN FINE TO COARSE SAND WITH LENSES OF DARK BROWN TO BLACK CLAYEY SILT (DENSE)
40	12	58	SM	GRADING LIGHT BLUE-GRAY AND GREEN GRADING WITH SOME GRAVEL
45	13.5	35	CL/CH	DARK GRAY-GREEN SILTY CLAY, A TRACE OF FINE SAND WITH SLIGHT HORIZONTAL BANDING (HARD)
50	15	20	CL/CH	GRADING BLACK TO DARK GRAY-GREEN
55	17	49	CL/CH	
60	18	72	CL/CH	GRADING WITH A LITTLE MODERATELY TO HIGHLY WEATHERED ROCK FRAGMENTS (SHALE)
65	20	72	DR	GRAY-GREEN DECOMPOSED GRANITIC ROCK WEATHERED TO CLAYEY SILT WITH A TRACE OF MICA AND FINE SAND SIZE PARTICLES (SOFT)
70	21	46	DR	
75	23	70	DR	GRADING TO MOTTLED BLUE-GRAY AND REDDISH BROWN
80	24	50/5"	DR	GRADING TO REDDISH-BROWN
85	26			

PLATE B-36

LOG OF BORINGS

Dames & Moore

BORING DM-1(cont'd)

SURFACE ELEVATION: +37.2
LOCATION: See Figure 2

LABORATORY TEST DATA

Other Tests	Triaxial Compression: $\frac{\sigma_1-\sigma_3}{2}$	Triaxial Compression: σ_3	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plasticity Index (%)	Moisture Content (%)	Dry Density (pcf)	Depth (Feet)	Blow Count	Samples	Symbols	Description
							85	80	▪	DR	GRADING MORE CLAYEY WITH LITTLE FINE SAND SIZE PARTICLES AND MICA
							90	60/5"	▪	DR	
M&D					20.9	99.8	95	65	▪	DR	GRADING REDDISH-BROWN MOTTLED WITH GRAY
							100	80	▪	DR	GRADING WITH LESS GRAY
							105	70	▪	DR	
Py M&D					24.0	106.0	110	60/6"	▪	DR	
							115	60/10"	▪	DR	GRADING WITH TRACE OF PARENT BEDROCK STRUCTURE
							120	65	▪	DR	
							125			DR	
M&D					22.4	93.7	130	97	▪	DR	GRADING BADLY WEATHERED TO BLUE-GRAY CLAYEY SILT AND FINE SAND
							135			DR	

Depth scale (meters): 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41
Depth scale (feet): 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135

BORING COMPLETED AT A DEPTH OF 136 FEET ON 6-10-83

PLATE B-36 (cont'd)

LOG OF BORINGS

Dames & Moore

MW-DM2

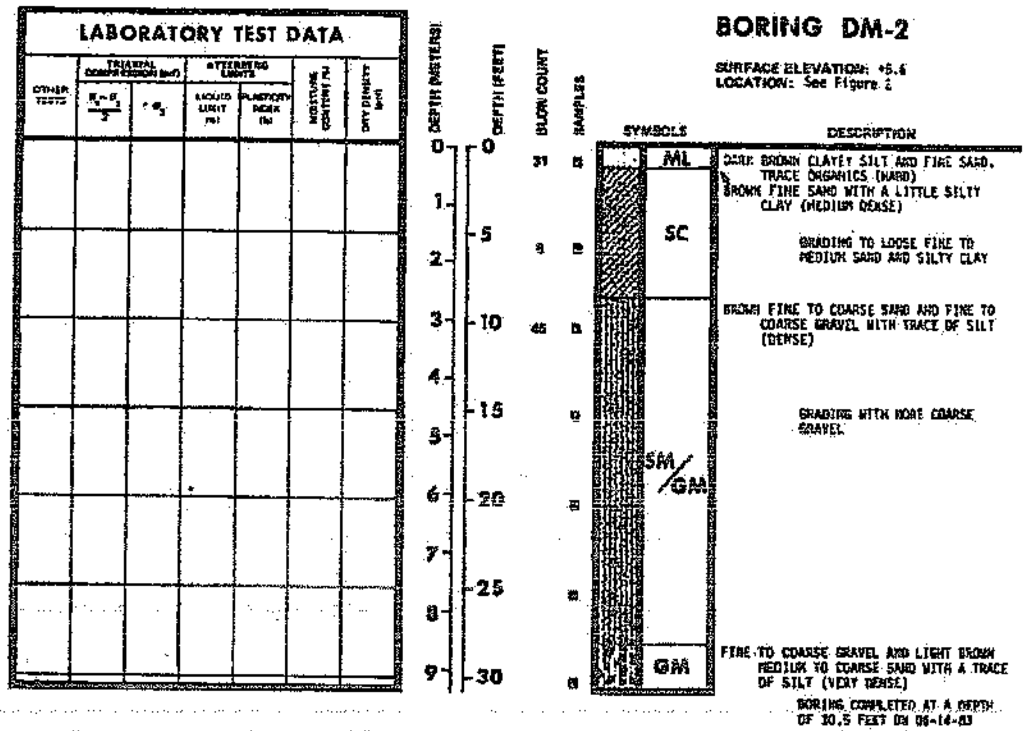


PLATE B-37

LOG OF BORINGS

Dames & Moore

BORING DM-3

SURFACE ELEVATION: +5.7
LOCATION: See Figure 2

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION (ksf) $\frac{\sigma_1-\sigma_3}{2}$	TRIAXIAL COMPRESSION (ksf) σ_3	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DEPTH (METERS)
SA/HA					28.0	95.5	23

DEPTH (FEET)	BLOW COUNT	SYMBOLS	DESCRIPTION
0			REFER TO DM-2 FOR DESCRIPTION OF SUBSURFACE CONDITIONS FROM 0 TO 28 FEET
25	35		
30	41	GM	FINE TO COARSE GRAVEL AND LIGHT BROWN MEDIUM TO COARSE SAND WITH A TRACE OF SILT (VERY DENSE)
35	140	GM	GRADING WITH SOME COBBLES
40	106	SC	WHITE TO BUFF MEDIUM TO COARSE SAND WITH SOME FINE GRAVEL AND A LITTLE SILTY CLAY (VERY DENSE) GRADING WITH OCCASIONAL WHITE CLAYEY SILT NODULES AND IRON STAINING GRADING WITH SOME SILTY CLAY AND A FEW SILTSTONE AND FINE SANDSTONE FRAGMENTS
45	31	CH	DARK GRAY TO BLACK SILTY CLAY (HARD)
50	30	CH	GRADING TO STIFF OLIVE SILTY CLAY
55	22	SC	LIGHT GRAY MEDIUM TO COARSE SAND WITH A LITTLE SILTY CLAY AND A TRACE OF FINE TO COARSE GRAVEL (MEDIUM DENSE)
60	105	SC	MOTTLED WHITE, GRAY AND GREEN FINE TO COARSE SAND AND SILTY-CLAY WITH A TRACE OF FINE GRAVEL (VERY DENSE)
65	118	SC	GRADING WITH OCCASIONAL LENSES OF BLACK SILTY CLAY
70	80	SC	LIGHT GRAY-GREEN FINE TO MEDIUM SAND WITH SOME SILTY CLAY (VERY DENSE)
75	62	SC	GRADING WITH SOME COARSE SAND
80	89	SC	GRADING WITH A TRACE OF FINE GRAVEL AND OCCASIONAL NODULES OF CLAYEY SILY GRADING TO VERY DENSE
85			

PLATE B-38

LOG OF BORINGS

Dames & Moore

BORING DM-3(cont'd)

SURFACE ELEVATION: +5.7
LOCATION: See Figure 2

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION (ksf) $\frac{\sigma_1-\sigma_3}{2}$	TRIAXIAL COMPRESSION (ksf) σ_3	ATTERBERG LIMITS LIQUID LIMIT (%)	ATTERBERG LIMITS PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DEPTH (METERS)	DEPTH (FEET)	BLOW COUNT	SAMPLES
HSD					21.2	103.0	26	85	33	
							27	90	48	
							28			
HSD					22.1	103.6	29	95	97/10"	
							30	100	72/11"	
							31			
HSD					17.7	103.7	32	105	120/8"	

SYMBOLS	DESCRIPTION
SC	GRADING WITH LESS SILTY CLAY GRADING TO DENSE
CL	OLIVE SILTY-CLAY WITH A TRACE OF FINE SAND (HARD)
	GRADING RED-BROWN MOTTLED WITH OLIVE
DR	BLUE-GRAY-GREEN DECOMPOSED WEATHERED TO FINE-COARSE SAND AND SILTY CLAY WITH SOME MICA (VERY DENSE)
	GRADING LESS DECOMPOSED WITH TRACE OF ROCK STRUCTURE

BORING COMPLETED AT A DEPTH OF 105.5 FEET ON 06-21-83

PLATE B-38 (cont'd)

LOG OF BORINGS

Dames & Moore

MW-DM5

BORING DM-5

SURFACE ELEVATION: +9.6
LOCATION: See Figure 2

LABORATORY TEST DATA						
OTHER TESTS	TRIAXIAL COMPRESSION (ksf)		ATTERBERG LIMITS		MOISTURE CONTENT (%)	DRY DENSITY (pcf)
	$\frac{\sigma_1-\sigma_3}{2}$	σ_3	LIQUID LIMIT (%)	PLASTICITY INDEX (%)		

DEPTH (METERS)	DEPTH (FEET)	BLOW COUNT	SYMBOLS	DESCRIPTION
0	0	45	SM	REDDISH-BROWN FINE SAND WITH LITTLE SILT, TRACE ORGANICS AND GRAVEL (DENSE)
2	5	10	SM	GRADING TO LOOSE TO MEDIUM DENSE AND WITHOUT GRAVEL
3	10	12	SM	GRADING WITH SOME CLAYEY SILT
4–5	15	82	SM/GM	LIGHT BROWN FINE TO COARSE SAND AND FINE TO COARSE GRAVEL WITH A TRACE OF SILT (VERY DENSE)
6	20		SM/GM	GRADING TO DENSE
8	25		SM/GM	
9	30			REFER TO DM-6 FOR DESCRIPTION OF SOIL LAYERS BELOW 30 FEET
11	35			
12	40	50/0"		LAYER CHANGE NOTED (CLAY CUTTINGS IN WASH)
14	45		SM	POSSIBLE LAYER CHANGE NOTED
15	50	75/3"	SM	WHITE TO LIGHT GRAY MEDIUM TO COARSE SAND WITH A LITTLE CLAYEY SILT (VERY DENSE)

BORING TERMINATED AT A DEPTH OF 50.5 FEET ON 06-15-83

PLATE B-39

LOG OF BORINGS

Dames & Moore

MW-DM6

LABORATORY TEST DATA

Depth (feet)	Other Tests	Triaxial Compression (ksf): $\frac{\sigma_1 - \sigma_3}{2}$	σ_3	Atterberg Limits: Liquid Limit (%)	Plasticity Index (%)	Moisture Content (%)	Dry Density (pcf)
20	SA/HA H					11.6	
55	PT SA/HA RGD					12.5	123.0

BORING DM-6

SURFACE ELEVATION: +8.8
LOCATION: See Figure 2

Depth (feet)	Blow Count	Symbol	Description
0	21	SM	REDDISH-BROWN FINE SAND WITH LITTLE CLAYEY SILT, TRACE ORGANICS AND GRAVEL (MEDIUM DENSE)
5	8	SM	GRADING LOOSE
10	6	SM	
15	80	SM/GM	LIGHT BROWN FINE TO COARSE SAND AND FINE TO COARSE GRAVEL WITH A TRACE OF SILT (VERY DENSE)
20	43	SM	MOTTLED ORANGE-BROWN AND WHITE MEDIUM TO COARSE SAND WITH SOME SILTY-CLAY AND FINE TO COARSE GRAVEL, OCCASIONAL CLAY LENSES AND SAND POCKETS, IRON STAINING (DENSE)
25	150/9"	SM	GRADING MOSTLY WHITE AND VERY DENSE WITH SOME SHALE FRAGMENTS
30	104	SP	TAN MEDIUM TO COARSE SAND WITH A TRACE OF SILT AND FINE TO COARSE GRAVEL (VERY DENSE)
		CL	POSSIBLE CLAY LAYER FROM 33 TO 34 FEET
35	123/10"	SM	ORANGE-BROWN FINE SAND WITH LITTLE CLAYEY SILT (DRY)
		CH	BLACK TO DARK GRAY AND OLIVE SILTY CLAY WITH TRACE OF ORGANICS (HARD)
		SM	ORANGISH-BROWN MEDIUM TO COARSE SAND WITH A LITTLE CLAYEY SILT AND TRACE OF FINE GRAVEL (VERY DENSE)
40	[illegible]	ML	GRAY-GREEN CLAYEY SILT (HARD)
45	143/10"	SM	LIGHT GRAY FINE TO COARSE SAND WITH LITTLE CLAYEY SILT (VERY DENSE)
50	118 110/2"	SM	GRADING WITH TRACE SILT AND FINE GRAVEL
55	35	SM	GRADING WITH SOME FINE TO COARSE GRAVEL AND LITTLE CLAYEY-SILT, GRADING TO DENSE
60	91	SM	GRADING WITH OCCASIONAL POCKETS OF WHITE CLAYEY SILT
65	82	SM	GRADING WITH A LITTLE CLAYEY SILT AND FINE GRAVEL
70	70	SM	GRADING WITH TRACE COARSE GRAVEL AND LENSE OF LIGHT GREEN-GRAY CLAYEY SILT
75	10	SP/SM	BUFF MEDIUM TO COARSE SAND WITH A TRACE OF SILT (MEDIUM DENSE)
80	127/3"	SM	LIGHT GREEN MEDIUM TO COARSE SAND WITH A LITTLE SILT AND FINE GRAVEL AND POCKETS OF OLIVE SILTY CLAY (VERY DENSE)

PLATE B-40

LOG OF BORINGS

Dames & Moore

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION (ksf) $\frac{\sigma_1-\sigma_3}{2}$	$-\sigma_3$	ATTERBERG LIMITS: LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)
PF SA/HA					22.8	104.2
PF ATT R&D			43	14	27.9	99.4
CEC M					24.1	

DEPTH (METERS): 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45

DEPTH (FEET): 85, 90, 95, 100, 105, 110, 115, 120, 125, 130, 135, 140, 145, 150

BORING DM-6(cont'd)

SURFACE ELEVATION: +8.6
LOCATION: See Figure 2

DEPTH (FEET)	BLOW COUNT	SYMBOLS	DESCRIPTION
85	47	SM	GRADING WITH LESS CLAYEY SILT AND WITHOUT GRAVEL GRADING TO DENSE
90	123/11"	SM	GRADING WITH SOME SILTY CLAY AND FINE GRAVEL GRADING VERY DENSE
95	65	GP	FINE TO COARSE GRAVEL WITH SOME SAND AND TRACE SILT (VERY DENSE)
100	67	CL	MOTTLED OLIVE AND BROWN AND ORANGE SILT CLAY (HARD)
105	35	CL	
110	62	CL	GRADING TO BROWN
115	64	CL	GRADING TO MOTTLED BLUE-GRAY AND REDDISH-BROWN
120	65	CL	GRADING TO BROWN
125	120/11"	CL	GRADING TO MOTTLED OLIVE AND BLUE-GRAY-BROWN SILTY CLAY
130	125/11"	CL	GRADING RED-BROWN
135	75/6"	DR	DARK GREENISH-RED-BROWN DECOMPOSED BED-ROCK (HARD) WEATHERED PRIMARILY TO MICACEOUS CLAYEY SILT WITH TRACE OF FINE SAND
140	60/6"	DR	GRADING TO DARK GREEN-BROWN WEATHERED TO SILTY-CLAY
145	60/6"	DR	GRADING GREEN MOTTLED WITH REDDISH-BROWN AND TRACE OF PARENT BEDROCK STRUCTURE

BORING COMPLETED AT DEPTH OF 150.0 FEET ON 06-18-83

PLATE B-40 (cont'd)

LOG OF BORINGS

Dames & Moore

MW-DM7

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION (ksf): $\frac{\sigma_1 - \sigma_3}{2}$	σ_3	ATTERBERG LIMITS: LIQUID LIMIT (%)	PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DEPTH (METERS)	DEPTH (FEET)	BLOW COUNT
PT ATT HGD CEC pH			49	14	27.6	95.2	12	40	35
							15	50	118/9"

BORING DM-7

SURFACE ELEVATION: +9.2
LOCATION: See Figure 2

SYMBOLS	DESCRIPTION
	REFER TO DM-6 FOR DESCRIPTION OF SUBSURFACE CONDITIONS FROM 0 TO 35 FEET
	ORANGE-BROWN MEDIUM TO COARSE SAND WITH A LITTLE CLAYEY SILT AND TRACE FINE GRAVEL (VERY DENSE)
ML	DARK GRAY-GREEN CLAYEY-SILT (HARD)
SM	LIGHT GRAY MEDIUM TO COARSE SAND WITH A LITTLE CLAYEY-SILT

BORING COMPLETED AT A DEPTH OF 55.0 FEET ON 06-23-92

PLATE B-41

LOG OF BORINGS

Dames & Moore

BORING DM-8/8A

SURFACE ELEVATION: +22
LOCATION: See Figure 2

LABORATORY TEST DATA

Depth (feet)	Other Tests	Triaxial Compression (ksf) $\frac{\sigma_1-\sigma_3}{2}$	σ_3	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plasticity Index (%)	Moisture Content (%)	Dry Density (pcf)
15	SA/HA M&D					76.3	111.4
25	ATT M&D CEC pH			45	12	47.0	77.4
55	M&D					29.7	91.4
75	M&D					34.2	89.2

Depth (feet)	Blow Count
5	10
10	7
15	13
20	3
25	11
30	3
35	42
40	60
45	[illegible]
50	[illegible]
55	13
60	77/10"
65	41
75	45

Depth scales: 0–25 meters; 0–85 feet.

SYMBOLS / DESCRIPTION

SM/ML — REDDISH-BROWN FINE SAND AND CLAYEY SILT (MEDIUM DENSE, STIFF)

GRADING WITH OCCASIONAL LENSES OF MEDIUM SAND

SM — REDDISH-BROWN FINE TO COARSE SAND WITH SOME CLAYEY SILT (LOOSE)

GRADING MEDIUM DENSE WITH A TRACE OF FINE GRAVEL

CL/ML — OLIVE CLAYEY SILT AND SILTY CLAY WITH SOME FINE SAND AND LITTLE ORGANICS (SOFT)

GRADING TO BROWN-GRAY AND MEDIUM STIFF WITH MORE CLAY

GRADING TO SOFT WITH TRACE OF ORGANICS AND OCCASIONAL LENSES OF FINE SAND

GRADING HARD WITH A LITTLE FINE TO COARSE GRAVEL

GRADING TO BROWN WITH SOME FINE TO COARSE GRAVEL

GC — REFUSAL AT 42': UNABLE TO BORE BECAUSE OF GRAVEL IN HOLE: RELOCATE BORING 7 FEET TO WEST

CL/ML — OLIVE-GRAY SILTY CLAY AND CLAYEY SILT WITH A LITTLE MICA (HARD)

GRADING MORE SILTY WITH MORE MICA

GRADING MORE CLAYEY

SM/ML — LIGHT GREEN MICACEOUS FINE SAND AND SILT WITH OCCASIONAL LAYERS OF BLACK VARVED SILTY CLAY (VERY DENSE, HARD)

PLATE B-42

LOG OF BORINGS

Dames & Moore

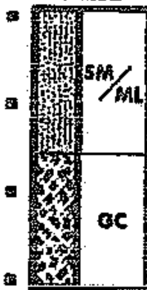
BORING DM-8/8A(cont'd)

SURFACE ELEVATION: +22
LOCATION: See Figure 2

LABORATORY TEST DATA						
OTHER TESTS	TRIAXIAL COMPRESSION (ksf)		ATTERBERG LIMITS		MOISTURE CONTENT (%)	DRY DENSITY (pcf)
	$\frac{\sigma_1-\sigma_3}{2}$	σ_3	LIQUID LIMIT (%)	PLASTICITY INDEX (%)		

DEPTH (METERS)	DEPTH (FEET)	BLOW COUNT	SAMPLES
26	85	50/5"	■
27			
	90	50/2"	■
28			
29	95	50/3"	■
30			
	100	50/4"	■

SYMBOLS / DESCRIPTION



FINE TO COARSE GRAVEL AND SANDY CLAY (VERY DENSE)

GRADING WITH MORE COARSE SAND AND SOME SILTY-CLAY.

BORING TERMINATED AT A DEPTH OF 42.0 FEET ON 05-17-83

BORING COMPLETED AT A DEPTH OF 100.5 FEET ON 05-24-83

PLATE B-42 (cont.d)

LOG OF BORINGS

Dames & Moore

BORING DM-9

SURFACE ELEVATION: +19.5
LOCATION: See Figure 2

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION $\frac{\sigma_1-\sigma_3}{2}$	q_u	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
PF SA/HA MSD					9.6	99.9
MSD pH					43.6	75.3
MSD CEC pH					30.5	94.6
PF SA/HA W					22.0	

DEPTH (FEET)	BLOW COUNT
~2	11
~6	23
~11	9
~16	3
~21	3
~26	87
~31	40
~36	100/8"
~41	(sample, no count)
~51	75
~56	77
~61	60
~66	70
~71	40
~76	45
~81	72

SYMBOLS	DESCRIPTION
SP/SM	LIGHT BROWN FINE TO MEDIUM SAND WITH TRACE OF SILT (MEDIUM DENSE) GRADING WITH SOME COARSE SAND GRADING TO LOOSE
ML	BROWN CLAYEY SILT WITH TRACE OF FINE SAND (SOFT)
SM	BROWN FINE SAND WITH SOME CLAYEY SILT (VERY LOOSE)
CH	OLIVE-GRAY SILTY-CLAY WITH A TRACE OF GRAVEL (HARD)
SM	LIGHT GREENISH-GRAY FINE TO MEDIUM SAND WITH LITTLE CLAYEY SILT, AND A TRACE OF FINE TO COARSE GRAVEL (VERY DENSE) GRADING WITH OCCASIONAL SILTY CLAY POCKETS AND LITTLE GRAVEL (NO SAMPLING ATTEMPT POSSIBLE DUE TO COARSE GRAVEL) GRADING WITH SOME SILTY CLAY AND COARSE SAND
SP/SM	LIGHT GRAY FINE TO COARSE SAND WITH A TRACE OF SILT (VERY DENSE) GRADING WITH A LITTLE CLAYEY SILT
SC	GRAY FINE TO COARSE SAND WITH A LITTLE SILTY CLAY AND TRACE FINE GRAVEL (DENSE)
CH	MOTTLED OLIVE AND REDDISH-BROWN SILTY-CLAY (HARD)

DEPTH (METERS): 0–25; DEPTH (FEET): 0–85

PLATE B-43

LOG OF BORINGS

BORING DM-9(cont'd)

SURFACE ELEVATION: +19.5
LOCATION: See Figure 2

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION (ksf) $\frac{\sigma_1-\sigma_3}{2}$	TRIAXIAL COMPRESSION (ksf) σ_3	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)
ATT NAD			73	43	21.6	107.9

DEPTH (METERS)	DEPTH (FEET)	BLOW COUNT	SYMBOLS	DESCRIPTION
26	85	[illegible]	CH	GRADING MORE REDDISH-BROWN
27–28	90	78	CH	GRADING MOTTLED WITH OLIVE
29	95	50/5"	CH	GRADING WITH A LITTLE FINE SAND
30	100	[illegible]		BORING COMPLETED AT A DEPTH OF 101.0 FEET ON [illegible]

PLATE B-43 (cont'd)

LOG OF BORINGS

Dames & Moore

BORING DM-10

SURFACE ELEVATION: +14
LOCATION: See Figure 2

LABORATORY TEST DATA

Depth (feet)	Other Tests	Triaxial Compression: $\frac{\sigma_1 - \sigma_3}{2}$	Triaxial Compression: σ_3	Atterberg Limits: Liquid Limit (%)	Atterberg Limits: Plasticity Index (%)	Moisture Content (%)	Dry Density (pcf)
0	%FINES MAD					10.5	105.4
20	CEC %FINES U					20.3	
30	MAD CEC					15.2	118.1

LOG

Depth (feet)	Blow Count	Symbol	Description
0	12	SM	REDDISH-BROWN FINE SAND AND CLAYEY SILT (MEDIUM DENSE)
5	7	SM	GRADING LOOSE WITH TRACE OF GRAVEL
10	6	SM	GRADING WITH MORE SILTY CLAY
15	100	SP/SC	ORANGE-BROWN AND WHITE WITH FINE TO COARSE SAND WITH LITTLE SILTY-CLAY AND TRACE COARSE GRAVEL (VERY DENSE)
20	62	SC	LIGHT GRAY FINE TO MEDIUM SAND WITH SOME SILTY CLAY (VERY DENSE)
25	50	SC	GRADING WITH OCCASIONAL REDDISH-BROWN MICACEOUS SILTY CLAY LENSES AND LENSES OF BLACK SILTY CLAY
30	67	CL	GREEN-GRAY DECOMPOSED GRANITIC ROCK WEATHERED TO PREDOMINANTLY MICACEOUS CLAYEY SILT AND SILTY CLAY WITH TRACE OF FINE SAND (SOFT)
35	77/9"	CL	GRADING MOTTLED GREEN, REDDISH-BROWN, AND WHITE
40	70/9"	CL	GRADING MORE CLAYEY
45	[illegible]	CL	GRADING REDDISH-BROWN WITH OCCASIONAL GREEN POCKETS
50	[illegible]	CL	
55	[illegible]	CL	
60	79	CL	GRADING WITH MORE GREEN AND TRACE QUARTZ FRAGMENTS
65	81/10"	CL	
75	70/9"	CL	

Depth scale: 0–25 meters; 0–85 feet.

PLATE B-44

LOG OF BORINGS

Dames & Moore

BORING DM-10(cont'd)

SURFACE ELEVATION: +14
LOCATION: See Figure 2

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION (psf) $\frac{\sigma_1-\sigma_3}{2}$	σ_3	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DEPTH (METERS)	DEPTH (FEET)	BLOW COUNT	SAMPLES	SYMBOLS	DESCRIPTION
							26	85	84/10"	☒	CL	
							27					
								90				
							28					
							29	95	87/8"	☒		

BORING COMPLETED AT A DEPTH OF 95.8 FEET ON 06-22-83

PLATE B-44 (cont'd)

LOG OF BORINGS

Dames & Moore

MW-DM11

LABORATORY TEST DATA

OTHER TESTS	TRIAXIAL COMPRESSION (ksf) $\frac{\sigma_1-\sigma_2}{2}$	TRIAXIAL COMPRESSION (ksf) σ_2	ATTERBERG LIMITS: LIQUID LIMIT (%)	ATTERBERG LIMITS: PLASTICITY INDEX (%)	MOISTURE CONTENT (%)	DRY DENSITY (pcf)	DEPTH (METERS)	DEPTH (FEET)
pH K					47.9		3	10

BORING DM-11

SURFACE ELEVATION: +3?
LOCATION: See PLATE B-33

DEPTH (FEET)	BLOW COUNT	SAMPLES	SYMBOLS	DESCRIPTION
0–10		■	SM	BROWN FINE TO MEDIUM SAND WITH A LITTLE SILT, GRAVEL AND ORGANICS (MEDIUM DENSE)
	20	■	SM	GRADING GRAY-BROWN WITH SOME SILT AND TRACE OF GRAVEL GRADING WITH OCCASIONAL BROWN CLAYEY SILT NODULES (MEDIUM DENSE)
			SP	BROWN-GRAY FINE TO MEDIUM SAND WITH TRACE OF SILT (LOOSE)
	6	■	ML/OL	DARK-BLACK-GREEN SILT WITH SOME ORGANICS (SOFT TO MEDIUM STIFF)
	12	■	ML	GRAY-GREEN MOTTLED WITH BLUE-GRAY CLAYEY SILT WITH SOME FINE SAND AND TRACE OF QUARTZ GRAVEL (STIFF)
			SM/GM	FINE TO COARSE SAND AND FINE TO COARSE GRAVEL WITH LITTLE SILT (MEDIUM DENSE)
	75	■	GM/GP	FINE TO COARSE GRAVEL

BORING COMPLETED AT A DEPTH OF 21 FEET ON 6-21-83

PLATE B-45

LOG OF BORINGS

Dames & Moore