Attachment IV
Closure Plan

Solid Waste Permit #498
Bristol Integrated Solid Waste Management Facility
2655 Valley Drive
Bristol, VA 24201
(276) 645-7233

SCS ENGINEERS

02218208.17 | January 31, 2023

15521 Midlothian Turnpike Suite 305
Midlothian, VA 23113
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1.0 CLOSURE PURPOSE

The following Closure Plan for the City of Bristol Integrated Solid Waste Management Facility (ISWMF), Solid Waste Permit 498, describes those activities necessary to close the sanitary landfill in accordance with *Virginia Solid Waste Management Regulations* 9VAC20-81-160. The permit modification drawings, appendices, tables and figures should be considered an integral part of this Closure Plan. Closure drawings are provided as Attachment IV to the Major Permit Modification submittal.

The revised Closure Plan is being submitted as part of a major permit modification as identified under 9VAC20-81-600, Table 5.2, relative to revisions to the design of the final closure cover. The existing closure plan for Permit 498 is dated December 1990 and has not been updated since its original submittal and approval by VDEQ. As discussed with VDEQ, the updated Closure Plan will address:

- Revised Final grades
- Cap section design and configuration
- Modification to the stormwater management system to address new grades;
- Update to post closure care plan; and
- Other general modifications to meet the requirements of Submission Instruction 6.

1.1 SITE LOCATION

The existing Permit 498 municipal sanitary landfill is located within the incorporated limits of the City at 2655 Valley Road, approximately two miles east of downtown Bristol, Virginia. The City of Bristol Integrated Solid Waste Management Facility (ISWMF), which includes Permits 221, 498, and 588, is owned and operated by the City of Bristol, Virginia. The facility encompasses approximately 183 acres. The limits of Permit 498 encompass 18.9 acres. See plat included in Appendix B.

1.2 BACKGROUND INFORMATION

On August 29, 2004, VDEQ approved the mining of materials from the Permit 498 facility. Waste and fill material from the Permit 498 facility was mined for disposal in and cover for the Permit 588 facility. Landfill operations were generally limited to mining activities. Waste and soil were removed from the Permit 498 area and hauled to the active Permit 588 area for disposal or use as daily/intermediate cover (as appropriate). Limited quantities of vegetative waste material and inert wastes were placed in the Permit 498 disposal unit.

Landing mining activities have ceased, and a temporary intermediate cover has been installed over the majority of the existing grade. The facility will be closed in accordance with the amended Closure Plan.

The limits of Permit 498 based on the plat provided by the City are 18.9 acres. Under current conditions this would be considered the “facility boundary.” Actual waste limits and hence the closure cap are estimated at 12.4 acres. The original design of the facility completed by Thompson and Litton in the 1990s required that a significant clay berm be placed around the toe of the disposal area and periodically on the outer edge with subsequent phases. In discussions with VDEQ, it was determined that the outer slope of this berm would not require formal capping as it is stabilized at this time. During closure, limited if any disturbance to this berm is anticipated beyond tie-in of the cap materials. Because of the very limited disturbance to this berm and considering the

existing stabilized vegetative cover, no stability issues are anticipated, and no additional engineering needed.

2.0 CLOSURE TIMEFRAMES

As outlined in Section 1, waste is no longer being accepted at the landfill and mining activities has ceased. Timeframe estimates for closure construction activities are provided in section 6.0.

At the completion of the final cap construction, VDEQ will be notified and a professional engineer representing the City will provide the VDEQ with the required closure documentation and certification. VDEQ will review the information and make a site inspection after which, the City will receive final certification of closure and the 30-year post-closure care period will begin.

3.0 CLOSURE OF SURFACE IMPOUNDMENTS

The existing stormwater retention pond will be maintained throughout the post-closure period. Leachate is collected in a 75,000-gallon sewage pump station and overflow tank.

3.1 REMOVAL

Leachate from this pump station is pumped to discharge into the ISWMF main interceptor line where it is combined with leachate from Permit 588 and then flows by gravity to the BVU sewer system. The City has a discharge limit of 200,000 gallons per day of leachate to the BVU system. The pump station and forcemain will be maintained throughout the post-closure care period. The City indicates that this system is in good working condition. Liquid wastes will be pumped and drained to the BVU sewer system.

3.2 STABILIZATION

The existing pump station is not anticipated to require stabilization.

3.3 DECONTAMINATION

At the end of the post closure care period, the pump station will be evaluated to determine its continued need and closure requirements (if any). Prior to removal, the pump station will be flushed with clean water to remove any remaining leachate or residue. Water from this process will be pumped and drained to the BVU sewer system. Once the structure has been effectively flushed to remove wastes and residue, the structure will be excavated and disposed of at an active permitted waste disposal facility.

Underlying soils will be tested using the same parameters as those used for detection monitoring in groundwater wells. If those soils are determined to be contaminated, they will be excavated to a depth at which contamination is no longer detected. Soils will be disposed of at an active permitted waste disposal facility. The resulting void will be backfilled using clean fill.

3.4 FINAL COVER

Once decontamination is complete, at a minimum, an 18-inch erosion control layer and 6-inch vegetative support layer will be placed over the area previously occupied by the pump station. Seeding shall be placed according to the seeding schedule enumerated in this report. Proper erosion and sediment control measures shall be in force at all stages of this closure process. Considering the pump station and contaminated soils will be removed, installation of infiltration layer will not be necessary for the pump station.

4.0 CLOSURE OF LANDFILL UNITS

The Attachment III – Final Closure Drawings illustrate the proposed closure grades and proposed final closure activities. These activities are further described below. Responsibilities are assigned as follows:

City of Bristol

The City will be responsible for temporary/interim stormwater management, daily/intermediate cover, preparation of the intermediate grades and maintenance of the site as outlined in the Operating Plan and the Closure Plan. The City will provide surveying for design. The City will use a third-party engineer to develop construction documents (including erosion and sediment control and stormwater management plans) and will review the documents for conformity with local and State regulations. The City will issue the land disturbance permit to the Contractor and regularly inspect the site during construction.

Contractor

The City will develop construction documents based on the intermediate grades and procure a qualified contractor to complete the work. The Contractor's work will include but not be limited to, re-grading to the intermediate grade, development of on-site borrow area, preparation of cap bedding layer, installation of cap materials, installation of gas collection system, construction of stormwater BMPs, and final stabilization of the site. The Contractor will be the responsible land disturber on the site and will be required to adhere to the final erosion and sediment control/stormwater management plans approved by the City.

Engineer

A third-party engineer will develop the construction documents as outlined above, assist with bidding, and provide Construction Quality Assurance services in conformance with the permit. The Engineer will certify construction as to conformance with the permit and regulations.

4.1 FINAL COVER DESIGN

Final grading of the site will be in accordance with the closure drawings. The landfill will be brought to the approximate final grades using waste and soil fill.

Runoff over the final closure surface will be controlled using diversion berms, down chutes, and conveyance channels as designed. Final cover runoff will generally drain to the bottom of the slope and into a stormwater conveyance system. Slope drains will convey stormwater into the existing

storm drain system. Positive drainage will be maintained to reduce pooling of water on landfill surface.

The final cover system (cap) will be installed over the extents of the waste footprint (i.e., disposal unit boundary) shown on the closure drawings. The cover will include the following from bottom to top:

4.1.1 Infiltration Layer

As outlined in Guidance Memo No. 2014-01 – Clarification of Required Final Cover Designs and Acceptable Alternate Designs, the proposed final cover design does not include a separate infiltration layer. The design does include a bedding layer. The top 6 inches of the 12- inch daily/intermediate cover layer will provide a protective cushion and stable foundation for the hydraulic barrier.

4.1.2 Barrier Layer

The closure cap barrier layer will consist of a 40-mil thick textured LLDPE FML. The material will be anchored in trenches as shown on the drawings. Adjacent panels of the material will be welded together to form a continuous cover over the support layer. This layer will act as a hydraulic barrier layer reducing infiltration of rainwater through the cap and into the waste mass.

4.1.3 Erosion Control/Protective Cover Layer

4.1.3.1 Geocomposite Drainage Layer

A geotextile/geonet/geotextile composite material will be placed on top of the geomembrane to protect the cap from punctures, to relieve tension stresses from the cap, and to provide a drainage medium for the cap.

4.1.3.2 Soil Cushion

An 18-inch thick soil cushion will protect the soil cap from mechanical damage from vehicles on the cover, from burrowing animals, from taproots, and from freeze-thaw stresses. An erosion layer of soils suitable for the establishment of a vegetative cover will be placed atop the finished geocomposite drainage layer. This layer will be placed in a single lift of 18” minimum thickness.

4.1.3.3 Erosion Calculations

Calculations are included in Appendix D using the Universal Soil Loss Equation that shows the design slopes will not cause significant cover soil erosion. These calculations show with control measures and establishment of a grass cover, the calculated soil loss is less than 2 tons/acre/year.

4.1.3.4 Vegetative Support Layer

Six inches of topsoil or amended soil will be placed and seeded with shallow-rooted grass.

The completed erosion/vegetative support layer shall be a minimum of 24” in thickness and graded to a minimum slope of 5% on the top of the cap and a maximum 33% grade on the side slopes to protect the drainage layer and FML, promote positive drainage, reduce infiltration, and facilitate maintenance.

Seeding will be in accordance with the Specifications and as determined by the timing of construction. Timing on seeding is critical for stabilization. If permanent seeding cannot be placed immediately then temporary seeding shall be placed. Matting will be used with temporary seeding also. The contractor will be held to rigorous standards for stabilization.

Soils shall be tested for need of both lime and fertilizer. Recommended application rates per acre will be placed prior to seeding and mulching.

The temporary seeding is to be applied within 7 days of placement of top soil, if additional grading will occur more than 30 days after topsoil has been placed.

4.1.4 Final Slopes

4.1.4.1 Description

The side slopes of the closed landfill will not generally exceed 33 percent (3:1). Localized areas exceeding a 33 percent slope such as the road tie-ins will receive further erosion control measures as necessary to reduce erosion. The minimum top slope is to be five percent after construction. A minimum top slope of two percent will be maintained during the post-closure period.

4.1.4.2 Stability

The final slopes have been determined to be stable for the design conditions. See calculations in Appendix E.

4.1.4.3 Maintenance

The cover system will be graded and seeded for low maintenance. The slopes should require infrequent repairs once the vegetative cover is established. Competent stands of vegetation, along with functional run-on and run-off control structures, will minimize erosion and sediment problems.

Maintenance efforts will include periodic mowing, liming and fertilizing, and reseeding. Mowing will initially be conducted in accordance with good management practices to allow the establishment of vegetation. The landfill cap will not be mowed for the first year or two to allow time for the vegetation to establish. After the establishment period, mowing will occur on an as-needed basis to allow for inspection of the cap and to deter woody vegetation from becoming established. Reseeding, liming and fertilizing will occur on an as-needed basis to minimize bare areas or to re-establish vegetation after repairs.

4.2 RUN-OFF CONTROLS

4.2.1 Erosion and Sediment Control

After final grades have been reached and the area capped and seeded, mulching or erosion control matting will be placed on the disposal unit's slope faces. Calculations (using the Universal Soil Loss Equation) showing that the cap design adequately mitigates erosion are provided in Appendix D. These calculations show that if the landfill were left bare, with no vegetation or other erosion control measures, the total annual soil loss would be 223 tons per acre per year. With control measures and grass cover, the calculated soil loss decreases to less than 0.7 tons per acre per year.

Erosion control matting or other erosion control measures may be used on the slopes after final grades have been established, if necessary. Remnants of temporary erosion control measures such as silt fences shall be removed when the site has stabilized.

Erosion control of the site is designed in accordance with the *Virginia Erosion and Sediment Control Handbook*, latest edition.

Erosion control measures will be inspected routinely as required by the erosion and sediment control plan throughout the construction and stabilization periods. See Section 4.2.3 below.

4.2.2 Stormwater Management

Stormwater will sheet flow eastward across the top of the landfill and into stormwater conveyance channels on the slopes of the facility. Flow in these channels will discharge into a lined channel and slope drains that connect to the existing stormwater collection system that runs into a sediment basin. Stormwater on side slopes will flow directly into the existing stormwater collection system or to conveyance channels that flow into the existing stormwater collection system. Stormwater calculations are provided on the Closure Drawings.

Stormwater management structures and BMPs will be inspected routinely as required by the Stormwater Pollution Prevention Plan and permits throughout the construction and stabilization periods. See Section 4.2.3 below.

4.2.3 Maintenance

The following maintenance schedule is suggested for erosion and sedimentation control during closure construction and the stabilization periods. It represents a minimum level of maintenance and inspection and should be increased as necessary:

4.2.3.1 Silt Fences

Inspect immediately after each rainfall and daily during a prolonged rainfall. Make repairs as needed.

Should the fabric on a silt fence decompose or become ineffective prior to the end of the expected usable life, the fabric will be replaced promptly.

Sediment should be removed when deposits reach approximately one-half the height of the barrier or sooner. Sediment deposits remaining in place after the silt fence or filter barrier is no longer required will be dressed to conform to the existing grade, prepared and seeded.

4.2.3.2 Stormwater Channels

During initial establishment of the vegetative cover, channels should be inspected weekly and after every major storm event and repaired immediately if necessary. After grass in the surrounding areas has become established, the channel should be checked periodically to determine if the grass is remaining viable. Mow periodically.

4.2.3.3 Stormwater Basin

Clean out sediment whenever the storage volume in a sediment basin is reduced to less than 34 cubic yards per acre of runoff.

During closure construction and the stabilization periods as appropriate, the City will inspect the basin quarterly for structural or erosion problems.

4.2.3.4 Final Seeding

Once the vegetative support layer is graded, the site will be seeded. Prior to seeding, the soil will be tested for nutrient and pH levels. Fertilizer and lime will be added according to test results. The recommended seed mixtures are specified in the Closure Drawings. The City reserves the right to substitute other seed types.

If timing for permanent seeding is inappropriate, temporary seeding shall be used with mulch or matting. Trees and bushes will not be planted within the liner limits.

Maintenance of the seeded areas will be on-going throughout the post closure care period. Erosion rills, bare areas, and low areas created by settlement will be repaired as needed.

4.3 SETTLEMENT, SUBSIDENCE, AND DISPLACEMENT

4.3.1 Cover Settlement

The majority of the settlement occurring at a sanitary landfill occurs during the operational life of the facility, since the primary mechanism for settlement is waste decomposition. In addition, this landfill has been actively mined, which will reduce settlement. The settlement is anticipated to occur before closure and installation of the final cover system (cap). After capping, the relatively impermeable cap should greatly reduce infiltration, slowing the decomposition of the buried materials.

4.3.2 Effects of Settlement on Cap

LLDPE was selected for use as the cap geomembrane based on its elongation properties. Since settlement due to localized waste subsidence is the most likely type of settlement, the ability of the cap to elongate is important. Calculations on the adequacy of the geomembrane to adequately handle potential settlement and subsidence are provided in Appendix G.

When significant settlement is discovered that could compromise the final cover system or create ponding, repairs will be scheduled. Likely repairs will include the following steps:

- Removal of vegetative cover in the affected area.
- Placement of soil on the settled area to create positive drainage. A minimum top slope of five percent is recommended to allow for additional settlement. The soil used should be in accordance with the final cover system soil types noted on the permit drawings and described in the technical specifications.
- Placement of vegetative support layer.
- Seeding and mulching.

- If the area is on a long slope, diversion berms may be needed to control erosion by decreasing the length of stormwater runoff.

If the settlement causes failure of the geomembrane, additional measures will be required to repair the damage to the cover. Note that VDEQ should be notified of this situation prior to repairs. These additional measures will include the following:

- Remove the vegetative support and erosion control/protective cover layers to expose the geocomposite and geomembrane.
- Remove the geocomposite.
- Remove the geomembrane and regrade the settled area to create positive drainage.
- Place and seam new geomembrane where applicable. The geomembrane material and installation will be in conformance with the specifications and CQA Manual.
- Place new geocomposite above the geomembrane, in accordance with the specification and CQA Manual.
- Place protective cover and vegetative support soil.
- Seed and mulch

If these repairs are needed, the work will be documented in accordance with the CQA Manual for cap construction and a CQA Certification prepared and submitted to the VDEQ for the repair work.

4.3.3 Stability of Slopes

The maximum slopes of the final landfill closure will not generally exceed 33 percent. Veneer stability of the slopes was evaluated using an infinite slope method and typical friction angle data from published literature. Calculations are contained in Appendix E.

5.0 CLOSURE OF STORAGE AND/OR TREATMENT UNITS

There are no solid waste management facilities under the landfill's solid waste permit that would require a separate discussion of closure.

6.0 SCHEDULE FOR CLOSURE

Closure activities for the landfill have begun with the placement of intermediate cover over the surface of the landfill Closure activities will be completed within approximately 1 year following the beginning of closure, unless an extension is approved by the VDEQ. Initiation of certain closure activities will be a function of season and weather.

Estimated time for the closure activities are outlined in Table 1.

Table 1. Schedule for Closure

Closure Activity	Estimated Target Date or Timeframe
Issuance of Invitation to Bid for Closure Construction	1st Quarter 2023
Regrading of the landfill	2nd Quarter 2023
Installation of Final Cap	3rd Quarter 2023
Installation of Stormwater Features	4th Quarter 2023
Final Seeding	4th Quarter 2023
Final Survey and Inspection	1st Quarter 2024
Submittal of Certification Report	1st Quarter 2024
Groundwater and Gas Monitoring	30 years
Post Closure Care	30 years

7.0 CLOSURE IMPLEMENTATION

7.1 POSTING

Steps will be taken by the City of Bristol to adequately identify the facility as closed. Because this facility is included in the ISWMF, signage specific to the public is not required. Control is at the scale house. Close surveillance will be kept on the site however, to prevent illegal dumping. Additional security measures, such as fencing or signage, may be required and will be provided as necessary.

7.2 NOTIFICATION

Submittal of this Closure Plan shall serve as notice from the City to VDEQ of the intent to close.

Within 90 days after closure, the City will submit to the local land recording authority, in accordance with the *VSWMR*, a survey plat indicating the location and dimensions of the disposal area and the groundwater monitoring well and landfill gas monitoring probe locations. The survey plat will be prepared by a professional land surveyor registered by the Commonwealth of Virginia or a person qualified in accordance with Title 54 of the Code of Virginia. The survey plat shall identify by number all landfill gas monitoring wells and groundwater monitoring probes in place. The plat shall contain notations stating the owner's future obligation to restrict disturbance of the site and the landfill had been used to manage solid waste, and its use is restricted under 9VAC20-81-170A.2.c. The recommended language for the notation is:

> *This property has been used for the management and disposal of solid waste. Any future use of the site shall not disturb the integrity of the final cover, liners, or any other components of the containment systems, or the function of the monitoring system unless necessary to comply with the Virginia Solid Waste Management Regulations or approved by the Department of Environmental Quality.*

In addition, within 90 days after closure is completed, owner will complete the requirements of 9VAC 20-81-160.D.5.c to record a notation on the deed to the facility property that would notify potential purchasers of the property that the land was used to manage solid waste and that the use is restricted under 9VAC20-81-170A.2.c. The plat and deed notation will be recorded with the City of Bristol, Virginia and copies submitted to VDEQ.

Appendix B includes a compiled closure plat which will be updated as necessary and signed by a professional land surveyor prior to final recordation with the local land recording authority.

7.3 CERTIFICATION

When the closure of the landfill is completed, in accordance with the *VSWMR*, the City shall submit to VDEQ a certification signed by a professional engineer verifying that closure has been completed in accordance with the regulations. This certification shall include the results of the CQA requirements under 9VAC20-81-130.Q.1.b(6). In addition, under 9VAC20-81-160.D.5.d, the City shall submit to the VDEQ a certification signed by a professional engineer verifying that closure was completed in accordance with the regulations and approved landfill closure plan.

The following is a sample letter that should be adhered to when producing the certification letter:

> *I certify that closure has been completed in accordance with the Closure Plan dated January 31, 2023 for Permit Number 498 issued to the City of Bristol, Virginia with the exception of the following discrepancies:*
>
> *[List any discrepancies if applicable]*
>
> *In addition, a sign(s) was(were) posted on [date of posting] at the landfill entrance notifying all persons of the closing and barriers [indicate types] were installed at [location] to prevent new waste from being deposited.*
>
> *A survey plat prepared by [name and credentials of professional land surveyor or qualified person in accordance with Title 54.1 of the Code of Virginia] was submitted to the City of Bristol, Virginia clerk of the circuit court on [date]. A copy of the survey plat is attached to this certification.*
>
> *A notation was recorded on the deed to the landfill property on [date]. A copy of the revised deed is attached to this certification.*
>
> *Signature of Professional Engineer*
>
> *Date and Stamp*

The VDEQ may inspect the landfill at the time of closure to confirm that the closing is complete and adequate. VDEQ shall notify the City, in writing, if the closure is satisfactory, or outline construction or such other efforts necessary to bring the landfill into compliance with the regulations. Notification by the VDEQ that the closure is satisfactory does not relieve the City of its responsibility under post-closure care to prevent or abate problems caused by the facility.

Unless the City completes all provisions of the requirements of closure implementation in the regulations, the VDEQ will not consider the facility closed, and the beginning of the post-closure care period will be postponed until all provisions have been completed. If the VDEQ's inspection at the time of closure reveals that the facility has not been properly closed in accordance with the regulations, post-closure will begin on the date that the VDEQ acknowledges proper closure has been completed.

8.0 CLOSURE COST ESTIMATE

The closure cost estimates are included in Appendix H. Estimated quantities for final closure are indicated on the estimate. Closure costs for this report were estimated for the closure of the entire facility, based on the acreage of active landfill areas that have been constructed.

The estimate has been prepared based on the designs depicted in Attachment III – Final Closure Drawings. The closure cost estimate is provided on the VDEQ standard Landfill Cost Estimate Worksheet 1 (CEW-01).

On an annual basis, the facility will provide the mechanism for financial assurance separately from this document. Closure costs for financial assurance will be based on the cells developed at the time of the financial assurance document submission.

Appendix A

Site Life and Cell/Phase/Area Capacity Calculations

No changes to the site life or capacity are included as part of this Closure Plan. No supporting calculations are required or included in this section.

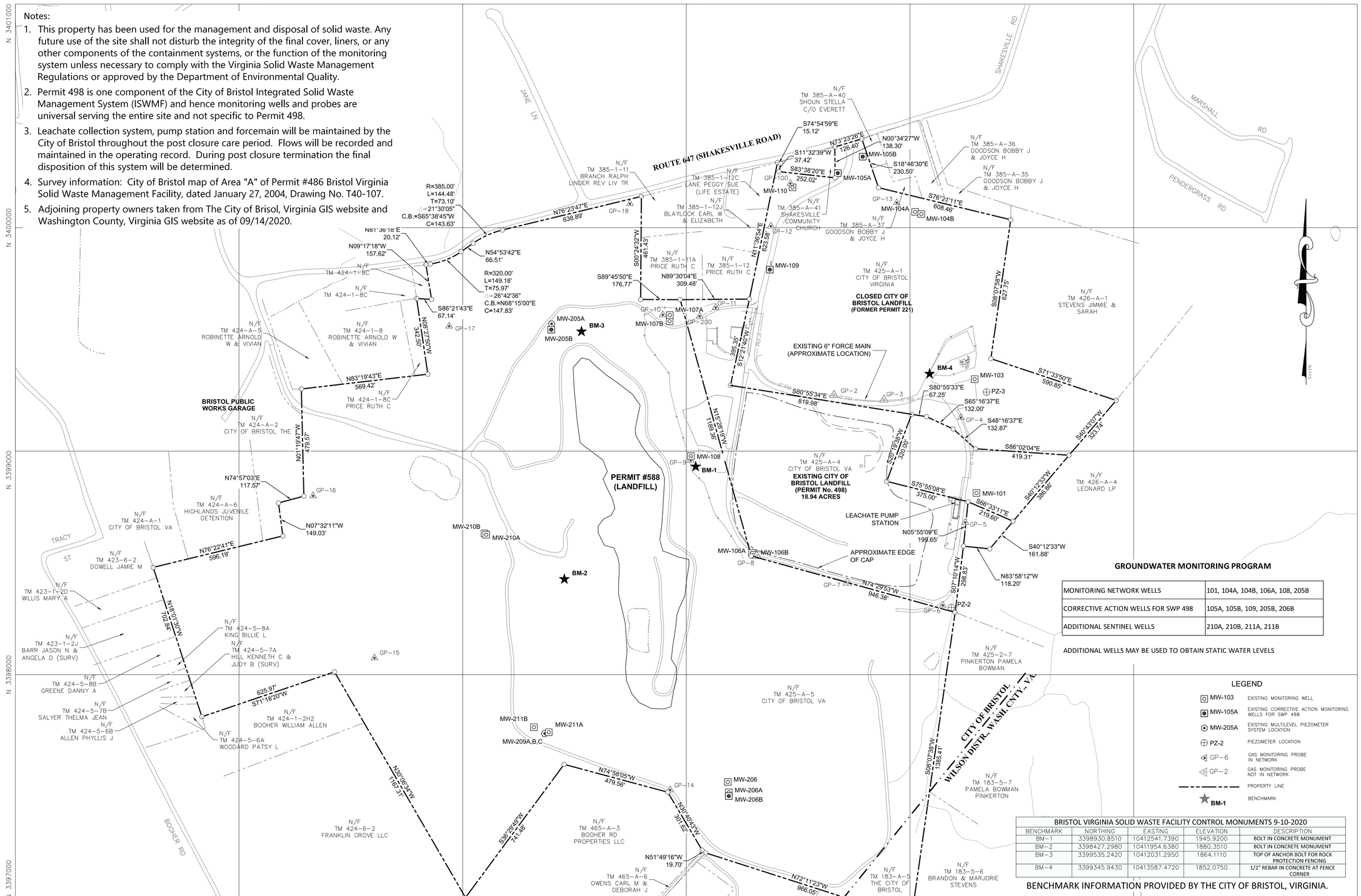
Appendix B

Closure Design Plans

Closure Design Plans are being submitted as Attachment III separately from this Closure Plan. Included in this section is the Compiled Closure Plat prepared by Draper Aden Associates.

Notes:

1. This property has been used for the management and disposal of solid waste. Any future use of the site shall not disturb the integrity of the final cover, liners, or any other components of the containment systems, or the function of the monitoring system unless necessary to comply with the Virginia Solid Waste Management Regulations or approved by the Department of Environmental Quality.
2. Permit 498 is one component of the City of Bristol Integrated Solid Waste Management System (ISWMF) and hence monitoring wells and probes are universal serving the entire site and not specific to Permit 498.
3. Leachate collection system, pump station and forcemain will be maintained by the City of Bristol throughout the post closure care period. Flows will be recorded and maintained in the operating record. During post closure termination the final disposition of this system will be determined.
4. Survey information: City of Bristol map of Area "A" of Permit #486 Bristol Virginia Solid Waste Management Facility, dated January 27, 2004, Drawing No. T40-107.
5. Adjoining property owners taken from The City of Brisol, Virginia GIS website and Washington County, Virginia GIS website as of 09/14/2020.



GROUNDWATER MONITORING PROGRAM

MONITORING NETWORK WELLS	101, 104A, 104B, 106A, 108, 205B
CORRECTIVE ACTION WELLS FOR SWP 498	105A, 105B, 109, 205B, 206B
ADDITIONAL SENTINEL WELLS	210A, 210B, 211A, 211B

ADDITIONAL WELLS MAY BE USED TO OBTAIN STATIC WATER LEVELS

LEGEND

- MW-103 — EXISTING MONITORING WELL
- MW-105A — EXISTING CORRECTIVE ACTION MONITORING WELLS FOR SWP 498
- MW-205A — EXISTING MULTILEVEL PIEZOMETER SYSTEM LOCATION
- PZ-2 — PIEZOMETER LOCATION
- GP-6 — GAS MONITORING PROBE IN NETWORK
- GP-2 — GAS MONITORING PROBE NOT IN NETWORK
- PROPERTY LINE
- BM-1 — BENCHMARK

BRISTOL VIRGINIA SOLID WASTE FACILITY CONTROL MONUMENTS 9-10-2020

BENCHMARK	NORTHING	EASTING	ELEVATION	DESCRIPTION
BM-1	3398930.8510	10412541.7390	1945.9200	BOLT IN CONCRETE MONUMENT
BM-2	3398427.2980	10411954.6380	1880.3510	BOLT IN CONCRETE MONUMENT
BM-3	3399535.2420	10412031.2950	1864.1110	TOP OF ANCHOR BOLT FOR ROCK PROTECTION FENCING
BM-4	3399345.9430	10413587.4720	1852.0750	1/2" REBAR IN CONCRETE AT FENCE CORNER

BENCHMARK INFORMATION PROVIDED BY THE CITY OF BRISTOL, VIRGINIA.

LANDFILL GAS MONITORING PROGRAM

MONITORING NETWORK PROBES FOR SWP 498	GP-4, GP-5, GP-6, GP-9, GP-11, GP-12, GP-13, GP-14, GP-15, GP-16, GP-17, GP-18, GP-100, GP-200
PROBES NOT IN MONITORING NETWORK	GP-2, GP-3, GP-7, GP-8

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COMPILED CLOSURE PLAT
CITY OF BRISTOL, VIRGINIA
PERMIT 498
BRISTOL, VIRGINIA

REVISIONS

DESIGNED BY:	
DRAWN BY:	DLD
CHECKED BY:	LPK
SCALE:	1" = 200'
DATE:	09/14/2020
PROJECT NUMBER:	B11145R-24A

1

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Appendix C

CQA Plan and Technical Specifications

The CQA Plan and Technical Specifications will be submitted under separate cover.

Appendix D

Universal Soil Loss Demonstration

On the following pages is a Universal Soil Loss Calculation prepared by Draper Aden Associates.

UNIVERSAL SOIL LOSS EQUATION

Project: Bristol SWP498 Closure
Prepared By: AST
Checked By:
Project Number: B11145R-24A
Date: May 2020

Universal Soil Loss Equation: **A = R x K x LS x C x P**

Where: A = Computed soil loss in tons/acre/year
R = Rainfall factor
K = Soil erodibility factor
LS = Slope length and gradient factor
C = Cropping management factor
P = erosion control practice factor

1. Assume Bare Slopes:

R =	150	[Table IIIA-1]
K =	0.32	[Va E & SC Handbook, App. 6A]
LS =	5.16	[Table IIIA-6]
C =	1.00	[Table IIIA-4]
P =	0.90	[Table IIIA-5]
A =	**223**	**tons/acre/year**

2. Assume Permanent Seeding - Stabilized Growth

R =	150	[Table IIIA-1]
K =	0.32	[Va E & SC Handbook, App. 6A]
LS =	5.16	[Table IIIA-6]
C =	0.003	[USDA Table 3-2]
P =	0.90	[Table IIIA-5]
A =	**0.7**	**tons/acre/year**

Notes:
1. Calculation is based on the Virginia DCR, Water Conservation Training Book.
2. USDA National Engineering Handbook Table 3-2 is used to obtain a C-Factor after final closure.
3. Slope and slope length based on longest, steepest slope within capping area.

TABLE IIIA-1

Rainfall Factors (R) for Virginia Counties and Cities

R = 125	R = 150	R = 175	R = 200	R = 225	R = 250	R = 300
Highland	Alleghany Amherst Augusta Bath Bedford Bland Botetourt Buchanan Carroll Clarke Craig Dickenson Floyd Franklin Frederick Giles Grayson Greene Lee Loudoun Montgomery Page Patrick Pulaski Roanoke Rockbridge Rockingham Russell Scott Shenandoah Smyth Tazewell Warren Washington Wise Wythe	Albemarle Appomattox Buckingham Campbell Culpeper Cumberland Fauquier Fluvanna Goochland Henry Louisa Madison Nelson Orange Pittsylvania Prince Edward Prince William Rappahannock Spotsylvania Stafford	Amelia Caroline Charlotte Fairfax Hanover King George Lunenburg Nottoway Powhatan	Chesterfield Henrico Mecklenburg New Kent Richmond (City)	Accomack Brunswick Charles City Dinwiddie Essex Gloucester Greensville Isle of Wight King and Queen Lancaster Mathews Middlesex Northampton Northumberland Prince George Richmond (Co.) Southampton Surry Westmoreland York	Chesapeake Hampton James City Newport News Suffolk Virginia Beach

APPENDIX 6A

SOILS INFORMATION

In many instances, a major soil-related problem is discovered after a site has been selected and construction is either well under way or in some cases completed. These problems often necessitate delays in construction and ultimately increase the total cost of the project. By consulting a soil survey during early in the planning process, designs can be prepared to address soil characteristics or alternate sites can be selected. Knowing the types of soil, the topography, and surface drainage patterns will prove very beneficial in planning and designing almost any type of land development project and is essential for erosion control planning.

Reference to soil maps and accompanying supportive data contained in soil surveys enables planners to determine the soil conditions in proposed construction areas. Soil surveys have proven to be of great savings in time and money, and their use has resulted in improved designs, more effective planning, and more accurate preliminary estimates of construction costs. In many cases, the survey will provide adequate information, but in other situations, it may only provide warnings or indications of soil-related problems likely to be encountered. In such cases, a more in-depth, on-site investigation may be needed.

Soil surveys are helpful in providing interpretations of the effect of soil properties on various land uses. This information can aid in determining soil suitability as a source of topsoil, fill for highway subgrade, or sand and gravel. The interpretations also show the degree of limitation of soils used for such purposes as: building foundations, highways, streets, roads, parking lots, pipelines, underground utility lines, and septic tank absorption fields.

Soil surveys describe soil properties that become important in erosion and sediment control planning for construction sites. These properties include the following:

Erodibility - The major soil consideration from an erosion and sediment control standpoint is its erodibility. An erodibility factor (K) indicates the susceptibility of different soils to the forces of erosion. A soil survey report includes the K factor for each soil found in the survey area. These K factors are used in the Universal Soil Loss Equation to determine soil loss from an area over a period of time due to splash, sheet, and rill erosion. K factors in Virginia range from about .10 (lowest erodibility) to about .50 (highest erodibility). K factors can be grouped into three general ranges:

0.23 and lower	-	low erodibility
0.23 to 0.36	-	moderate erodibility ← say .32
0.36 and up	-	high erodibility

Cohesiveness of soil particles varies with different layers of the same soil, causing varying degrees of erodibility at different depths. Therefore, depth of excavation must be considered in determining soil erodibility on a construction site.

TABLE IIIA-6

Length/Slope (LS) Factors

for both grassed and bare

Slope Length In Feet

% Slope	10	20	40	60	80	100	110	120	130	140	150	160	180	200
0.2	0.04	0.05	0.06	0.07	0.08	0.08	0.08	0.09	0.09	0.09	0.09	0.09	0.10	0.10
0.3	0.04	0.05	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.11
0.4	0.05	0.06	0.07	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.11	0.11	0.11	0.11
0.5	0.05	0.06	0.08	0.08	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.11	0.12	0.12
1.0	0.06	0.08	0.10	0.11	0.12	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15	0.16
2.0	0.10	0.12	0.15	0.17	0.19	0.20	0.21	0.21	0.22	0.22	0.23	0.23	0.24	0.25
3.0	0.14	0.18	0.22	0.25	0.27	0.29	0.30	0.30	0.31	0.32	0.32	0.33	0.34	0.35
4.0	0.16	0.21	0.28	0.33	0.37	0.40	0.42	0.43	0.44	0.46	0.47	0.48	0.51	0.53
5.0	0.17	0.24	0.34	0.41	0.48	0.54	0.56	0.59	0.61	0.63	0.66	0.68	0.72	0.76
6.0	0.21	0.30	0.43	0.52	0.60	0.67	0.71	0.74	0.77	0.80	0.82	0.85	0.90	0.95
8.0	0.31	0.44	0.63	0.77	0.89	0.99	1.04	1.09	1.13	1.17	1.21	1.25	1.33	1.40
10.0	0.43	0.61	0.87	1.06	1.23	1.37	1.44	1.50	1.56	1.62	1.68	1.73	1.84	1.94
12.0	0.57	0.81	1.14	1.40	1.61	1.80	1.89	1.98	2.06	2.14	2.21	2.28	2.42	2.55
14.0	0.73	1.03	1.45	1.78	2.05	2.29	2.41	2.51	2.62	2.72	2.81	2.90	3.08	3.25
16.0	0.90	1.27	1.80	2.20	2.54	2.84	2.98	3.11	3.24	3.36	3.48	3.59	3.81	4.01
18.0	1.09	1.54	2.17	2.66	3.07	3.43	3.60	3.76	3.92	4.06	4.21	4.34	4.61	4.86
20.0	1.29	1.82	2.58	3.16	3.65	4.08	4.28	4.47	4.65	4.83	5.00	5.16	5.47	5.77
25.0	1.86	2.63	3.73	4.56	5.27	5.89	6.18	6.45	6.72	6.97	7.22	7.45	7.90	8.33
30.0	2.52	3.56	5.03	6.16	7.11	7.95	8.34	8.71	9.07	9.41	9.74	10.06	10.67	11.25
40.0	4.00	5.66	8.00	9.80	11.32	12.65	13.27	13.86	14.43	14.97	15.50	16.01	16.98	17.30
50.0	5.64	7.97	11.27	13.81	15.94	17.82	18.69	19.53	20.32	21.09	21.83	22.55	23.91	25.21
60.0	7.32	10.35	14.64	17.93	20.71	23.15	24.28	25.36	26.40	27.39	28.36	29.29	31.06	32.74

Slope Length In Feet

% Slope	300	400	500	600	700	800	900	1000	1100	1200	1300	1500	1700	2000
0.2	0.11	0.12	0.13	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.19	0.20
0.3	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.18	0.18	0.18	0.19	0.20	0.21	0.22
0.4	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.20	0.21	0.22	0.23
0.5	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.23	0.24
1.0	0.18	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.27	0.28	0.29	0.30	0.32
2.0	0.28	0.31	0.33	0.34	0.36	0.38	0.39	0.40	0.41	0.42	0.43	0.45	0.47	0.49
3.0	0.40	0.44	0.47	0.49	0.52	0.54	0.56	0.57	0.59	0.61	0.62	0.65	0.67	0.71
4.0	0.62	0.70	0.76	0.82	0.87	0.92	0.96	1.01	1.04	1.08	1.12	1.18	1.24	1.33
5.0	0.93	1.07	1.20	1.31	1.42	1.52	1.61	1.69	1.78	1.86	1.93	2.07	2.21	2.40
6.0	1.17	1.35	1.50	1.65	1.78	1.90	2.02	2.13	2.23	2.33	2.43	2.61	2.77	3.01
8.0	1.72	1.98	2.22	2.43	2.62	2.81	2.98	3.14	3.29	3.44	3.58	3.84	4.09	4.44
10.0	2.37	2.74	3.06	3.36	3.62	3.87	4.11	4.33	4.54	4.74	4.94	5.30	5.65	6.13
12.0	3.13	3.61	4.04	4.42	4.77	5.10	5.41	5.71	5.99	6.25	6.51	6.99	7.44	8.07
14.0	3.98	4.59	5.13	5.62	6.07	6.49	6.88	7.26	7.61	7.95	8.27	8.89	9.46	10.26
16.0	4.92	5.68	6.35	6.95	7.51	8.03	8.52	8.98	9.42	9.83	10.24	11.00	11.71	12.70
18.0	5.95	6.87	7.68	8.41	9.09	9.71	10.30	10.86	11.39	11.90	12.38	13.30	14.16	15.36
20.0	7.07	8.16	9.12	9.99	10.79	11.54	12.24	12.90	13.53	14.13	14.71	15.80	16.82	18.24
25.0	10.20	11.78	13.17	14.43	15.59	16.66	17.67	18.63	19.54	20.41	21.24	22.82	24.29	26.35
30.0	13.78	15.91	17.79	19.48	21.04	22.50	23.86	25.15	26.38	27.55	28.68	30.81	32.80	
40.0	21.92	25.31	28.30	31.00	33.48									
50.0	30.87													
60.0														

TABLE IIIA-3

R-Factor (Statistical Probabilities)

Location	Average Annual (R)	Probability One Year in 5	Probability One Year in 20	Single Storm Normally Exceeded Once in 5 Yrs.	Single Storm Normally Exceeded Once in 10 Yrs.	Single Storm Normally Exceeded Once in 20 Yrs.
Richmond	225	275	361	86	102	125
Roanoke	150	176	237	48	61	73
Lynchburg	175	232	324	66	83	103
Washington	200	250	336	86	108	136

TABLE IIIA-4

C-Factors for Construction Sites

COVER CONDITION	C-FACTOR
Bare Soil	1.0
Temporary Seedings (90% stand)	
Ryegrass (perennial)	0.05
Ryegrass (annual)	0.10
Small grain	0.05
Permanent Seedings (90% stand)	0.01
Sod	0.01
Mulch	
Straw (2 tons/acre)	0.05
Wood chips (7 tons/acre)	0.08
Wood cellulose (1-3/4 tons/acre)	0.10
Crushed stone (135 tons/acre)	0.05

Table 3–2.—C factors for permanent pasture, grazed forest land, range, and idle land[1]

Vegetative canopy		Cover that contacts the soil surface						
			Percent ground cover					
Type and height[2]	Percent cover[3]	Type[4]	0	20	40	60	80	95+
No appreciable canopy		G	0.45	0.20	0.10	0.042	0.013	0.003
		W	.45	.24	.15	.091	.043	.011
Tall grass, weeds, or short brush with average drop fall height of 20 in. or less	25	G	.36	.17	.09	.038	.013	.003
		W	.36	.20	.13	.083	.041	.011
	50	G	.26	.13	.07	.035	.012	.003
		W	.26	.16	.11	.076	.039	.011
	75	G	.17	.10	.06	.032	.011	.003
		W	.17	.12	.09	.068	.038	.011
Appreciable brush or bushes, with average drop fall height of 6½ ft	25	G	.40	.18	.09	.040	.013	.003
		W	.40	.22	.14	.087	.042	.011
	50	G	.34	.16	.08	.038	.012	.003
		W	.34	.19	.13	.082	.041	.011
	75	G	.28	.14	.08	.036	.012	.003
		W	.28	.17	.12	.078	.040	.011
Trees, but no appreciable low brush. Average drop fall height of 13 ft	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.089	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.087	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.084	.041	.011

vegetated

[1]The listed C values require that the vegetation and mulch are randomly distributed over the entire area. For grazed forest land multiply these values by 0.7.

[2]Canopy height is measured as the average fall height of water drops falling from the canopy to the ground. Canopy effect is inversely proportional to drop fall height and is negligible if fall height exceeds 33 ft.

[3]Portion of total-area surface that would be hidden from view by canopy in a vertical projection (a bird's-eye view).

[4]G: cover at surface is grass, grasslike plants, decaying compacted duff, or litter. W: cover at surface is mostly broadleaf herbaceous plants (as weeds with little lateral-root network near the surface) or undecayed residues or both.

R = 185
K = 0.37
LS = 1.4
C = 0.43
P = 1.00

A (annual soil loss) = 185 × 0.37 × 1.4 × 0.43 × 1.0
= 41.2 tons/acre

Pasture: 170 acres; 50 percent of area has canopy cover of short brush (0.5-m [1.6-ft] fall height); 80 percent of surface is covered by grass and grasslike plants; soil is Fayette silt loam; slopes are 8 percent and 200 ft long.

R = 185
K = 0.37
LS = 1.4
C = 0.012

A (annual soil loss) = 185 × 0.37 × 1.4 × 0.012
= 1.15 tons/acre

TABLE IIIA-5

P-Factors (conditions of Exposed Soil Surface)

SURFACE CONDITION WITH NO COVER	P-FACTOR
Compact and smooth, scraped with bulldozer or scraper up and down hill	1.3
Same condition, except raked with bulldozer root rake up and down hill	1.2
Compact and smooth, scraped with bulldozer or scraper across the slope	1.2
Same condition, except raked with bulldozer root rake across the slope	0.9
Loose, as a disced plow layer	1.0
Rough irregular surface, equipment tracks in all directions	0.9
Loose with rough surface greater than 12" depth	0.8
Loose with smooth surface greater than 12" depth	0.9

Appendix E

Slope Stability

On the following pages are Slope Stability Calculations prepared by Draper Aden Associates

Part B Permit Modification
Closure Plan
Cap Calculations

Bristol - SWP498 Closure

DAA #B11145R-24A
Prepared by AST
Reviewed by WGH
June 2, 2020

Calculations:

Infinite Slope Analysis
FMC Strength
Tensile Stength due to Liner Weight
Protective Cover Veneer Stability - Method A
Protective Cover Veneer Stability - Method B

Infinite Slope Analysis

[Calculate minimum factors of safety for components assuming infinite slope]

Project: Bristol - SWP498 Closure
Project No.: DAA #B11145R-24A
Date: June 2, 2020
Prepared by AST

Factor of Safety = friction angle between components / slope angle

Maximum slope angle = 18.43 degrees

Pre-Approved Alternate Final Cover

Interface	Friction Angle, Degrees	Factor of Safety
Waste to intermediate cover	25	1.4
Intermediate cover internal angle of friction	30	1.6
Cap bedding layer internal angle of friction	28	1.5
Cap bedding layer to GCL	25	1.4
Cap bedding layer to FMC	26	1.4
GCL to FMC	26	1.4
FMC or GCL to geocomposite	28	1.5
Geocomposite to erosion layer	30	1.6
erosion layer internal angle of friction	28	1.5
erosion layer to vegetative support layer	27	1.5
Vegetative support layer internal angle of frictio	27	1.5

Note: friction angles taken from published data or from engineering judgment.
FMC = flexible membrane cap (aka geomembrane or FML)
GCL = geosynthetic clay liner

Cover FMC Required Strength

[Calculate required biaxial strength of FMC taking into account subsidence]

Project: **Bristol - SWP498 Closure**

Project No.: **DAA #B11145R-24A**

Date: **June 2, 2020**

Prepared By **AST**

ó(req'd) = 2*D*L²*Ycs*Hcs/(3*t(D²+L²))

ó (allow) = allowable strength of FMC	ó(allow) =	1600	lb/in²
Ycs = unit weight of cover soil	Ycs =	110	lb/ft³
Hcs = height of cover soil	Hcs =	2	feet
t = thickness of FMC	t =	40	mils
D = depth of subsidence	D =	2	feet
L = radius of depression circle	L =	4	feet
ó = FMC strength needed to prevent ripping from subsidence	**ó(req'd) =**	**488.89**	**lb/in²**
FS = factor of safety = ó(allow) / ó(req'd)	**FS =**	**3.27**	

The magnitude of the induced tensile stresses in the FMC depends upon the dimensions of the subsidence zone and the cover soil properties.

Worst case assumption is the FMC is assumed to be fixed at the circumference of the subsidence zone.

Shape of deformation is assumed to be spheroid.

Allowable strength of FMC typical manufacturer's data for 40 mil LLDPE.

References:

EPA, "Design and Construction of RCRA/CERCLA Final Covers", May 1991, p. 28.

Tensile Strength - Liner Weight

[Evaluates ability of FMC to support its own weight]

Project: Bristol - SWP498 Closure
Project No: DAA #B11145R-24A
Date: June 2, 2020
Prepared By: AST

T = W sinB - F
W = (S.G.* γ*t)(1*D/sinß)
F = W cosßtan δ

t = FMC thickness	*t* =	40	mil
	t =	0.003333	feet
S.G. = FMC Specific gravity	S.G. =	0.93	
γ = unit weight of water	γ =	62.4	lb/ft^3
D = Height of slope	*D* =	100	feet
ß = Slope angle (degrees)	*ß* =	18.43	deg
δ = Friction angle (degrees) - FMC to Bedding	δ =	26	deg
W = Weight (lb/ft)	*W* =	61.19	lb/ft
F = Friction Force	*F* =	28.31	lb/ft
***T* = Tensile Force**	***T* =**	**-8.97**	**lb/ft**

Note: only minor slope (<100 ft in length) are as steep as 3:1 (18.43-deg), so this calculation is conservat

Tensile Stress

S = T/x-section

T = tensile force	T =	-8.97	lb/ft
x-section = 1 * thickness	x-sec. =	0.003333	ft
S = tensile stress	**S =**	**(2,690.5)**	**lb/ft^2**
	=	**-18.68**	**lb/in^2**
S_y = Minimum FMC Yield Stress	Sy =	1600	lb/in^2
Dr = Design Ratio = S_y/S	**Dr =**	**(86)**	

Note: since the friction angle between the liner and the underlying GCL significantly exceeds the slope angle, the tensile stress shows a negative number (i.e., friction force greater than tensil

Conclusion: FMC on top of GCL will support its self-weight.

References:

EPA, "Requirements for Hazardous Waste Landfill, Design, Construction, and Closure", April 1989, p.38.

Protective Cover Soil Stability - Method A

Project: Bristol - SWP498 Closure
Project No: DAA #B11145R-24A
Date: June 2, 2020
Prepared By: AST

$a = .5 * g * L * H * \sin^2(2b)$
$b_1 = g*L*H* \cos^2 b*\tan d*\sin(2b)$
$b_2 = c_a*L* \cos b*\sin(2b)$
$b_3 = g*L*H*\sin^2 b*\tan\phi*\sin(2b)$
$b_4 = 2*c*H*\cos b + g*H^2*\tan\phi$
$b = -b_1-b_2-b_3-b_4$
$c = [(g*L*H*\cos b*\tan d + c_a*L)*(\tan\phi* \sin b* \sin(2b)]$
$FS = [-b+\sqrt{(b^2-4ac)}]/2a$

b = slope angle	b =	18.43	deg
ø = internal friction angle of soil cover material	ø =	28	deg
d = geocomposite to soil cover material friction ang	d =	30	deg
g = density of cover	g =	110	lbs/ft^3
L = slope length	L =	100	feet
H = depth of cover	H =	2	feet
c = cohesion of soil cover material	c =	500	
c_a = adhesion of soil cover material to geotextile	c_a =	0	[to be conservative]
	a =	3,958	
	b_1 =	6,858	
	b_2 =	0	
	b_3 =	701	
	b_4 =	2,131	
	b =	-9690	
	c =	1,215	
	FS =	**2.32**	
		(minimum 1.5 required)	

Reference: Designing with Geosynthetics, Third Edition, R.M. Koerner, pg. 384.

Protective Cover Soil Stability - Method B

Project:	Bristol - SWP498 Closure
Project No:	DAA #B11145R-24A
Date:	June 2, 2020
Prepared By:	AST

Source: EPA Publication EPA/625/4-89/022, Requirements for Hazardous Waste Landfill Design, Construction, and Closure, pg. 49.

Parameters:

Slope Height, H =	100	feet
Slope Angle, b =	18.43	degrees
Cover Soil Thickness, t =	2	feet
Unit Weight of Cover Material, g =	110	pounds per cubic foot
Friction Angle, Geocomposite to Soil Cover Material, d =	30	degrees

Equations:

Length of Slope, L = H/sinb
Weight Cover, w = t*L*g
Weight Neutral Block, w_{nb} = 0.5*t*(t/sinb)*g
Force Neutral Block, F_{nb} = w_{nb}*cosb*tand
Sliding Force, F_{sl} = w*sinb
Friction Force, F_{fr} = w*cosb*tand
Factor of Safety = Resisting Forces/Sliding Force = (F_{nb} + F_{fr})/F_{sl}

Analysis:

Length of Slope, L =	100	feet
Weight Cover, w =	22,000	pounds per foot of width
Weight of Neutral Block, w_{nb} =	696	pounds per foot of width
Force Neutral Block, F_{nb} =	381	pounds per foot of width
Sliding Force, F_{sl} =	6,955	pounds per foot of width
Friction Force, F_{fr} =	12,050	pounds per foot of width

Factor of Safety = 1.79 OK
(minimum 1.50 required)

Appendix F

Stormwater Calculations

Stormwater calculations are included on Closure Design Plans submitted as Attachment III separately from this Closure Plan.

Appendix G

Settlement, Subsidence, and Displacement

Settlement, subsidence, and displacement calculations will be submitted under separate cover.

Appendix H

Closure Cost Estimate

The closure cost estimate will be submitted under separate cover.