Bristol Integrated Solid Waste Management Facility
Plan of Action in Response to Expert Panel Report

Bristol Integrated Solid Waste Management Facility
2125 Shakesville Road Valley Drive
Bristol, VA 24201
(276) 645-7233

SCS ENGINEERS

02218208.05-2 | July 06, 2022

15521 Midlothian Turnpike, Suite 305
Midlothian, VA 23113
804-378-7440

Table of Contents

Table of Contents

Table of Contents

Exhibits

Figures

Tables

Appendices

EXECUTIVE SUMMARY

SCS Engineers (SCS) has developed this Plan of Action (Action Plan or Plan), on behalf of the City of Bristol, Virginia (City) to address and propose recommended actions to the Expert Panel's (the Panel) recommendations pertaining to the mitigation of odors emanating from the Landfill, proposed engineered mitigation actions, feasibility of continued waste disposal operations of the Landfill, and options for early closure of the Landfill.

The following sections outline a conceptual approach for the methods to address the action items listed in the report. The narratives and figures within and attached to this report are intended to be used as a first step in implementation of the recommendations of the expert panel.

SCS has organized the recommended actions by timeframe. The timeframe categories in this Plant are Immediate (generally defined as occurring within the next 90-180 days or so), short-term (generally defined as occurring within the next 1 year or so), and long-term (5+ years). Within these timeframes, the City will begin the process of collecting additional information, refining the design, procuring contract services, and implementing the actions.

The actual number, location, alignment, configuration, and function of proposed features described in this plan and depicted in the associated figures may need to be modified to accommodate field conditions, other monitoring activities, additional background data, or City resources.

SCS has also included preliminary ballpark budgetary "ballpark" costs for certain recommendations that require substantial capital investment, where sufficient definition and information was available. A summary of the action items that were identified in the report is outlined in Table 1. A summary of the proposed approach, section of the report where the approach is described, and the proposed timeline for implementation are also included in the table.

Although not originating as a specific recommendation in the Expert Panel Report, included in this Plan is the response to provision 3 in the EPA Temperature Higher Operating Values (HOV) Approval Letter from August 2021.

Table 1. Summary of Action Items and Proposed Approaches

Action Item from Expert Panel Report	Proposed Approach	Section Where Addressed	Timeframe for Implementation
Test and construct a sidewall odor mitigation system around the Landfill perimeter that will be designed and constructed to mitigate landfill gases emanating from the Landfill/quarry sidewalls.	Development of a pilot sidewall odor mitigation system	4.3	Short Term
	Development of a large network perimeter odor mitigation system to be implemented on an as-needed basis	5.3	Long Term
Sources and supply of clay/soil should be addressed	A proposed approach for assessing available on-site soil	4.1	Short-Term
Improve the performance of existing gas extraction wells including minimizing air intrusion pathways through landfill cover.	Implement a procedure to identify and mitigate air intrusion	3.8.1	Immediate

Action Item from Expert Panel Report	Proposed Approach	Section Where Addressed	Timeframe for Implementation
Address any air intrusion caused by well over-drawing from the landfill	Implement an approach to reduce over-drawing of the GCCS	3.8.2	Immediate
Weekly monitoring activities of gas emissions at the Landfill surface	Conduct weekly monitoring of surface emissions	3.5	Immediate
Identify and eliminate to the extent practical any landfill gas fugitive emissions at the Landfill surface.	Implement a procedure to address fugitive emissions identified during emissions monitoring events	3.5	Immediate
Install settlement plates	Installation of settlement plates at select locations within the landfill	3.4	Immediate
Conduct monthly topographic surveys to document the locations and rates of settlement in the waste mass.	Capture topography within the quarry on a monthly basis using photogrammetric methods.	3.6	Immediate
Strongly consider a cessation of waste disposal operations at the Landfill	The facility will cease accepting waste at the Solid Waste Permit 588 Landfill	3.1	Immediate
Install and monitor a dedicated system of thermocouples in the waste mass to monitor Landfill temperatures (above and within the water-saturated waste) for greater spatial resolution (horizontal and vertical) and to provide data at a greater frequency.	Install temperature sensors in borings within the waste mass and equip them with remote monitoring equipment to track temperature fluctuations	3.3	Immediate
Install additional gas extraction wells to reduce emissions and temperatures.	Expand the existing gas system by installing a series of large diameter dual extraction wells	4.2	Short-Term
Install at least five (5) deep dedicated monitoring wells to enable sampling and characterization of leachate and measurement of temperature profiles in the waste. Should include multi-screens at several depths.			
Install and operate large-diameter dual-phase extraction wells for removal of gas and leachate.			

Action Item from Expert Panel Report	Proposed Approach	Section Where Addressed	Timeframe for Implementation
Install a temporary geosynthetic cover over the entire Landfill.	Install a temporary exposed geomembrane cover following grading of the landfill surface	5.2	Long Term
Direct runoff to the southeast corner of the Landfill where it is expected a stormwater management pond can be constructed to manage stormwater that is collected on top of the geomembrane cover	Grade the landfill to a perimeter channel that will direct stormwater to the southeast corner	4.5	Short-Term
Develop and implement an effective and sustainable stormwater management plan and settlement management plan for the Landfill.	Excavate a stormwater storage pond in the southeast corner of the quarry capable of storing the 24-hour 100-yr storm and install a pump to pump water out of the quarry	4.4	Short-Term
Perform frequent testing of clean stormwater being discharged offsite to ensure no contamination has occurred.	Stormwater will be tested in accordance with the facility's existing VPDES Permit	4.6	Short-Term
The Panel recommended an active community outreach program to communicate strategies, provide status and progress reports, and receive citizen feedback.	The City will hire a public relations firm to manage public outreach	3.2	Immediate
Develop a long-term plan to monitor landfill conditions, repair and replace equipment, construct a Landfill cap, and maintain the gas and leachate collection systems.	The City's existing landfill staff will be transitioned to roles managing and overseeing closure and monitoring of the landfill. They will be supported by the City's environmental consultants and contractors.	3.9	Immediate

1.0 INTRODUCTION

On March 1, 2022, the Virginia Department of Environmental Quality (VDEQ) invited 10 landfill industry experts that formed into an Expert Panel (the Panel). The sole purpose of this Panel was to evaluate the Integrated Solid Waste Management Facility (ISWMF or the Facility) operated by the City of the City, and specifically the active waste disposal unit identified as the Quarry Landfill (Landfill), which is governed under Solid Waste Permit No. 588. The Panel set about identifying solutions to the challenges associated with odors, liquids management, heat accumulation, and landfill operations.

The Panel evaluated a substantial body of information including site maps prior to Landfill construction, pictures of Landfill construction, tables of odor complaints, gas and liquid sample data, input from local residents, and technical papers dealing with landfill odor problems similar to this site. The Panel inspected the Landfill and received presentations by several landfill experts with experience dealing with odors associated with similar landfill types at a meeting convened in Bristol on March 21-22, 2022. The VDEQ's charge to the Expert Panel was that options put forth to mitigate odors and address landfill operations must be practicable.

On April 25, 2022, the Panel issued a report (Expert Panel Report or Report) outlining recommendations to address these challenges. On May 6, 2022, VDEQ sent a letter to the City requesting that the City develop a plan of action to address the Panel's recommendations. VDEQ indicated that this Plan of Action should be phased (e.g. immediate, short-term and long-term), and must address specific itemized Panel recommendations, steps the City will execute to accomplish those items, along with a specific associated timelines for each recommendation. Furthermore, VDEQ issued correspondence to the City, dated June 8, 2022, stating that the Department's intentions will be to incorporate the Plan of Action's timelines and proposals into any future enforcement action.

2.0 FACILITY DESCRIPTION

The Integrated Solid Waste Management Facility is an active solid waste management facility owned and operated by the City of Bristol, Virginia. The Landfill uses the space within a former limestone rock quarry that is located almost entirely inside the City limits. The Facility is located about a quarter of a mile north of Bristol, Tennessee.

The ISWMF has three landfill units within its property boundary. The first landfill unit (Permit 221) received waste from 1977 to 1986 and is closed and capped. The second landfill unit (Permit 498) received waste from 1986 to 1998 and is currently being mined in order to recover airspace for potential future use as a construction and demolition debris (CDD) landfill. Mined materials are processed, segregated, and the residual wastes are disposed in the active Quarry Landfill. The third landfill unit (Permit 588) is an active landfill that commenced operation in March 1998.

Permit 588 receives an average of approximately 500 tons of municipal solid waste per day. The current Solid Waste Permit allows for disposal of up to 1,600 tons a day. The current permitted volume-based design capacity is 7,800,000 cubic yards (yd^3). Landfill gas (LFG) collection and control systems (LFGCCS) are installed in Permits 221 and 588. When the mining in Permit 498 has concluded, a LFGCCS will be installed prior to any closure activities in accordance with the Solid Waste Permit.

Leachate collection systems are installed in Permits 498 and 588. The Facility is equipped with various stormwater management features. Multiple comprehensive detailed descriptions of the various infrastructure, as well as the monitoring and control systems, are presented in a myriad of other documents, such as the solid waste permit documents, the Groundwater Monitoring Plan, the Leachate Management Plan, the NSPS GCCS Design Plan, the VPDES Permit, the Expert Panel Report, etc.

3.0 IMMEDIATE

In response to multiple recommendations outlined in the Expert Panel Report pertaining to waste disposal operations, community outreach and engagement, temperature monitoring activities, settlement, and controlling LFG fugitive emissions, the City intends to accomplish the activities described within this Section of the Plan within the timeframe designated as immediate (90-180 days):

3.1 CESSATION OF WASTE DISPOSAL OPERATIONS

On June 14, 2022, a preliminary injunction was issued in the United States District Court for the Western District of Virginia in the case of The City of Bristol, Tennessee v. The City of Bristol, Virginia. The injunction required that the City of Bristol, Virginia cease acceptance of all waste at the Landfill within 90 days. The City has begun the process of preparing to cease waste acceptance and intends to stop accepting waste within Permit 588 by September 9, 2022. The City has commenced the process of notifying private and public customers in accordance with contract terms. The City has commenced the process of identifying an alternate disposal facility for the City's waste.

The technical and operational implementation of the various control measures recommended in the Expert Panel Report may preclude resuming of waste fill operations after September 12, 2022 (the 90-day injunction deadline for cessation of waste acceptance). It is unclear whether it will be practicable for the City to resume filling in Permit 588 in the mid- or long-term once supplemental environmental controls are in place. Much will depend on the initial and continued effectiveness and overall implementation of the environmental control measures once designed, tested (if applicable) and constructed.

As a result, the City has taken steps to develop an RFP for identifying an alternative disposal facility where the City's Solid Waste Division may dispose of its own internally managed waste streams. The City is equipped with its own transfer station infrastructure in the form of PBR #121, a baler building/transfer station at the ISWMF.

However, the facility's current format and equipment are oriented towards accomplishing production of solid waste bales (for use as perimeter buffer within the quarry disposal unit) rather than optimal efficient use as a solid waste transfer station. It is unclear the degree to which the facility is suitable to manage the City's generated waste over an extended duration (multiple years) through consolidation of waste loads dropped off by the Collections Division for long-haul transfer and disposal.

3.2 COMMUNITY OUTREACH AND ENGAGEMENT PROGRAM

The Expert Panel Report recommends an active community outreach program to communicate strategies, provide status and progress reports, and receive citizen feedback. A public relations and engagement plan will include many specific activities and initiatives. The facility's odor management plan should be referenced during development of the public relations and engagement plan.

The City will be moving forward with procuring and retaining a public relations organization (PR Firm). It will be growing its active community outreach program to communicate strategies, provide status and progress reports, and receive citizen feedback with regards to the Landfill.

Public relations and gathering feedback from stakeholders are important aspects of partnering with the community for the successful management of the various issues facing the ISWMF, particularly odor issues from the Landfill. It is important for the City and community stakeholders to put together

a plan and strategy for engaging the public under the guidance of the PR Firm, keeping in mind the activities in this plan may be different for the diversity of stakeholders. The old adage "communicate early" and "communicate often" should guide outreach and engagement activities. The City will develop a comprehensive public communications program that will serve as a "living document" subject to continual improvement. Additional efforts may include the sections below.

3.2.1 Highlight Design Features to Minimize Nuisances

Solid waste facilities are critical infrastructure but can be unique in their impact on a community. Problems such as odors are issues that affect quality of life and are top concerns in the community. In simple/non-technical terms the City will proactively communicate the importance of controlling/mitigating these issues and provide information on how they will be addressed. Examples of possible measures to reduce impacts on the surrounding community include designing the Facility to incorporate the measures presented in the Expert Panel Report.

3.2.2 Value Public Involvement and Feedback

The City is a partner with the community with this project and the facility must serve the needs and address the concerns of all stakeholders. The City will continue to receive feedback, value it, and provide an avenue for individuals and groups to submit their thoughts and ideas. The feedback received must be respected and considered. Also, specific responses must be provided when appropriate.

3.2.3 Provide Timely and Accurate Information

The City has established an avenue for communicating timely and accurate information about aspects of the facility management process via its public website. This allows members of the community to obtain comprehensive information on the details, timelines, and impacts of the various measures employed. Having a centralized "clearinghouse" for information on the project also helps counter inaccurate and deceptive information about the project that can spread through various types of media. The City needs to keep information updated throughout the process.

3.2.4 Foster Continual Dialogue

Public relations and engagement is a continuing process that starts now and will continue through all phases of the project. A key part of this is providing opportunities for citizens and other stakeholders to submit questions and provide feedback. This will give individuals or groups that have a concern about the project a constructive avenue for sharing and reporting on their concern in "real-time," rather than making them wait for the next public meeting or posting a negative comment about the project on social media.

3.2.5 Remain Transparent

An effective strategy to continue to build trust and support for the projects is to continue transparency with information and the decisions that have been made. This means that the City will continue be clear when decisions/commitments have been made, and not use industry or technical jargon that can create confusion for the general public.

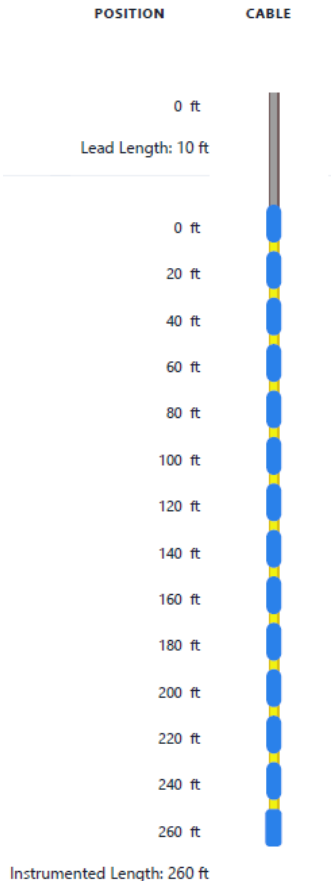
3.2.6 Emphasize Community Stewardship

An overall message that should be incorporated into public relations and community engagement is the environmental management of the facility. Allowing the community to understand that this facility will be managed under a closely-monitored, data-driven program will emphasize the actions being taken. The two main reasons for the facility's development is stakeholder desire to: 1) enhance the community's environmental quality; and 2) use public funds responsibly. Stakeholders also should be allowed to contribute feedback on how environmental programs are intended to be effective as well as safe, socially equitable, and economically sound.

3.3 DEDICATED TEMPERATURE MONITORING IN LANDFILL WASTE

The Expert Panel Report recommended that the City install a system of dedicated "thermocouples" within the waste at 10 to 20 feet intervals to continuously monitor landfill temperatures. The following discussion presents recommendations for the equipment, instrumentation, installation, and design for the system. SCS proposes installing approximately 9 or so temperature probes with suitable sensors distributed throughout the landfill.

Figure 1. Typical Temperature Sensor Spacing



Three options were explored for temperature monitoring equipment: thermocouples, thermistors, and fiber optic cable. Preliminary research found that thermocouples would not withstand long-term deployment in landfill waste, and instrument life is limited to approximately one year. According to the preliminary injunction, temperature monitoring within landfill waste will be required during the closure and post-closure period of the landfill; therefore, thermocouples were eliminated as a consideration for the project.

SCS has been involved with elevated temperature landfill (ETLF) projects where landfill temperature monitoring was performed. In one case, a thermistor string was used; in the other case, a fiber-optic temperature sensor was used.

Review and analysis of these sensors are discussed herein. Both sensor technologies are believed to be suitable and appropriate for this application but particular attention needs to be paid to the following:

- Temperature rating of the overall assembly
- Whether the materials are designed for landfill use
- Cost
- Whether the sensors can be deployed on a location by location basis or whether the power supply and/or output communication are integrated into a single "loop".

The sensor technologies below are capable of being integrated into the remote monitoring and control (RMC) system that is being developed and deployed to monitor landfill gas (LFG) wellhead temperatures.

3.3.1 Looped Fiber-Optic Temperature Sensors

Fiber-optic temperature sensors are essentially a fiber-optic loop connected to a light source, photodetector, and controller that measure the scattering of the light and the traveling time of the light to measure the temperature and corresponding location along the fiber loop.

In this configuration, two fiber optic strings (primary and secondary) would be installed in conduit below the landfill surface. The strings would connect all of the boreholes together and would drop down into each borehole. The primary string would be terminated at a head-end monitoring unit that would measure and report temperature readings. The head-end monitoring unit would transmit data via an industrial internet of things (IIoT) transmitter to a cloud-based RMC system where data can be viewed and interacted with remotely.

The advantage of this approach is relatively low cost, but the disadvantage is the system is vulnerable to whole system failure and offers little resiliency as discussed below.

- Since the temperature monitoring device utilizes one string and one head-end, if either one of these breaks, the entire system is broken and no temperatures are read or recorded.

Another disadvantage is this technique correlates to the highest cost to repair a system failure. If the fiber optic string were to be broken somewhere, it would be costly and difficult to find and repair the broken string. Other disadvantageous considerations are:

- The head-end monitoring unit is a specialty device that comes from a manufacturer in Japan – lead times are expected to be long;

- The head-end monitoring unit requires a power from a custom-built solar photo-voltaic system with batteries – this increases cost and complexity.

3.3.2 Individual Borehole Fiber-Optic Temperature Sensors

In this configuration, each individual borehole would have its own dedicated fiber-optic temperature monitoring system. The individual systems would include a down-hole fiber-optic loop with primary and secondary strings and a head-end monitoring unit. Each head-end monitoring unit would transmit its data via an IIoT transmitter to a cloud-based RMC system to remotely view and interact with the data.

The pros and cons for this approach are below.

- Pros:
  - The distributed approach allows you to continue to gather data from other wells if one borehole was damaged (e.g., run over by a compactor).
- Cons:
  - Highest overall cost;
  - The head-end monitoring unit is a specialty device that comes from a manufacturer in Japan – lead times are expected to be long;
  - The head-end monitoring unit requires a power from a custom-built solar photo-voltaic system with batteries – this increases cost and complexity.

3.3.3 Thermistors

The materials within a thermistor change their resistance as their temperature changes. A thermistor temperature monitoring system applies a known current to a thermistor; the monitoring system calculates the temperature based on the resulting voltage from the thermistor. In this configuration, a thermistor string would be installed in each borehole. Each thermistor string would monitor the temperature within the borehole every 20-feet. At the top of each borehole, an IIoT transmitter would collect the data from the thermistors and transmit it to a cloud-based RMC system.

Figure 2. Example of a Thermistor String

3.3.4 Remote Monitoring System

In each of the temperature monitoring options identified above, the output from the temperature monitoring system(s) can be connected into a cloud-based RMC system. This system will allow users to do the following.

- Remotely monitor landfill temperatures through a web browser. Data will be available on:
  - A map-based view of the landfill
  - Individual pages for each borehole location showing the temperatures along that borehole's temperature monitoring system
- View pre-configured graphs of the landfill temperatures
- View and adjust alarm set points for landfill temperature alerts
- Create graphs based on whatever data points are being collected by the system
- View and export historical data from the system
- Analyze the alarms coming from the system (e.g., high landfill temperature)

Typical RMC systems come with an automatic report customized to specifications based on the data recorded by the system. This report will be emailed out to landfill staff and selected intervals (ex: daily, weekly, monthly, or quarterly). Example automatic reports include minimum, maximum, and average temperature by location.

3.3.5 Installation

3.3.5.1 Drilling Methodology

Drilling in waste to install equipment requires that the boring remain open during the installation process. Of available options for the thermistor installation, SCS recommends using RotoSonic drilling technology. RotoSonic or Sonic, as the name suggests, utilizes sonic vibration and rotation to advance 10- or 20- foot lengths of inner steel casing, followed by an outer steel casing that remains in place while the inner casing removes the substrate. The drill rig repeats the process to final depth, after which the inner casing is removed. Once the construction and installation within the borehole is complete, the outer casing is removed. Boring sizes range from four to 12 inches in diameter as required. Current available data indicate waste thicknesses of up to 250 feet. The locations of the proposed thermocouples (see Figure 1) will dictate the total depth to which the thermocouple string will be deployed. To prevent compromising the liner integrity, boring depths will be advance to approximately 25 feet above the bottom of waste or a maximum depth of 225 feet below surface of waste.

3.3.5.2 Sensor and RMC Deployment

The drilling contractor will attach the sensors at the top of each borehole to the solid cap. The contractor will drill a hole in the cap and insert a cord grip to hold the sensor string and prevent it from falling into the hole. The grip will also prevent gasses from the hole from escaping into the atmosphere.

The temperature probe will be equipped with an outdoor-rated cable from the sensor string, outside of conduit, into the RMC IIoT equipment. Using outdoor-rated cable outside of conduit will prevent landfill gas (LFG) from potentially entering the IIoT equipment.

The IIoT equipment will be mounted to the borehole casing, similar to how the LFG wellhead monitoring IIoT equipment is mounted. The IIoT equipment will be battery-powered and contain a small panel and the IIoT transmitter.

3.4 SETTLEMENT PLATES

The Panel recommended a number of engineering actions to identify and remediate odors and the potential for increased temperatures throughout the landfill. One recommendation was the addition of settlement plates to the site to identify areas with rapid settlement. Rapid localized settlement can occur in ETLFs and, in order to track these elevation changes, it was suggested that the City complete monthly topographic surveys (refer to section 3.6) and implement settlement plates throughout the Landfill.

Settlement plates are comprised of a steel base plate and a stand pipe or rod. The rod or pipe acts a reference above ground. The rod indicates the center of the base plate, and the initial location and elevations is survey by a professional surveyor (refer to the settlement plate detail in Figure B-3 in Appendix B). Subsequent surveys of the settlement plate will show the movement in any direction. Additionally, there is the option to choose to equip settlement plates with a GPS system attached and monitoring of the plate can be completed remotely. SCS has prepared a drawing to depict proposed locations for settlements plates within the Permit 588 boundary. SCS has proposed 12 locations for settlement plates on Figure B-1 in Appendix B. The actual number of settlement plates may be adjusted depending on active construction within the pit. The plates may be moved within a limited area based on field conditions and necessity. Plates can be added or removed as deemed appropriate.

Although settlement plates are used regularly to monitor settlement on landfills, they are susceptible to damage and destruction while landfill activities are being completed. A significant effort should be made to protect the rod above the surface and make it visible; however, it is still likely that the plate will be moved or damaged. Additionally, settlement plates only monitor a small area. The base plate only covers about 1 to 4 square feet depending on the size. The Permit 588 landfill is approximately 17.3 acres and numerous settlement plates still may not provide the coverage necessary. Because the City plans to initially complete monthly topographic surveys to monitor settlement, the addition of settlement plates may not be as critical.

3.5 WEEKLY MONITORING

The Facility currently performs surface emissions monitoring (SEM) on a quarterly basis following the guidelines and procedures in the Facility's Title V Permit, 40 CFR 63.1960 (c) and (d), 40 CFR 60.36f (c) and (d) and 40 CFR 60, Appendix A-7, Method 21. However, considering that fugitive emissions are often a source of malodorous emissions, the Panel has recommended instituting a weekly SEM event in order to identify and correct fugitive emission sources.

The Permit 588 Landfill has a surface area of approximately 17.3 acres. Utilizing an approximate 30-meter interval grid, SCS and the City have developed a route drawing that will be used by technicians performing the monitoring. The proposed route constitutes 87 points, or 5 points per acre, which is greater than the 4.75 points per acre required. Note that during monitoring events, certain areas may be excluded due to active filling or other ongoing landfill activities. In addition to this monitoring

route, monitoring will be conducted at all surface cover penetrations in accordance with 40 CFR 63.1958(d) and 40 CFR 60.34f(d). Furthermore, monitoring will be conducted at any locations where visual observations indicate a potential for elevated concentrations of LFG, such as distressed vegetation, leachate seeps, and surface cover cracks. A drawing depicting the monitoring route and the surface penetrations will be developed.

Monitoring will likely be conducted with either a TVA 2020A Flame Ionization Detector or an Elkins Earthworks Methane Leak Detector, or equivalent suitable instrumentation. Measurements will be obtained between 5 to 10 cm above the landfill surface and the route will include the "buffer area" near the sidewall liner.

Upon identification of methane concentrations greater than 500 ppm, the technician will mark the location in the field with a marking flag and record the GPS coordinated. The technician will notify City and/or LFG system O&M personnel to initiate corrective actions. Corrective actions may include (but are not limited to), addition and compaction of low permeability cover soil, adjustments to nearby LFG collectors, or improvements to the existing LFG infrastructure (such as pump maintenance, regrading header/lateral piping, blower maintenance, etc.) When exceedances are documented at surface penetrations, corrective actions may include (but are not limited to), addition and compaction of cover soil, wellhead adjustments, installation of a bentonite or foam seal, or installation of a well-bore skirt.

Following completion of corrective actions, monitoring will be performed within 10-days of the initial exceedance in accordance with 40 CFR 63.1960 (c)(4) and 40 CFR 60.36f(c)(4). Additional monitoring and recordkeeping, as necessary, will follow the requirements of 40 CFR 63.1960 (c)(4) and 40 CFR 60.36f(c)(4).

The Facility plans to initially perform this monitoring on a weekly basis as suggested in the Panel Report. However, the Facility intends to implement an alternative schedule for future events based on the results, such that the frequency may be reduced for areas where fugitive emissions concentrations decline. The Facility proposes that in the case of four consecutive weekly monitoring events, where no regulatory exceedances are recorded, monitoring can move to a monthly basis. In the case that three consecutive monthly monitoring events record no exceedances, monitoring can move to a quarterly basis. In the case that an exceedance is documented, monitoring will return to a weekly basis.

3.6 MONTHLY TOPOGRAPHIC SURVEYS

In the Executive Summary of the Expert Panel Report, the Panel recommended that the site undertake monthly surveys to document the locations and rates of settlement. Under the Summary of Recommendations, the report recommends the use of drones for the monthly survey of the landfill surface.

SCS proposes the use of a DJI Phantom 4 Pro v2 as the primary UAS for topographic surveys. The flight will be performed under fair weather conditions at approximately ±200 feet above ground level at a speed of ±13 miles per hour. The UAS flight will encompass the entirety of the quarry landfill perimeter along with an outer boundary of approximately 150 feet outside of the perimeter allowing for image overlap.

SCS will use Propeller AeroPoints for ground control points (GCP) during each survey event. The AeroPoints are moveable targets with built-in GPS receivers. In coordination with the AeroPoints, SCS proposes hiring a licensed professional surveyor to establish benchmarks and/or permanent control points within the UAS flight path. The benchmarks and AeroPoints will be combined in the post-processing to establish ground control at the site and to have established surveyed points in which

to compare the variable landfill surface. Due to the critical nature of surveying the rapid settlement and the potential for variability if the control points are move during each visit, SCS recommends working with the City to find locations around the perimeter of the landfill to set up permanent control points in order to maintain consistency. The surveyed benchmarks will be outside of the waste boundary to reduce risk of settlement, obstruction, or damage. The AeroPoints would be placed on top of waste during each visit to assist with accurate readings within the waste boundary. The flight boundary will take place outside of controlled airspace, therefore no air traffic control authorization is required. Each flight will be conducted by an FAA Part 107 licensed pilot.

Post-processing will be completed by photogrammetric software utilizing the UAS images, GCPs, and benchmarks. The output from processing will include an orthomosaic (combination of all images), point cloud files, and contours files. These contour files and point cloud files will be brought into AutoCAD 2020 for analysis. Analysis will consist primarily of surface comparison in order to determine the settlement from previous topographic surveys. SCS will provide the City with the volume of settlement each month. Additionally, the topographic surveys will help address necessary changes to stormwater management features.

If consecutive surveys demonstrate that the average settlement over the course of three months is less than 0.5', then the survey frequency will be reduced to quarterly. If any quarterly survey indicates average settlement of more than 0.5', the frequency will be increased back to monthly. If consecutive surveys demonstrate that the average settlement over 1 year is less than 0.5', then the survey frequency will be reduced to once per year. If any annual survey indicates average settlement of more than 0.5', the frequency will be increased back to quarterly.

3.7 LANDFILL GAS FUGITIVE EMISSIONS

The Panel identified fugitive emissions through the landfill surface as a potential source of malodourous emissions at the Facility. Fugitive emissions correlate to uncollected gas that is emitted through the landfill surface (or from the exposed geocomposite drainage net or from fractures in the sidewall rock formations) into the environment.

The primary source of controlling fugitive emissions is through the LFG collection and control system. Over the past year, the Facility has made significant improvements to the system, with the addition of 21 vertical wells and two horizontal collectors. These improvements, along with the associated header and lateral collection piping and dewatering infrastructure, were installed and connected to the existing system in late 2021. In the first half of 2022, these wells have been adjusted to increase collection. This consists primarily of increasing vacuum as needed to the 21 new vertical wells, keeping in mind to not "over pull" which could potentially cause oxygen intrusion into the landfill.

In addition to the new vertical wells, liquids dewatering infrastructure was installed. A total of 19 pumps were installed in vertical wells, along with the associated air and forcemain piping. Liquids removal from individual wells, opens more length of slotted pipe. In theory, this increases the zone-of-influence for that particular well, increasing gas collection. As a result of these infrastructure improvements, flow has increased by approximately 97 percent in 2022. This increase in collected gas indicates that current collection rates are around 40 percent, up from 19 percent in 2021

Fugitive emission locations are often identified during Surface Emissions Monitoring events. These locations are typically in areas where there is less than typical cover soil. Fugitive emissions may occur as a result of erosion, insufficient cover placement, cover cracks, and pipe penetrations. In addition, emissions can occur in areas of the landfill where collection is either limited (i.e. low density of collectors) or where collection is impacted (i.e. wells that are inundated with liquids).

As referenced in Section 3.5 above, the Facility is planning to complete SEM events on a greater frequency than what is required in the Title V Permit and applicable regulations. This will allow the Facility to identify sources of fugitive emissions. The Facility will document a root cause analysis of each SEM point that is greater than the regulatory limit. Based on the assessed root cause of the exceedance, the Facility will begin making the appropriate corrective actions. In many cases, the corrective actions will involve cover improvements, through the addition and compaction of low permeability soil. In other cases, corrective actions will involve wellhead adjustments to potentially increase gas collection in the vicinity. Other cases may involve more significant modifications such as installation of a dewatering pump, repairs to existing LFG infrastructure or even installation of a new LFG collector, if the instance occurs in a portion of the landfill with low collection density.

In addition to SEM, the Facility will review wellfield monitoring data to assist with identification of potential areas of fugitive emissions. Some indicators, such as methane greater than 56 percent at a wellhead, indicate that all gas in that area is not being collected. In addition, any locations with abnormally low system vacuum could potentially result in uncollected LFG. The Facility or their consultant will evaluate all wellfield monitoring data, and propose any investigations or corrective actions to increase LFG collection.

Furthermore, the City will continue to add additional intermediate cover soil throughout the landfill. In addition, the City and its consultants will continue to evaluate additional LFG extraction components and plan to install additional wells, dewatering pumps, and connect to the existing LFG collection system, however, expansion of the LFG collection system in this manner is anticipated to be accomplished within the Short-Term timeframe (within one year) rather than the Immediate timeframe.

3.8 AIR INTRUSION

3.8.1 Identifying and Mitigate

Intermediate cover will play a significant role in preventing air intrusion into the landfill. Monitoring efforts described in Section 3.5 of this Plan at the LFG vertical well pipe penetrations will assist in identifying wells that may need an additional near surface foam/bentonite seal to prevent air intrusion and/or fugitive LFG emissions at the LFG well pipe penetration. LFG well pipe penetrations that record surface fugitive methane concentrations greater than 500 ppm shall require a foam/bentonite seal within two to four feet from the landfill surface around the pipe penetration covering an area equivalent to the original 36-inch diameter borehole.

The well riser height of the 21 most recently installed vertical LFG extraction wells must be measured and recorded every six months. The Permit 588 Landfill is settling faster than the average landfill, which will most likely lead to more of the LFG extraction well riser penetrating the landfill surface over time. This in turn indicates the perforated section of the well is migrating closer to the surface, which increases the likelihood of air intrusion through the landfill surface. Additional soil cover will be required to mitigate the risk of air intrusion and to also allow the LFG technician to safely reach and monitor each LFG vertical extraction well.

3.8.2 Over-Drawing

LFG is a product of the natural biological decomposition of organic material contained in wastes deposited in landfills. The production of methane gas (a principal component of LFG) by methanogenic bacteria usually begins after oxygen contained in the refuse is depleted. The LFG which results from anaerobic decomposition is predominantly methane (CH_4) and carbon dioxide

(CO_2). The methane content of LFG produced within the established (greater than 1 year) waste mass is typically in the range of approximately 55 to 60 percent. The remainder is mostly CO_2 with trace constituents typically comprising less than 1 percent of the total gas volume. The presence of oxygen and nitrogen in LFG is attributed to infiltration of ambient air into the LFG extraction components through the surface of the landfill since the microbial decomposition of organic waste under anaerobic conditions does not produce oxygen and nitrogen directly.

Accordingly, methane concentrations (along with other parameters such as oxygen and nitrogen concentrations, CH_4:CO_2 ratio, etc.) are evaluated as an indication of whether the applied vacuum at the wellhead and the extraction rate is sufficient to achieve "comprehensive control" of LFG emissions from the waste mass. A slight reduction in the methane concentration along with the introduction of slight oxygen and nitrogen concentrations due to dilution from air intrusion is generally accepted as an industry best management practice. This demonstrates that the wellfield is balanced or "tuned" to establish a zone-of-influence that extends throughout the waste mass without creating excessive "over pulling" (which can result in subsurface oxidation). The term "over pulling" refers to the condition of applying too much vacuum such that the flowrate into the well exceeds the LFG generation rate and results in air intrusion into the waste mass, which is problematic because the landfill is an anaerobic environment. Inversely, high methane concentrations (and little to no oxygen and nitrogen) can be indicative that the vacuum applied at the wellfield is insufficient to extend as far as practicable and may reflect a condition of "under pulling", which results in greater fugitive LFG emissions. The term "under pulling" refers to the condition of applying too little vacuum such that the flowrate into the well is less than the LFG generation rate. In some scenarios, when wellheads with high methane exhibit high vacuum that should correlate with increased LFG flowrates, there is a possibility that these extraction components have a partial or total blockage of perforated piping, reducing the zone-of-influence.

Adjustments in applied vacuum at the individual wellhead induced by the LFG system operator during routine wellfield monitoring and balancing are intended to improve LFG system performance and effectiveness. If gas composition at a wellhead indicates low methane concentrations and high oxygen/nitrogen concentrations, the LFG system operator generally will perform fine tune adjustments to lower the applied vacuum in order to introduce less air into the waste mass. This typically (although not always) reduces the flow and increases the methane concentrations of the LFG being collected at the well. Conversely, if methane concentrations are high and oxygen/nitrogen concentrations are low, the LFG system operator will usually perform fine tune adjustments to increase the applied vacuum, which typically (although not always) increases flow and decreases the methane content of the LFG (due to slight introduction of air into the waste mass).

Variations and fluctuations in the vacuum that unintentionally occur to large portions of the system often have detrimental impacts to wellfield operations because these instances result in changes in the gas composition and flowrates. The frequency and magnitude of these fluctuations have an effect on the extent of the zone-of-influence at each LFG extraction components and potentially impose undesirable "over pulling" and/or "under pulling." Because the control valve at each well is adjusted according to the vacuum measured in the lateral piping that is connected to the wellhead (referred to as the "available system pressure" or "available vacuum") at the time of the monitoring event, frequent and/or large variations and fluctuations in the vacuum can cause marginal or ineffective wellfield performance. This results in a low collection efficiency by either escalating too high (and introducing excessive air intrusion and potential subsurface oxidation) or by decreasing too low (and allowing excessive fugitive emissions while not optimizing the collection efficiency). In 2022, the City and SCS agreed to set the LFG system VFD vacuum setpoint at the blower inlet to yield available vacuum of -25 in-wc to reduce vacuum fluctuations, and the potential of overdrawing the wellfield.

Fine-tuning of the wellfield is an ongoing challenge to prevent over pulling LFG and pulling oxygen into the landfill. In areas that lack LFG coverage, such as areas of ongoing landfill operations or the haul road, additional LFG components should be installed to mitigate surface fugitive emissions and odors. However, areas with sufficient well densities greater than 2 wells per acre, precision tuning using a QED or equivalent "globe" style precision tuning wellhead with quick change orifice plate works best to optimize LFG collection efficiency.

3.9 LONG-TERM MONITORING AND MAINTENANCE PLAN

The Expert Panel Report recommends the development of a long-term plan to monitor landfill conditions, repair and replace equipment, construct a Landfill cap, and maintain the gas and leachate collection systems.

In accordance with Section 9VAC20-81-170 of the Virginia Administrative Code, sanitary landfills post-closure care requirements are governed by standards that require monitoring and maintenance of aspects including the following:

- Final cover integrity and effectiveness
- Leachate collection system operation
- Groundwater monitoring system
- LFG monitoring system

The duration of post-closure care is a minimum of 30 years for sanitary landfills that received wastes on or after October 9, 1993, such as the City of Bristol Landfill. The Post-Closure Plan (PCC Plan) provides a description of the monitoring and maintenance activities required during the 30-year post-closure period. Elements of the PCC Plan for the ISWMF include the following by permitted landfill:

3.9.1 Permit 498

The following post closure care activities for SWP #498 have been identified based on Major Permit Modification Attachment V – Post-Closure Care Plan, Solid Waste Permit 498, October 16, 2020 (Revision 1). They consist of inspection, maintenance, and monitoring actions:

3.9.1.1 Inspections

Implementation of an inspection program of physical aspects of the site. Inspections include:

- As-needed site inspections after a major storm event, to determine if excessive erosion or other damage has occurred, with repairs made as necessary.
- As-needed site inspections after a major storm event, to determine if excessive erosion or other damage has occurred, with repairs made as necessary.
- Monthly security inspections of the gate, lock and fencing.
- Quarterly complete site inspections with repairs made as necessary. The complete inspection will include, but not be limited to:
    a. security control devices,
    b. erosion damage,

c. cover settlement,
d. subsidence and displacement,
e. vegetative cover,
f. run-on and runoff control measures,
g. leachate collection and removal system,
h. landfill gas venting system, landfill gas monitoring system, and,
i. groundwater monitoring wells.

Frequency of complete inspections may be reduced to semi-annual with final stabilization of the site.

- **Annual mowing** in which all woody vegetation on the cap must be cut (site will not be mowed for 1 to 2 years after cap is placed to allow time for the grass cover to mature; woody vegetation would still be cut)
- **Annual reseeding**
- **Annual integrity checks of site benchmarks**
- **Biannual sampling of leachate and testing** for parameters set by the receiving WWTP.

3.9.1.2 Maintenance

Preventative and corrective maintenance activities apply to the following per the PCC Plan:

- Security control devices
- Final Cover integrity (including the following items):
  a. Erosion control damage
  b. Correction of settlement, subsidence and displacement
  c. Bare or dead vegetative cover
  d. Presence of woody stemmed vegetation
- Run-on and runoff control structures
- Vegetative cover condition (including vegetation)
- Leachate collection system (including the following items):
  a. Flow and test information, valves, pump station/overflow tank, manholes, etc.
  b. Final cap repairs
  c. Seep control
  d. Leachate treatment and disposal
- Groundwater monitoring system
- LFG monitoring system
- Benchmarks

3.9.1.3 Monitoring

Monitoring activities are anticipated to include the following:

- **Groundwater monitoring system** – Reference the Virginia Solid Waste Management Regulations and the landfill's Groundwater Monitoring Plan.
    a. The groundwater monitoring system consists of a series of groundwater monitoring wells.
- **LFG monitoring system** – Reference the Virginia Solid Waste Management Regulations and the landfill's Gas Monitoring Plan.
    a. Gas monitoring systems consist of a series of passive perimeter probes and gas vent infrastructure within the landfill itself.
    b. Monitoring will consist primarily of monitoring for LFG methane content as well as will sampling and testing.
    c. Underdrain monitoring

3.9.2 Permit 588

A current PCC plan for the Permit 588 landfill could not be identified. Due to the unique nature of the quarryfill, it is likely a modified version of the above inspection, maintenance, and monitoring paradigm will be required for Permit 588. It is anticipated a greater frequency of inspection/monitoring, additional number of individual aspects incorporated, and overall enhanced magnitude of activities will be required for Permit 588. Select aspects to be additionally considered as compared to Permit 498 include the following unique aspects of the facility as well as Expert Panel-recommended features.

3.9.2.1 Inspections

Implementation of an inspection program of physical aspects of the site. Inspections include:

- **Quarry wall inspections** to assess the condition of natural and engineered features adjacent to the waste mass, including granite quarry walls and sidewall liner system
- **Routine sampling of gradient water and testing** for parameters set by the receiving WWTP
- **Inspections of additional features,** including items b through g listed in the section below.

3.9.2.2 Maintenance

Potential additional maintenance activities associated with Permit 588 include that for features unique to the quarry landfill format such as:

a. Sidewall natural and engineered features adjacent to the waste mass, including granite quarry walls and sidewall liner system
b. Gradient control and witness zone elements
c. Access shaft and tunnel
d. Industrial wastewater benzene treatment system
e. Sidewall odor mitigation system
f. ETLF temperature monitoring (thermocouple) system
g. Cover and grading to facilitate shedding of stormwater for clean water aggregation and removal

3.9.2.3 Monitoring

Monitoring activities are anticipated to include the following

- **Underdrain monitoring system** including Witness Zone

3.9.3 Provision of Personnel

The table below outlines the staffing identified by the City to efficiently operate the facilities at the landfill at the current waste intake rate. It is expected that the target staffing of the ISWMF will decrease after closure; however, personnel will still be required to accomplish the above post-closure activities.

Table 2. Personnel

Position	Target Staffing
Landfill Facility Manager	1
Assistant Landfill Manager	1
Scale Operator	1
Equipment Operators/Laborers	10-12*
Secretary/Office Manager	2
Environmental & Safety Officer	1
Environmental Technician	1
Total	19

*Equipment Operators and laborers cover multiple aspects of Operation of the ISWMF including the transfer facility, landfill, composting, and support operations.

The above staffing table is anticipated to be utilized as a starting point for developing an approach for personnel staffing for continued inspection, maintenance, and monitoring of the facility.

4.0 SHORT-TERM

In response to multiple recommendations outlined in the Expert Panel Report pertaining to soil cover, extraction of fluids (liquids and gases), control of fugitive emissions, and stormwater management, the City intends to accomplish the activities described within this Section of the Plan within the timeframe designated as short-term (1 year):

4.1 PLACEMENT OF INTERMEDIATE COVER

In the short term, the City will require approximately 30,000 cubic yards of soil to cover the landfill with intermediate cover as a part of the temporary closure. This soil volume was estimated assuming a 12-in layer of soil cover over the entire 17.3 acres of the Permit 588 landfill boundary. Additionally, as part of the LFG control and odor mitigation, clay will be required in certain areas.

4.1.1 Soil and Clay Supply

SCS has provided a drawing, Figure C-1 in Appendix C, which shows proposed test pit locations and an area to inspect for potential on site soil. The City may complete additional test pits if none of the locations produce any positive results for on-site soil. If the City were to be unsuccessful locating a significant soil stockpile, the City would have to import soil from off-site. It is highly likely that the required amount of Clay will have to be imported from off-site and tested to make sure it meets all of the necessary clay requirements.

4.1.2 Soil Characteristics

Soil utilized for intermediate cover shall be soil free of debris, roots and other organic matter, frozen material, sharp objects or other harmful matter that may damage the synthetic cap. The soil shall have no particle size greater than 2 inches. Prior to placement of any soil, lab tests will be required to determine the soil characteristics. Exhibit 1 provides the necessary lab tests, test method, and frequency to be completed on all soil. Lab tests and frequencies should be followed as shown in Exhibit 1 whether soil is provided by on-site or off-site locations.

Exhibit 1. Laboratory Soil Testing

Test	*ASTM Designation or Other Test Method*	*Frequency*
Grain Size Analysis	D1140 and D6913	1 per 10,000 cy
Grain Size Analysis – Cushion Layer	D1140, D6913, and D7928	1 per soil type
Natural Moisture Content	D2216	1 per 10,000 cy
Classification	D2487	1 per 10,000 cy
Atterberg Limits	D4318	1 per 10,000 cy
Moisture-Density Relationship	D698 or D1557	1 per material type and changes in material

Note: Grain size analysis will be used to estimate hydraulic conductivity of the cushion layer using the Hazen's approximation (based on d10 size), or similar relationship. Remolded hydraulic conductivity may be used in lieu of the Hazen approximation. In the case that hydraulic conductivity is tested, one sample will be tested in accordance with ASTM 5084 (Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter) for every soil type in addition to Grain Size Analysis. ASTM 5856 (Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Rigid-Wall, Compaction-Mold Permeameter) may also be used.

4.1.3 Subsurface Soil

If the soil surface is to be lined with geosynthetic material, surface shall be smooth and free of rocks, stones, sticks, roots, sharp objects, or debris that could, in the opinion of the membrane installer, damage the membrane. The surface shall generally not contain particles larger than 3/8 inches. Screening of the material may be required. As necessary, the surface shall be groomed by hand to bring the surface up to the desired smoothness. The surface should provide a firm, unyielding foundation for the membraned with no sudden, sharp or abrupt changes or break in grade. No

standing water or excessive moisture shall be allowed. Compaction is not necessary but the ground should be resistant to pumping from vehicles during membrane deployment.

4.1.4 Soil Compaction

In the event that the city needs soil for structural backfill throughout the site. The backfill soil should follow the soil characteristics outlined in this section for intermediate cover soil. Soil shall be compacted at a moisture content of +/- 3% of the optimum moisture content. Backfill should be placed and compacted in lifts no larger than 6-in. Compaction should be completed utilizing specified compaction equipment (sheeps-foot roller, smooth roller, hand tamp, etc.) and shall complete a minimum of 2 passes or as many as necessary to achieve a minimum dry density of 95% of maximum dry density. Soil CQA should be completed for any areas that require structural backfill.

4.1.5 Clay

Clay will be utilized for LFG and odor mitigation activities. It is likely that clay will be imported from an off-site location. The off-site material will go through the lab tests specified in Exhibit 1. The clay must meet the grain size specifications for clay based on the Unified Soil Classification System. Additionally, clay must meet the permeability minimum of $1x10^{-5}$ m/s. Soil shall be tested using ASTM 5084 or similar.

4.2 LARGE DIAMETER WELL-FIELD EXPANSION PLAN

A primary approach to optimization of the LFG collection system at the ISWMF is to enhance the LFG collection efficiency. This includes extracting LFG from all viable LFG well components within the Permit 588 Landfill including horizontal collectors, leachate cleanouts, and vertical extraction wells. The following action plan summarizes LFG optimization in Permit 588 with regard to existing and proposed well components.

4.2.1 Leachate Cleanout Network Permanent Integration to LFG System

During a tour with the City in early 2020, SCS identified nine leachate cleanouts at the southern access shaft outside of the south end of the Permit 588 Landfill as candidates for active LFG extraction. SCS reviewed the City's data and collected confirmation data during site reconnaissance. The LFG to energy developer, Ingenco, expressed interest in collecting the additional LFG for their plant via pilot-study. The purpose of the pilot-study was to evaluate the efficacy of the leachate cleanouts potential to extract sustainable LFG quality and quantity to increase yields to the Ingenco plant. The pilot-study would determine whether it was appropriate to design and construct a permanent LFG Collection System for the leachate cleanout network.

Ingenco authorized a pilot-study LFG design/build with SCS, which was approved by the City. The pilot-study involved connecting in a 4-inch LFG header to the existing LFG Collection System and connecting the nine leachate cleanouts located at the southern access shaft into a pilot system manifold in three clusters consisting of three cleanouts per cluster. The 4-inch LFG header was installed above grade just outside the east quarry rim to connect the nine south end cleanouts. Initially, the pilot-study was considered successful since it yielded an increase from 150 scfm to 300 scfm to the Ingenco power plant in April 2020.

Over time, thermal expansion and contraction of the above grade 4-inch LFG header caused low points and condensate blockages in the undersized LFG header. As a result, some diminishing

returns in LFG flow from the southern cleanouts have been observed. However, the pilot-study demonstrated data over two years that suggest a permanent LFG header and manifold should be designed and constructed to commensurately capture LFG from the south end cleanouts.

A permanent LFG header will be designed to convey LFG collected from the nine southern access shaft leachate cleanouts to the existing LFGCCS. The design will include a manifold where each of the nine southern access shaft cleanouts individually connect to the manifold. The LFG header pipe shall be sized based on typical industry pressure headloss criteria and buried for the majority of the alignment (unless otherwise noted in the design). The permanent LFG design and System expansion for the southern access shaft leachate cleanouts will optimize LFG collection from these cleanouts.

In June 2021, SCS designed and installed a pilot-scale LFG System expansion for the northern access shaft leachate cleanouts per the City's authorization. The LFG System mitigated malodorous emissions around the northern leachate cleanout access shaft. However, unlike the southern access shaft cleanouts, the data collected suggested the LFG quality and volume is not commensurate to upgrade the northern access shaft leachate cleanouts to a permanent LFG expansion at this time. However, SCS will continue to monitor LFG data from the northern cleanouts and may reconsider this position if new data presents the need for expansion.

4.2.2 Permit 588 LFG Vertical Extraction Well Expansion

During summer 2021, SCS designed an LFG Collection System expansion in the Permit 588 Landfill that included an additional 21 LFG vertical extraction wells. The wells were drilled by Aptim in early fall 2021. The 21 wells were connected to vacuum by SCS-FS with dedicated dewatering pumps installed in 14 of the 21 wells by December 2021.

The wells installed in 2021 covered the majority of the interior portions of the Permit 588 Landfill. However, portions of the Permit 588 were in active filling areas and extraction wells were unable to be installed at that time. In addition, new extraction components were not able to be installed along the western haul road, which limits LFG extraction in the vicinity of the western side wall.

In accordance with the Court Order from the United States District Court for the Western District of Virginia dated June 14, 2022, the City is required to cease acceptance of all waste and provide intermediate cover over the entire landfill, except adequate daily cover over the working face within 90 days. SCS will design an LFG system expansion for Permit 588 that shall include vertical extraction wells installed in areas of the landfill deemed currently inaccessible due to active filling operations. The vertical extraction wells will be installed and connected to the existing LFG collection system within the Short-Term timeframe (approximately one year). All proposed vertical extraction wells will be issued a dedicated dewatering pump unless authorized by SCS based on field inspection and monitoring results. The proposed wells would be large diameter wells that could accommodate larger pumps and capable of extracting larger volumes of leachate.

The proposed vertical extraction wellfield layout is intended to cover the majority of the surface area of the Permit 588 Landfill. The proposed wells would be large diameter wells that could accommodate larger pumps and capable of extracting larger volumes of leachate. The broader coverage of the landfill surface area along with improvements to the southern access riser leachate cleanouts will optimize LFG collection of the total gas volume generated, thus reducing overall fugitive emissions and odors, and is expected to assist in extracting heat (in the form of fluids), which is intended to improve management of elevated LFG temperatures.

LFG vertical well maintenance will be necessary to optimize wellfield performance and minimize LFG fugitive emissions, odors, and elevated temperatures. LFG flow must be recorded along with standard LFG quality and compliance readings. In addition, the LFG well dewatering pump stroke

count data must be updated monthly and communicated between the O&M contractor and the City to coordinate non-routine pump maintenance. All pumps within the Permit 588 Landfill shall be pulled, cleaned, tested and reinstalled once every quarter unless a change in site conditions warrant a different frequency.

4.3 PILOT SIDEWALL ODOR MITIGATION SYSTEM

A high priority in the Odor Mitigation section of the Report was to construct a system to address the high wall gas spot emissions reffered to as “chimneys. The Report proposed pulling back the sidewall liner to install lateral gas collection pipes and construct a clay barrier to seal the perimeter.

In order to address the high wall gas spot emissions observed at the landfill, the City will construct a perimeter odor mitigation system along the walls of the quarry. SCS has prepared the conceptual detail shown in Figure 3.

4.3.1 Design

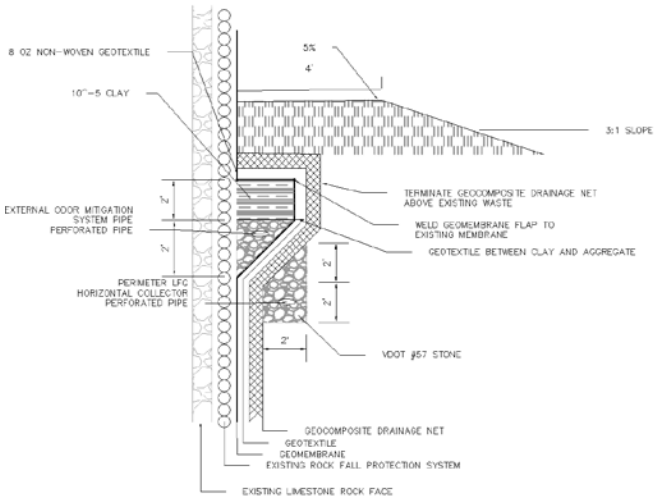
The sidewall odor mitigation system will primarily consist of three components: a perimeter LFG horizontal collector positioned within the waste, an external odor mitigation collector positioned between the sidewall liner geomembrane and the quarry rock sidewall, and a clay barrier “plug”. The LFG horizontal collector is intended to function in a similar manner as a typical horizontal collector installed within the waste mass. The external odor mitigation collector will be installed outside of the liner system to function as a secondary containment mechanism to collect fugitive emissions between the quarry wall and the liner system. The clay barrier will inhibit fugitive LFG emissions from the exposed leading edge of the geocomposite drainage net and from behind the sidewall liner geomembrane, as well as inhibit stormwater infiltration.

Both collectors will consist of a perforated pipe installed in a trench backfilled with coarse aggregate. The collectors will be installed in a single trench, excavated adjacent next to the liner. The LFG horizontal collector will be placed in the bottom of the trench inside the existing liner system. The liner adjacent to the LFG horizontal collector will remain in place during construction. Any defects identified in the liner will be repaired during the construction process.

Above the LFG horizontal collector, the liner system will be peeled away from the quarry wall and placed over the LFG horizontal collect at an angle of approximately 45 degrees. This will put the liner system geocomposite drainage net (GDN) in direct contact with the LFG horizontal collector. This will facilitate the collection of LFG that may be flowing through the GDN. Any liquids that enter the GDN above the LFG horizontal collector may also be intercepted and drained using the collector.

The external OMC will be placed on top of the relocated liner system. The existing geotextile will be folded back over the external OMC and approximately 2 feet of soil with a permeability less than 10^{-5} cm/sec will be placed on top of the geotextile. Additional geotextile may be sewn or leistered to the existing geotextile as needed to supplement materials. A new geomembrane flap will be welded to the existing geomembrane adjacent to the low permeability soil. The geomembrane and GDN will be place on top of the low permeability soil. The geomembrane flap will continue up the highwall for 5 to 10 feet and the GDN will terminate at the top of intermediate cove elevation.

Figure 3. Odor Mitigation System Detail



ODOR MITIGATION SYSTEM DETAIL
NOT TO SCALE

NOTES:
1. THE EXTERNAL ODOR MITIGATION SYSTEM PIPE WILL BE CONNECTED TO A SEPARATE BLOWER-FLARE STATION
2. THE PERIMETER GAS COLLECTION SYSTEM PIPE WILL BE CONNECTED TO THE LANDFILL GAS COLLECTION AND CONTROL SYSTEM
3. THE DOWNSTREAM END OF BOTH COLLECTION PIPES WILL BE CONNECTED TO A CONDENSATE DRAIN PIPE

Approximately two feet of controlled fill will be placed on top of the system to protect the system and limit air intrusion. The controlled fill will be graded so that stormwater drains away from the quarry high wall.

4.3.2 Location

The pilot system will be constructed in the same location as the existing experimental odor mitigation system. This system was installed at the approximate location of the most prominent high wall gas spot emission on the western side of the landfill. This location is adjacent to the quarry wet well liquids extraction system. By placing the pilot system at this location, it can utilize the existing blower and flare that has been installed, but has not commenced operation, and was intended to serve as a separate control system for low-BTU gas. A conceptual layout depicting the approximate location of the pilot system segment is shown in Figure C-1 in Appendix C.

4.3.3 Operation

The pilot system will be designed with a contingency that enables connection to a gas collection and control system (GCCS) that is separate from the existing landfill GCCS that conveys LFG to the main blower/flare station and ultimately to the power plant. This contingency anticipates that gas collected from the external odor mitigation collector will be low quality and would likely have a negative impact on the overall gas quality at the site.

The pilot system would be constructed with the intent of utilizing the existing experimental blower and flare adjacent to the wet well. Based on previous samples of gas collected from the high wall gas spot emissions, it does not have methane concentrations high enough to sustain combustion in the

solar-spark flare. Propane may be used to supplement the gas collected from the external odor mitigation collector. Alternatively, the gas collected from the LFG horizontal collector could be used to supplement the gas from the odor mitigation collector. If neither of these options provide a feasible solution, the City may consider other treatment options such as the use of a carbon filter.

The pilot system will likely be used as a method to evaluate multiple operating configurations and may be configured to allow modification of the system. The pilot system is anticipated to cover approximately 200 feet of the quarry high wall.

Both the external odor mitigation collector and the LFG horizontal collector will be designed to drain liquids that accumulate in these collectors into a common sump. This will facilitate liquids removal from the collector to maintain effective gas collection. A pump will be installed in the sump and connected to the existing gas system force main and pneumatic supply lines.

4.4 CONCEPTUAL STORMWATER MANAGEMENT PLAN

One of the Panel's recommendations included a revised Stormwater Management Plan in order to remove stormwater from the waste area while a geosynthetic cover is placed over the top of the landfill. The best course of action would be to direct stormwater off-site; however, the existing surface of the active quarry landfill is still well below the surrounding quarry rim ground level. In some areas, there exists a 150-feet rock face between the landfill surface and the surrounding rim elevation. Because of the existing topography within the landfill boundary, the City will have to direct stormwater runoff to a pond on the southeast end of the site. Stormwater collected within the landfill boundary will be conveyed to the detention pond and pumped outside of the waste limits on an interim basis while evaluating alternative potential management options and landfill surface configuration scenarios.

The detention pond will be located on the southeast corner of the quarry. Stormwater within the landfill boundary will flow south and east to the pond, where the stormwater will be stored and pumped out of the waste area. A geomembrane lined channel will be added on the eastern edge of the landfill to carry stormwater down to the pond, which will also have a geomembrane liner to impede infiltration into the Quarry Landfill. Section 4.5 discusses the changes to the existing grade necessary to achieve the revised Stormwater Management Plan. The revised Stormwater Management Plan assumes that a temporary geosynthetic cover covers the entire site; therefore the surface is considered impermeable. Figure B-3 in Appendix B presents the stormwater calculations for a 24-hr, 100-yr storm on the site. The detention pond is designed to hold the total volume of runoff and the channel has been sized to handle the peak flow rate of a 24-hr, 100-yr storm.

The bottom of the proposed pond is elevation 1748'. In order to remove stormwater, the City will acquire a pump that will be positioned at the bottom of the pond and pump stormwater to the north end of the landfill, up the existing access road, and into an existing stormwater management feature. The top of the existing access road at the north west corner is elevation 1842'. This location is approximately 2300-ft from the center of the detention pond. The City will install a pump (or a series of pump stations) that can achieve the head necessary to pump the water along a 2300-foot discharge pipe with an elevation change of approximately 100 feet. Electric power will likely be supplied to the pump via a generator located on the quarry rim adjacent to the pond on an interim basis while the Facility coordinates extension of electric power supply.

This Stormwater Management Plan may have to be revised based on conditions and issues encountered in the field over the coming months.

4.5 STORMWATER GRADING

In order to achieve the Stormwater Management Plan laid out in Section 4.4, SCS has created a proposed grading plan. The proposed grading plan and cut/fill volumes are based on comparison to topography which represents an aerial survey completed on June 15, 2021. The existing topography will be slightly different from the "existing topography" shown in Figure C-1 in Appendix C. This is the most current topography available. The proposed grading plan will facilitate stormwater runoff to the detention pond in the southeast corner, include a 10-ft wide channel for stormwater conveyance shown in Figure C-4 in Appendix C, and minimize the total volume of existing soil and waste that will be moved.

The existing landfill surface is represented by topography from a drone survey completed June 15, 2021.The current landfill features a steep slope towards the east edge of the landfill and a gradual slope towards the south end. The proposed conceptual grading modifies the slopes to provide consistency throughout the site. See Figure C-1 in Appendix C for the proposed grading plan. The modified slopes will have a grade of at least 5% but no greater than 33% directed towards the sediment pond. The proposed grading includes the 10-ft wide channel and the detention pond. The channel features a 5% grade with a 10-ft base, 2-ft depth, and side slopes of 3:1 (H:V). The channel will be lined with a geomembrane cover to convey water to the detention pond. The detention pond has a bottom elevation of 1748' and side slopes not greater than 3:1 (H:V). The pond will have a total storage volume capable of handling the 24-hr, 100-yr storm. See Figure C-3 in Appendix C for the stormwater calculations. Maintaining a minimum grade of 5% within the quarry will reduce the amount of maintenance required as a result of differential settlement.

The proposed grading plan will require cut or fill of different areas around the landfill. The proposed grades minimize the amount of cut and fill necessary throughout the site, while also trying to achieve a balanced cut and fill volume. Figure C-2 in Appendix C is the "heat map" for the proposed grading plan. The "heat map" depicts the volume differences between the existing topography, which is topography from an aerial survey completed June 15, 2021, and the proposed topography. Green indicates positive numbers or areas that will require fill, and red indicates negative numbers or areas that will require cut. The volume calculation completed in AutoCAD Civil3D 2020 yielded a fill volume of approximately 136,000 CY and a cut volume of approximately 106,000 CY, a net fill of 30,000 CY. SCS has assumed that since June 15, 2022, when the "existing grades" were captured, to now, the City has taken in approximately 30,000 CY of waste or more. The excess fill from the volume calculation should be accounted for with the additional waste placement over the last year. In the event additional fill is necessary, the backfill will be completed with soil. Soil used for backfill will have to follow the testing and compaction procedures outlined in Section 4.1.

Grading of the site should be completed in conjunction with the temporary geosynthetic cover detailed in Section 5.2.

4.6 STORMWATER SAMPLING

Stormwater removed from the quarry landfill area of the site will likely discharge to an existing stormwater basin. The existing stormwater basin is currently sampled in accordance with facility's VPDES Permit. Assuming the VPDES Permit will remain active, no additional sampling of stormwater specifically from the quarry landfill area is necessary. However, if a VPDES permit exceedance is identified, additional stormwater sampling may occur within the proposed in-quarry stormwater pond to identify the potential source area.

5.0 LONG-TERM

In response to multiple recommendations outlined in the Expert Panel Report pertaining to cessation of waste disposal, temporary geosynthetic cover, and large network perimeter odor mitigation, the City intends to accomplish the activities described within this Section of the Plan within the timeframe designated as long-term (5+ years):

5.1 CESSATION OF WASTE DISPOSAL OPERATIONS

5.1.1 Potential Impacts and Feasibility

The Preliminary Injunction's requirement for the City to cease acceptance of waste for landfilling combined with the requirement for placement of intermediate (IM) soil cover and shaping of the landfill surface grade will result in, at a minimum, temporary closure of the landfill. Continued operations beyond 90 days from the date of the injunction appears to be infeasible in the short run; the City has notified outside haulers/disposers with whom it has contracts in place to the need for cessation of waste acceptance by September 9, 2022.

The technical and operational implementation of the various control measures recommended in the Expert Panel Report may preclude resuming of waste fill operations after September 12, 2022 (the 90-day injunction deadline for cessation of waste acceptance). It is unclear whether it will be practicable for the City to resume filling in Permit 588 in the mid- or long-term once key environmental controls are in place. Much will depend on the initial and continued effectiveness and overall implementation of the environmental control measures once designed, tested (if applicable) and constructed. As a result, the City has taken steps to develop an RFP for identifying an alternative disposal facility where the City's Solid Waste Division may dispose of its own internally managed waste streams. The City is equipped with its own transfer station infrastructure in the form of PBR #121, a baler building/transfer station at the Facility.

However, the Facility's current format and equipment are oriented towards accomplishing production of solid waste bales (for use as perimeter buffer within the quarry disposal unit) rather than use as a true solid waste transfer station. It is unclear the degree to which the facility is suitable to manage the City's generated waste in the long run through consolidation of waste loads dropped off by the Collections Division for long-haul transfer and disposal. The City may need to implement direct-haul by its collections vehicles to a relatively proximate alternative landfill in the area for disposal. The City is investigating, and will continue to explore, the feasibility as well as alternatives to direct haul and/or use of the baler building for long-haul transfer to a regional disposal facility.

5.1.2 Conceptual Final Cover Design

In the event the City decides to close the Landfill permanently, the City will construct the permanent final cover system over the entire landfill. Cross section details of the Final Cover system are shown in Figure B-4 in Appendix B. The final cover system, starting from the lowest layer above the waste and going up to the surface, will consist of a 12-in Intermediate Cover layer, 40 Mil Textured LLDPE geomembrane, Geocomposite Drainage Net (5x10^-3 m^2/s), 18-in Protective Soil Cover, and 6-in Vegetative Cover layer. This is a standard Final Cover Design utilizing geosynthetic material. Construction methods and process for completing the final cover may change based on the status of the Temporary Geosynthetic Cover. Section 5.2 outlines the Temporary Geosynthetic Cover system implementation.

5.2 TEMPORARY GEOSYNTHETIC COVER

The Panel suggested placing a temporary geosynthetic cover over the entire site, which will help prevent odors and surface emissions from being released and help prevent additional leachate creation. The landfill will be covered by a 40 mil LLDPE geomembrane (membrane). The temporary cover will be placed over the landfill while mitigation activities are being completed. A cross section of the temporary geosynthetic cover can be found in Figure B-4 in Appendix B with the conceptual final cover detail.

The membrane will consist of 40 mil Linear Low Density Polyethylene (LLDPE). The manufacturer of the membrane should provide SCS and the City with a certification of the material and the quality control results. All manufacturers' quality control (MQC) reports should align with GRI-GM17 Standard Specification - "Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes". SCS and the City will review the MQC results to approve the material meets the standards. The manufacturer should, also, provide a specification sheet which provides instruction on proper equipment and material handling and site seaming requirements. The membrane should be installed by a professional contractor (Contractor) with a minimum of 500,000 square feet of cap installation experience.

The membrane will be placed over the 12-in intermediate cover. The soil surface should be free of debris and objects that may puncture or cut the geomembrane, see section 4.1 for additional soil subsurface requirements. A CQA representative, as well as, the Contractor should inspect the subsurface prior to geomembrane deployment. Deployment shall be completed utilizing the methods and equipment approved by the manufacturer. The Contractor, as well as, a CQA representative will observe and note the panel placement, the panel seaming, the length of the seams, and the locations of repairs. Seams may be completed using a wedge weld, but all repairs shall be completed using an extrusion welder and resin from the same batch as the membrane rolls.

Upon completion, the Contractor will weigh down the membrane utilizing sand bags at a specified interval to prevent any uplift or movement in the geomembrane. SCS will provide a calculation for the minimum offset of sandbags in order to prevent damage or movement. The geomembrane will remain uncovered for the short term. In the event that the City decides to permanently close the landfill, the additional layers of the final cover will be placed on top of the geomembrane, refer to section 5.1.2 for conceptual final cover design.

5.3 LARGE NETWORK PERIMETER ODOR MITIGATION SYSTEM

The Large Network Perimeter Odor Mitigation System will be designed and constructed following a review of the outcomes of the Pilot Network Perimeter Odor Mitigation System. The large network system will be an expansion of the pilot system using the same basic design and approach outlined in Section 4.3. The large network system will likely encompass the entire quarry high wall and will be intended to address all of the high wall gas spot emissions. The conceptual design may be modified based on the initial operation and development of the pilot system.

The following approach is proposed based on the assumption that the pilot system is effective at mitigating the high wall gas spot emissions. If the initial pilot system is not effective, then the original approach will need to be re-evaluated to identify a more effective approach.

5.3.1 Design

It is anticipated that the large network system will use the same basic design shown in Figure 3. Ideally the system will be installed following grading that will slope the existing topography so that there is a single low spot within the landfill. This will minimize the number of sumps and pumps that will be required to drain the system.

The system will likely require a new blower and flare to manage gas from the external OMC. It is anticipated that the system used in the pilot will not support the full scale system. The large network system is expected to cover 5,000 linear feet of high wall.

The proposed blower flare station will be connected to the external OMC by a series of well-heads anticipated to be placed every 100 feet along the system. Additional well-heads will be connect to the LFG horizontal collector at a similar interval. Depending on the outcome of the pilot system, the LFG horizontal collector wellheads will be connected to either the new blower flare station of the existing landfill GCCS.

The system would also be equipped with pumps and sumps at low points to remove liquids from both collectors. The sumps would be connected to the existing GCCS liquids removal system. A sample layout for the Large Network Perimeter Odor Mitigation System is shown in Figure C-2 in Appendix C.

6.0 PRELIMINARY COSTS

This section includes a preliminary effort to contextualize the potential expenditure of City economic resources to design and construct new infrastructure components described above and recommended in the Report. SCS prepared these cost estimates prior to any formal conceptual design for each recommendation as outlined in the following sub-sections, and they are solely intended to be an initial resource to provide assistance during budgeting for planning, engineering, and implementation of planned measures. The sections presented below are listed in order of implementation timeframe.

All cost estimates should be considered highly preliminary and will need to be reviewed and further evaluated as final concept and construction-level drawings are developed. Costs are based off of SCS' experience with similar projects performed in Virginia and the broader mid-Atlantic supplemented by information from published construction cost databases for the Bristol region.

6.1 IMMEDIATE

6.1.1 Dedicated Temperature Monitoring In Landfill Waste

The costs associated with the three different options for temperature monitoring (looped fiber-optic, individual borehole fiber-optic and individual borehole thermistor) are presented in Tables 3 through 5:

The estimated cost for looped fiber-optic solution is presented in Table 3 below.

Table 3. Looped Fiber-Optic Temperature Sensors Estimated Costs

Item Description	Quantity	Unit	Unit Price	Cost
Design and Management	1	LS	$8,400	$8,400
Furnish Equipment	1	LS	$238,700	$238,700
Programming	1	LS	$18,600	$18,600
Installation	1	LS	$40,800	$40,800
Remote Monitoring Costs (1st Year)[1]	1	YR	$2,400	$2,400
Mobilization of Sonic Drill Rig	1	LS	$2,500	$2,500
Sonic Drill Rig with Crew	40	Days	$4,500	$180,000
Casing (2 in. stainless steel) w/Grout (up to 2760 ft)	1	LS	$121,440	$121,440
Per Diem/Lodging/Travel (3-man crew)	32	Days	$600	$19,200
Mobilize Pozi Trac	1	LS	$750	$750
Pozi Trac (rental and usage)	8	Weeks	$2,500	$2,500
Demobilization	1	LS	$2,500	$2,500
			Total:	$637,790

[1] Remote monitoring is subject to ongoing operational costs.

The estimated cost for the individual borehole fiber-optic solution is presented in Table 4 below.

Table 4. Individual Borehole Fiber-Optic Temperature Sensors Estimated Costs

Item Description	Quantity	Unit	Unit Price	Cost
Design and Management	1	LS	$8,400	$8,400
Furnish Equipment	1	LS	$453,000	$453,000
Programming	1	LS	$18,600	$18,600
Installation	1	LS	$68,800	$68,800
Remote Monitoring Costs (1st Year)[2]	1	YR	$2,400	$2,400
Mobilization of Sonic Drill Rig	1	LS	$2,500	$2,500
Sonic Drill Rig with Crew	40	Days	$4,500	$180,000
Casing (2 in. stainless steel) w/Grout (up to 2760 ft)	1	LS	$121,440	$121,440
Per Diem/Lodging/Travel (3-man crew)	32	Days	$600	$19,200
Mobilize Pozi Trac	1	LS	$750	$750
Pozi Trac (rental and usage)	8	Weeks	$2,500	$2,500
Demobilization	1	LS	$2,500	$2,500
			Total:	$880,090

The estimated cost for the individual borehole thermistors optic solution is presented in Table 5 below.

Table 5. Individual Borehole Thermistor Temperature Sensors Estimated Costs

Item Description	Quantity	Unit	Unit Price	Cost
Design and Management	1	LS	$9,100	$9,100
Furnish Equipment	1	LS	$133,000	$133,000
Programming	1	LS	$14,000	$14,000
Installation	1	LS	$34,900	$34,900
Remote Monitoring Costs (1st Year)[3]	1	YR	$2,400	$2,400
Mobilization of Sonic Drill Rig	1	LS	$2,500	$2,500
Sonic Drill Rig with Crew	40	Days	$4,500	$180,000
Casing (2 in. stainless steel) w/Grout (up to 2760 ft)	1	LS	$121,440	$121,440
Per Diem/Lodging/Travel (3-man crew)	32	Days	$600	$19,200
Mobilize Pozi Trac	1	LS	$750	$750
Pozi Trac (rental and usage)	8	Weeks	$2,500	$2,500

[2] Remote monitoring is subject to ongoing operational costs.
[3] Remote monitoring is subject to ongoing operational costs.

Demobilization	1	LS	$2,500	$2,500
			Total:	$522,290

6.1.2 Settlement Plates Installation

The estimated cost for the installation of settlement plates is presented in Table 6 below.

Table 6. Settlement Plates Estimated Costs

Item Description	Quantity	Unit	Unit Price	Cost
Mobilization	1	LS	$9,000	$9,000
Settlement Plate Installation	12	EA	$5,000	$60,000
Design and Bidding Assistance	NA	NA	NA	$8,000
Surveying and Record Drawings	NA	NA	NA	$4,000
Field Observation	NA	NA	NA	$4,000
Contingency	10	%	$85,000	$8,500
			Total:	$93,500

6.1.3 Conducting Weekly SEM

The estimated cost for the first year of weekly surface emissions monitoring is presented in Table 7 below.

Table 7. Weekly SEM Estimated Costs

Item Description	Quantity[4]	Unit	Unit Price	Cost
SEM Event	52	Visits	$2,000	$104,000
Contingency[5]	10	%	$104,000	$10,400
Total			**Total:**	$114,400

6.1.4 Implementation of Large Diameter Wellfield Expansion Plan

The estimated cost of the construction and engineering associated with the large diameter wellfield expansion is presented in Table 8 below.

Table 8. Pilot Odor Mitigation System Cost Estimate

Item Description	Quantity	Unit	Unit Price	Cost
Preliminary Conceptual Design	NA	NA	NA	$5,812

[4] Assumes that weekly visits will be required for at least the first year following closure.
[5] Contingency may be used for follow-up and root cause analysis.

Item Description	Quantity	Unit	Unit Price	Cost
Engineering Design	NA	NA	NA	$12,786
Field Reconnaissance & Surveying	NA	NA	NA	$6,393
Sidewall Preparation by Owner	NA	NA	NA	$5,000
Development of Construction Bid Documents	NA	NA	NA	$9,590
Bidding Assistance & Contract Negotiations	NA	NA	NA	$9,590
Mobilization/ Demobilization	15	%	$1,458,100	$218,715
Driller Mobilization	1	LS	$16,000	$16,000
Large Diameter LFG Wells	4,000	VF	$200	$800,000
Well-heads	17	EA	$1,300	$22,100
Leachate Pumps	17	EA	$10,000	$170,000
Below Grade LFG Header	2,000	FT	$100	$200,000
Air Line and Leachate Force Main	2,000	FT	$60	$120,000
Leachate Sumps	2	EA	$65,000	$130,000
Surveying	3	%	$1,676,815	$50,205
Record Documentation	4	%	$1,676,815	$67,080
Construction Contingency	10	%	$1,794,100	$179,410
CQA & Certification Report/ As-Built Drawings	NA	NA	NA	$31,490
Project Contingency	10	%	$2,049,171	$204,917
			Total:	$2,259,088

6.1.5 Additional Placement of Intermediate Cover

The estimated cost for the placement of an intermediate cover over the entire quarry cell is presented in Table 9 below.

Table 9. Intermediate Cover Estimated Costs

Item Description	Quantity[6]	Unit	Unit Price	Cost
Planning and Bid Assistance	NA	NA	NA	$20,000
Mobilization	1	LS	$128,000	$128,000
Soil Hauling from On-site	15,000	CY	$5	$75,000
Soil Hauling from Off-site	15,000	CY	$20	$300,000
Surveying and Record Drawings	30,000	CY	$13	$390,000
Thickness Demonstration and Surveying	NA	NA	NA	$17,000
Contingency	10	%	$930,000	$93,000

[6] Quantities of soil assume that entire Permit 588 quarry landfill surface requires new cover and half the cover will need to be hauled from off-site of the ISWMF.

Item Description	Quantity[6]	Unit	Unit Price	Cost
			Total:	$1,023,000

6.2 SHORT-TERM

6.2.1 Pilot Network Perimeter Odor Mitigation System

The estimated cost of the construction and engineering associated with the proposed pilot scale perimeter odor mitigation system is presented in Table 10 below.

Table 10. Pilot Odor Mitigation System Cost Estimate

Item Description	Quantity	Unit	Unit Price	Cost
Preliminary Conceptual Design	1	LS	$5,812	$5,812
Engineering Design	1	LS	$12,786	$12,786
Field Reconnaissance & Surveying	1	LS	$6,393	$6,393
Sidewall Preparation by Owner	1	LS	$5,000	$5,000
Development of Construction Bid Documents	1	LS	$9,590	$9,590
Bidding Assistance & Contract Negotiations	1	LS	$9,590	$9,590
Mobilization/ Demobilization	15	%	$236,166	$35,425
Sidewall Preparation	1	LS	$2,576	$2,576
Excavation & Waste Relocation	200	CY	$13	$2,671
"In-Waste" Horizontal Collector (IWHC)	200	LF	$80	$16,000
"Odor Mitigation" Collector (OMC)	200	LF	$80	$16,000
Low Permeability Soil Fill	30	CY	$33	$1,001
Unspecified Soil Fill	200	CY	$18	$3,578
Geosynthetic Materials	2,000	SF	$2	$4,941
IWHC Connection to Existing LFG System	1	EA	$67,200	$67,200
OMC Treatment System	1	LS	$107,200	$107,200
Surveying	3	%	$271,591	$8,148
Site Restoration	1	LS	$5,000	$5,000
System Demonstration Testing & Commissioning	1	LS	$10,000	$10,000
Record Documentation	4	%	$271,591	$10,864
Construction Contingency	10	%	$290,602	$29,060
Monitoring & Evaluation of Pilot System Effectiveness	1	LS	$12,786	$12,786
CQA & Certification Report/ As-Built Drawings	1	LS	$31,966	$31,966

Item Description	Quantity	Unit	Unit Price	Cost
Project Contingency	10	%	$413,586	$41,359
			Total:	$454,945

6.2.2 Closure Grading and Stormwater Management

The estimated costs of the construction and engineering costs associated with the proposed closure grading and stormwater management is presented in Table 11 below.

Table 11. Stormwater Management and Grading

Item Description	Quantity	Unit	Unit Price	Cost
Preliminary Conceptual Design	NA	NA	NA	$11,000
Engineering Design	NA	NA	NA	$110,000
Permitting	NA	NA	NA	$165,000
Development of Construction Bid Documents	NA	NA	NA	$110,000
Bidding Assistance & Contract Negotiations	NA	NA	NA	$30,000
Mobilization/ Demobilization	15	%	$3,949,000	$394,900
Excavation & Waste Relocation	136,000	CY	$13	$1,768,000
Fill Soil Placement, Grading, & Compaction	30,000	CY	$13	$390,000
Landfill Gas Collection System Modifications	1	LS	$500,000	$500,000
Stormwater Management - Channels	2,000	LF	$8	$16,000
Stormwater Management - Basins	1	EA	$100,000	$100,000
Stormwater Management - Pump Station & Forcemain	1	LS	$50,000	$50,000
Access Road	62,500	SF	$6	$375,000
Surveying	1	LS	$85,100	$85,100
Geosynthetic Cover Installation	750,000	SF	$1	$750,000
Record Documentation	1	LS	$85,000	$85,000
Construction Contingency	1	%	$4,514,000	$451,400
Coordination w/Stakeholders	NA	NA	NA	$54,600
CQA & Certification Report/ As-Built Drawings	NA	NA	NA	$440,000
Project Contingency	10	%	$5,886,000	$588,600
			Total:	$6,474,600

6.3 LONG-TERM

6.3.1 Large Network Perimeter Odor Mitigation System

The estimated costs of the construction and engineering associated with the proposed large scale system is shown in Table 12 below.

Table 12. Large Network Odor Mitigation System Cost Estimate

Item Description	Quantity	Unit	Unit Price	Cost
Engineering Design	1	LS	$78,973	$78,973
Field Reconnaissance & Surveying	1	LS	$13,162	$13,162
Sidewall Preparation by Owner	1	LS	$50,000	$50,000
Development of Construction Bid Documents	1	LS	$52,648	$52,648
Bidding Assistance & Contract Negotiations	1	LS	$26,324	$26,324
Mobilization/ Demobilization	15	LS	$1,944,830	$291,725
Sidewall Preparation	1	LS	$64,400	$64,400
Excavation & Waste Relocation	5000	CY	$13	$66,763
"In-Waste" Horizontal Collector (IWHC)	5,000	LF	$80	$400,000
"Odor Mitigation" Collector (OMC)	5,000	LF	$80	$400,000
Low Permeability Soil Fill	1,000	CY	$33	$33,359
Unspecified Soil Fill	5,000	CY	$18	$89,444
Geosynthetic Materials	50,000	SF	$2	$123,517
IWHC Connection to Existing LFG System	1	EA	$368,000	$368,000
OMC Treatment System	1	EA	$375,000	$375,000
Surveying	3	%	$2,236,555	$67,097
Site Restoration	1	LS	$14,348	$14,348
System Demonstration Testing & Commissioning	1	LS	$10,000	$10,000
Record Documentation	4	%	$2,236,555	$89,462
Construction Contingency	10	%	$2,393,114	$239,311
CQA & Certification Report/ As-Built Drawings	1	LS	$31,966	$31,966
Coordination w/Stakeholders	1	LS	$26,324	$26,324
Project Contingency	10	%	$3,143,099	$314,310
			Total:	$3,456,057

APPENDIX A

Treatment Option for Subsurface Reaction Area

This section is to satisfy the condition of compliance provision 3 of the letter titled, *Approval of Higher Operating Temperature Values for Landfill Gas Wells and Submission of Gas Treatment Alternatives at the Bristol Virginia Integrated Solid Waste Facility,* issued by the Environmental EPA to the City of Bristol, dated August 23, 2021. Per discussions with the EPA and VDEQ, SCS has approval from the EPA to include the City's response to provision 3 along with this Action Plan. Below is a discussion of the proposed continued corrective actions for a discrete portion of the Landfill exhibiting elevated temperatures and other characteristics that are typical of elevated temperature landfills (ETLFs), which has been referred to by EPA as the subsurface reaction (SSR) area. Please note that the physical three-dimensional boundaries of such SSR area have not been definitively identified at this time; however, it can generally be described as the southcentral portion of the Quarry Landfill where existing landfill gas wells EW-46, 47, 52, 54, 55, 57, 60, and 67 are positioned.

1.0 INTRODUCTION

According to the Higher Operating Value (HOV) approval letter, landfill gas (LFG) wells EW-46 and EW-47 recorded steadily increasing temperatures to around 195°F at the time of the HOV request. The highest temperature recorded was 200°F at well EW-47 on 7/15/21. SCS and City personnel did not observe smoke, burning odors, melted riser pipes, or other evidence of a potential subsurface landfill fire. The landfill gas composition in these wells exhibited low methane concentrations, high carbon dioxide, and the presence of elevated hydrogen compared to typical LFG composition from anaerobic digestion of wastes in MSW landfills. According to the HOV Approval letter, due to these factors, "there is an unknown subsurface reaction ("SSR") occurring in this area.

Compliance provision 2 of the HOV Approval letter requires the Facility to submit semi-monthly status reports to EPA Region III and VDEQ on the 1st and 15th of each month. These semi-monthly reports include daily temperature measurements recorded at the existing and new LFG wellheads. In addition, a summary of work accomplished during the reporting period, including evaluation of LFG collection system and LFG analytical data is provided. The City and its consultants have completed the semi-monthly status reports for the ten-month period of September 2021 through June 2022.

Wells EW-46 and EW-47 exhibited temperatures between 160°F and 180°F from August 2021 through December 2021. This represents the period following the HOV approval (8/23/21) but prior to the installation and connection of the new LFG extraction wells.

2.0 LFG COLLECTION SYSTEM EXPANSION EVENT IN 2021

SCS developed an LFGCCS design during 2021 consisting of 21 LFG vertical wells. SCS prepared the bid package during summer 2021 and the City selected Aptim to drill and install the 21 vertical extraction wells. On behalf of the City, Draper Aden and Associates (DAA) conducted construction quality control (CQC) over the vertical well installation activities performed in September and October 2021.

In addition to the vertical well expansion project, SCS prepared a design/bid package for the LFGCCS header network to tie the 21 vertical wells into the existing LFG System network during fall 2021. The City selected SCS Field Services (SCS-FS) to install the above ground LFGCCS header network and connect the 21 new vertical extraction wells to the existing vacuum distribution piping network. SCS-FS performed this task beginning in November 2021 and finished construction efforts in early January 2022. As part of this effort, SCS-FS FS selected locations to install dedicated dewatering

pumps in select new wells throughout the landfill based on liquid monitoring data. Pumps were installed in GW-51, GW-52, GW-54, GW-55, GW-57, and GW-58 to the north, east, and southeast of target wells GW-46 and GW-47, but not in the new wells located directly to the south (GW-56) and west (GW-53) based on the criteria established from the well sounding data (e.g. dry, silted in, shallow liquid column).

3.0 CURRENT CONDITIONS IN THE SUBSURFACE REACTION AREA

SCS has reviewed data collected and stored in an electronic database, SCS eTools, over the past year and evaluated the conditions of the SSR. Furthermore, SCS has compared the carbon monoxide (CO) and hydrogen (H_2) laboratory analytical results over time and considered the effect of the dewatering pumping efforts. There is a clear drop in CO between sampling events on 1/26/22 and 2/9/22 in SSR well EW-46 reducing from 2,210 ppm to below the detection limit of 90 ppm. In addition, the hydrogen reduced from 17.9 percent to 0.5 percent during this period. In SSR well EW-47, H_2 reduced from 24.5 percent to 13.1 percent between sampling events conducted on 1/26/22 and 2/9/22, while CO reduced from 2,010 to 1,210 ppm. The reduction in CO and H_2 concentrations may potentially be attributed to the activation of the new wells with dewatering pumps located in the SSR area around the end of 2021.

It should be noted the temperatures in GW-46 and GW-47 dropped significantly from approximately 180°F in February 2022 to approximately 100°F in May 2022. This can likely be attributed to several months of steadily increasing the applied vacuum to the new LFG vertical extraction wells installed in 2021 as well as extracting the heat through liquids removal via the newly installed dewatering pumps in the new wells. Based on the data, it appears that these heat removal efforts have likely contributed to collectively lowering the wellhead temperatures of wells within the SSR area, as well as reducing CO and H_2 concentrations.

However, SCS has identified a recent reduction in liquids removal from the vertical wells in the SSR area. The resulting increased liquid level reduces the amount of LFG and heat collected by the LFG system as the zone-of-influence from the well is reduced. The results from the 6/8/22 sampling event at GW-46 showed an increase in CO concentrations to 959 ppm and H_2 increased to 6.57 percent, which is a significant increase from the 2/9/22 event. In addition, the temperature in GW-46 and GW-47 have increased to 170°F and 132°F respectively according to the latest measurements recorded on 6/16/22.

4.0 CONTINUED CORRECTIVE ACTIONS PROPOSED FOR SUBSURFACE REACTION AREA

The LFG system in the SSR area should be operated, maintained, and monitored such that overall LFG system performance is optimized. LFG flow, along with temperature and vacuum must be recorded during each wellhead monitoring event. Dewatering pump stroke counter data should be recorded once per week to monitor pump operational status in order to communicate and schedule pump maintenance. In addition, any wells that record a temperature greater than 145°F or an approved higher operating value will be monitored for CO via EPA Method ALT 145 in accordance with the enhanced monitoring protocol per Subpart AAAA 63.1961.(a)(ii)(5).

The City has recently authorized the purchase of 4 additional dewatering pumps and has committed to purchasing 4 more dewatering pumps to have on standby. This is important as backup pumps are critical to have in storage to replace non-functional pumps. In addition, the City authorized 25 temperature sensors to be installed in Permit 588 vertical LFG extraction wells. These automated remote monitoring control (RMC) sensors will provide real-time temperature data on hourly intervals that can be accessed in a cloud-based electronic database to eliminate sampling inconsistencies, such as human/instrument error, to better access the overall condition of the SSR area.

SCS recommends dewatering pumps in the SSR area be pulled, cleaned, and tested no less than once per quarter. The City has fabricated a pump cleaning and testing station at the wash bay area to service the pumps. The pumps are to be cleaned and tested to verify operational status prior to inserting back into the well.

The City must cover all non-active filling areas with intermediate cover materials as prescribed by the regulatory requirements and the Facility's Permit. This will assist in restricting air intrusion into the landfill from the surface, which along with the reduction of heat accumulation, should foster an environment for anaerobic decomposition of waste and conditions that encourage methanogenesis. This includes the areas of the LFG lateral, air, and forcemain piping. The City and its contractors will continue coordinating to move those lines temporarily in order for cover materials to be applied and graded before reconnecting the LFG, air, and forcemain as appropriate.

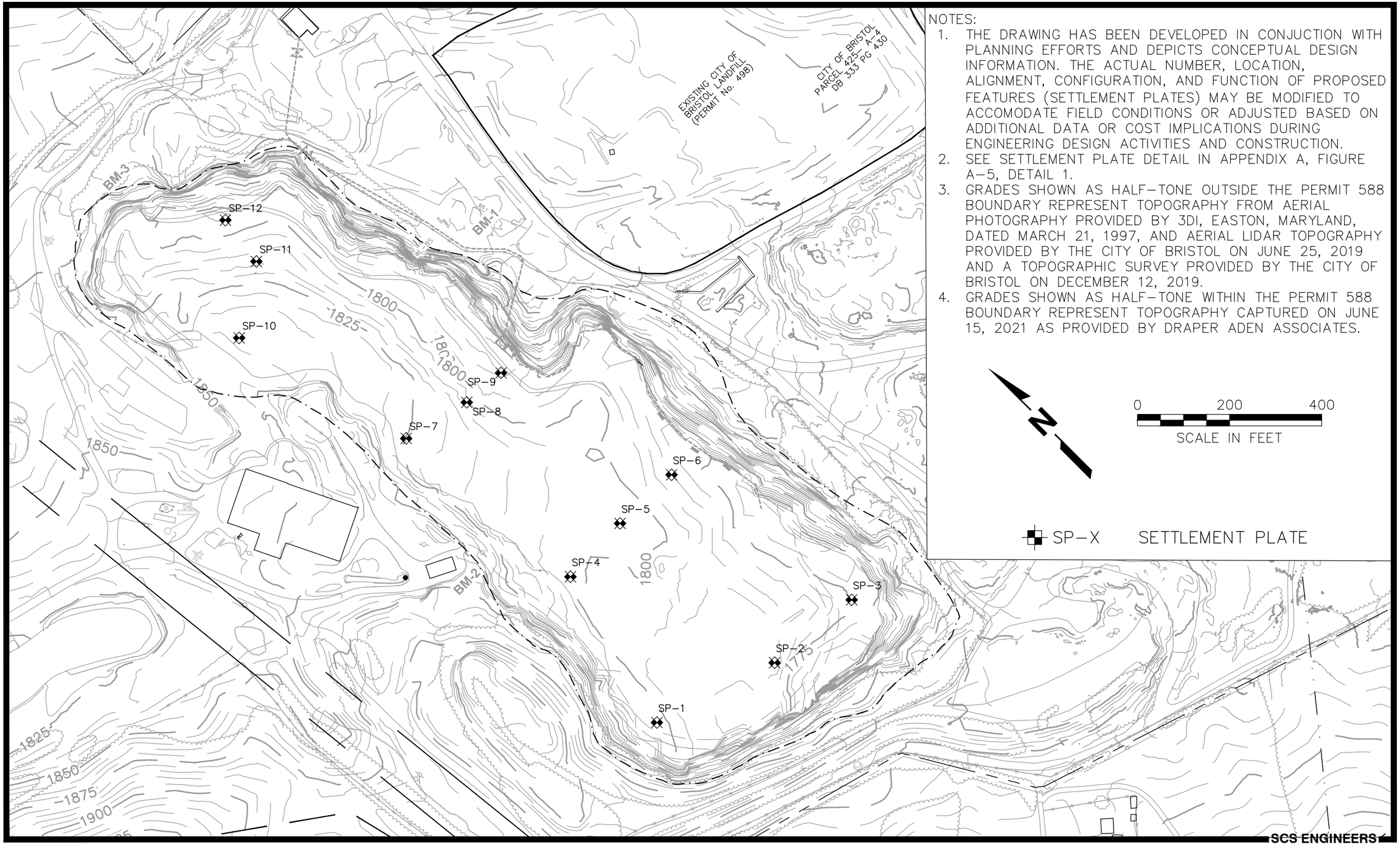
The 2021 LFG collection system expansion event assisted in lowering CO and H_2 concentrations, and temperatures in GW-46 and GW-47 and the SSR area collectively, which enhanced anaerobic decomposition of waste. The LFG collection system in the SSR area should be expanded to further enhance efficiency and effectiveness of the LFG system. Typically, LFG well spacing and density in SSR areas is closer than traditional landfill areas. This allows more comprehensive LFG system coverage in the SSR area with more capacity to extract the heat formed in ETLFs. Also, the subsequent LFG system expansions will include vertical wells installed to greater depths than were achieved during the 2021 expansion event, which had an average depth for the 21 new wells of only 103 feet. More importantly, landfill liquids are pumped from a tighter group of wells and from a greater depth, collectively lowering the liquid level of the SSR area, which is expected to result in long term temperature reduction and enhanced methanogenic process.

Other continued corrective actions being evaluated include the installation of a dedicated temperature monitoring system, improved stormwater management to reduce infiltration into the waste, and consideration of installation of an interim cap, which are discussed elsewhere in this Plan. Prior to interim capping, the City will accomplish sealing the soil/pipe interface at pipe penetrations of SSR LFG well casings using either a foam agent or hydrated bentonite. The seals around the well pipe penetrations will mitigate LFG from escaping while preventing air from infiltrating into the waste mass under vacuum.

APPENDIX B

Settlement Plate and Cover Drawings

DRAWN BY: RMM DATE: 07/06/2022 FILE NAME: 02218208.05 – Action Plan

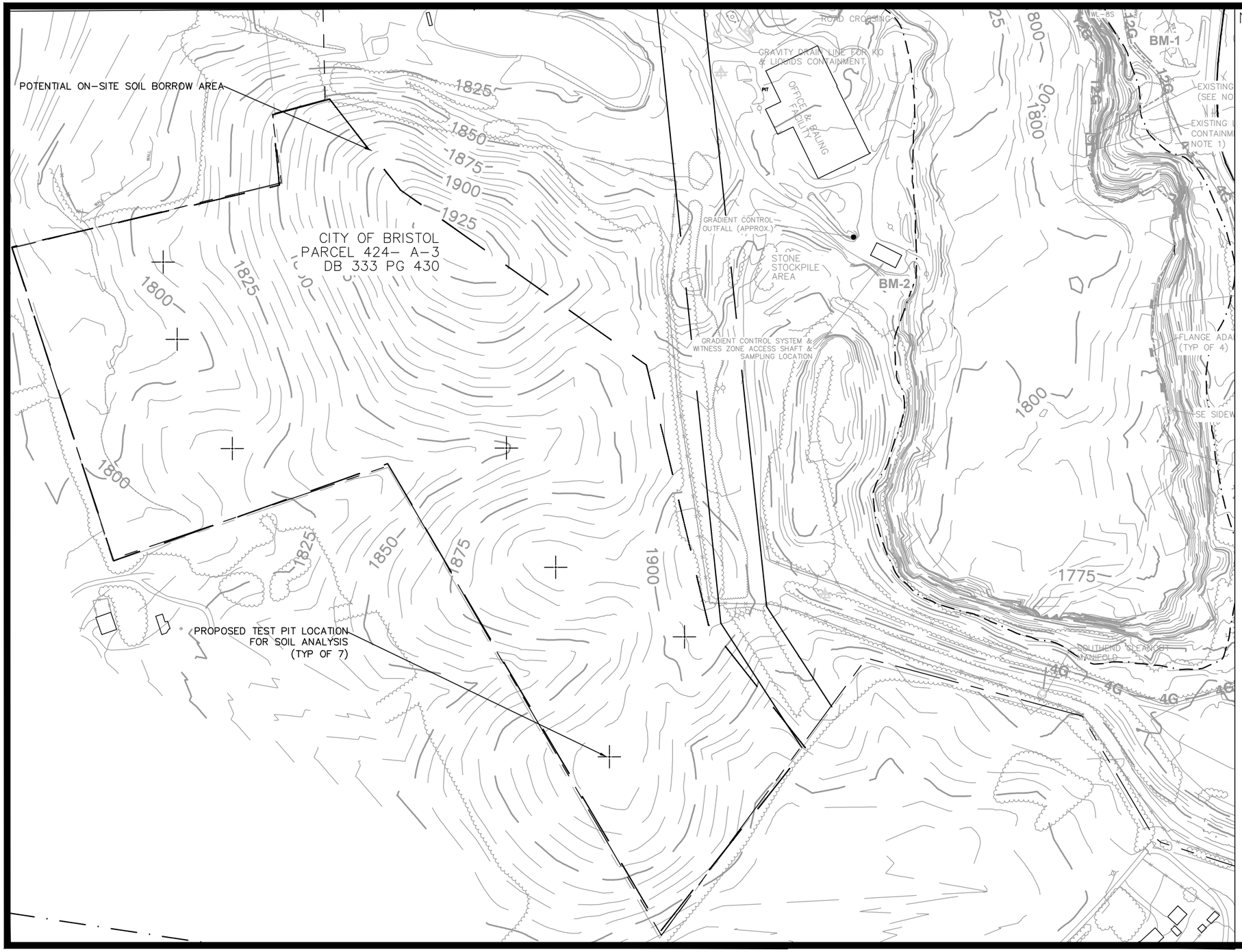


NOTES:

1. THE DRAWING HAS BEEN DEVELOPED IN CONJUCTION WITH PLANNING EFFORTS AND DEPICTS CONCEPTUAL DESIGN INFORMATION. THE ACTUAL NUMBER, LOCATION, ALIGNMENT, CONFIGURATION, AND FUNCTION OF PROPOSED FEATURES (SETTLEMENT PLATES) MAY BE MODIFIED TO ACCOMODATE FIELD CONDITIONS OR ADJUSTED BASED ON ADDITIONAL DATA OR COST IMPLICATIONS DURING ENGINEERING DESIGN ACTIVITIES AND CONSTRUCTION.
2. SEE SETTLEMENT PLATE DETAIL IN APPENDIX A, FIGURE A–5, DETAIL 1.
3. GRADES SHOWN AS HALF–TONE OUTSIDE THE PERMIT 588 BOUNDARY REPRESENT TOPOGRAPHY FROM AERIAL PHOTOGRAPHY PROVIDED BY 3DI, EASTON, MARYLAND, DATED MARCH 21, 1997, AND AERIAL LIDAR TOPOGRAPHY PROVIDED BY THE CITY OF BRISTOL ON JUNE 25, 2019 AND A TOPOGRAPHIC SURVEY PROVIDED BY THE CITY OF BRISTOL ON DECEMBER 12, 2019.
4. GRADES SHOWN AS HALF–TONE WITHIN THE PERMIT 588 BOUNDARY REPRESENT TOPOGRAPHY CAPTURED ON JUNE 15, 2021 AS PROVIDED BY DRAPER ADEN ASSOCIATES.

Figure B-1 - Settlement Plate Locations

DRAWN BY: RMM DATE: 07/06/2022 FILE NAME: 022189208.05 – ACTION PLAN



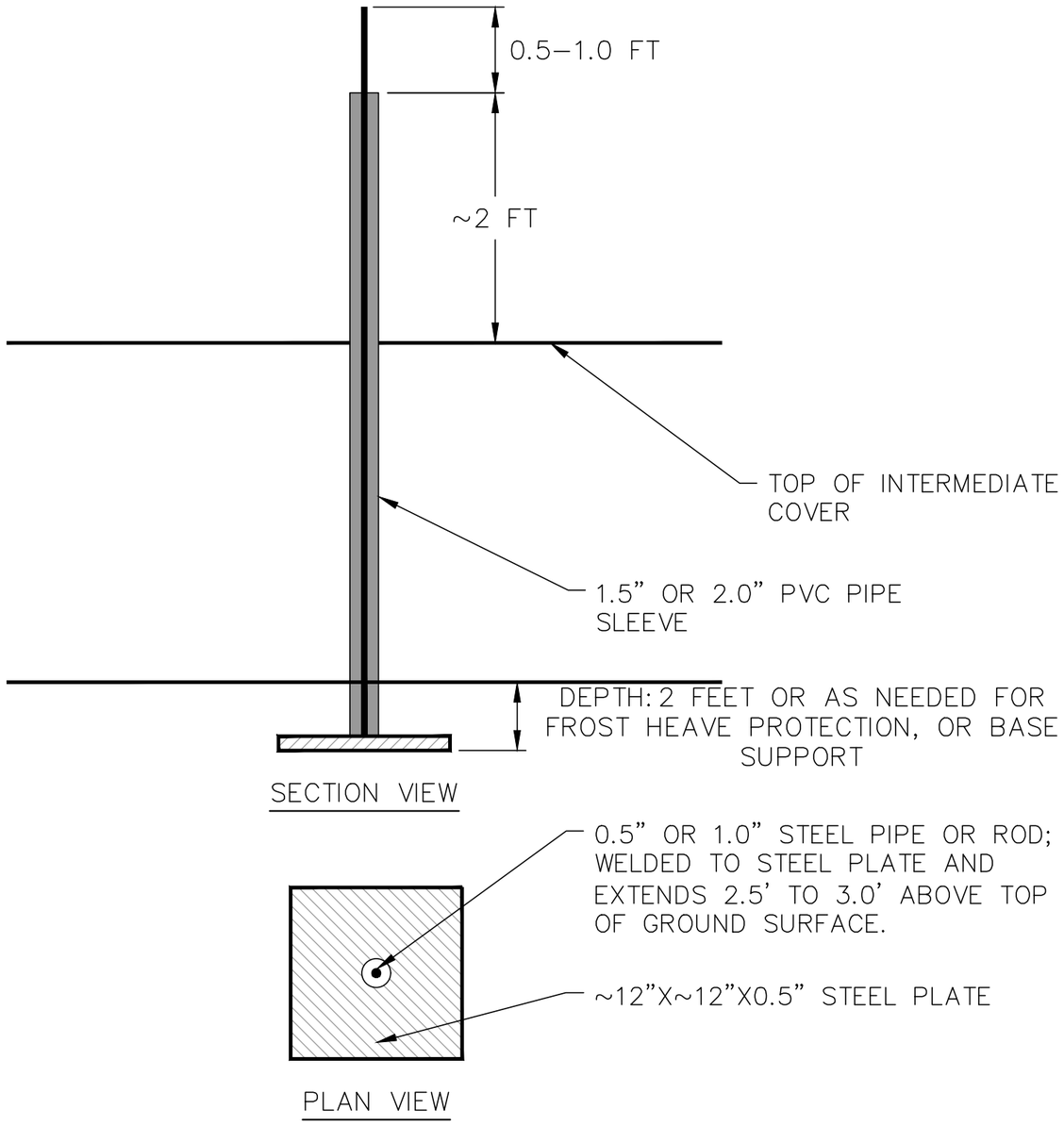
Notes:

1. THE OUTLINED AREA REPRESENTS THE AVAILABLE AREA FOR ON–SITE SOIL. THE FACILITY WILL HAVE TO DIG TEST PITS TO DETERMINE THE AVAILABILITY AND QUALITY OF SOIL.
2. PROPOSED SOIL TEST PIT LOCATIONS ARE DEPICTED ON THIS DRAWING. LOCATIONS CAN BE CHANGED OR ADDED BASED ON FIELD OBSERVATIONS. SEE SECTION 5.1 OF THE ACTION PLAN FOR SOIL SPECIFICATIONS AND TESTING.
3. GRADES SHOWN AS HALF–TONE OUTSIDE OF THE PERMIT 588 BOUNDARY REPRESENT TOPOGRAPHY DEVELOPED FROM AERIAL PHOTOGRAPHY PROVIDED BY 3DI, EASTON, MARYLAND, DATED MARCH 21, 1997, AND AERIAL LIDAR TOPOGRAPHY PROVIDED BY THE CITY OF BRISTOL ON JUNE 25, 2019 AND A TOPOGRAPHIC SURVEY PROVIDED BY THE CITY OF BRISTOL ON DECEMBER 12, 2019.
4. GRADES SHOWN AS HALF–TONE INSIDE THE PERMIT 588 BOUNDARY REPRESENT TOPGRAPHY CAPTURED ON JUNE 15, 2021 AS PROVIDED BY DRAPER ADEN ASSOCIATES.

SCS ENGINEERS

FIGURE B-2 - ON-SITE SOIL LOCATION

DRAWN BY: SHA DATE: 07/06/2022 FILE NAME: 02218208.05



SURFACE BENCHMARK SETTLEMENT PLATE NTS

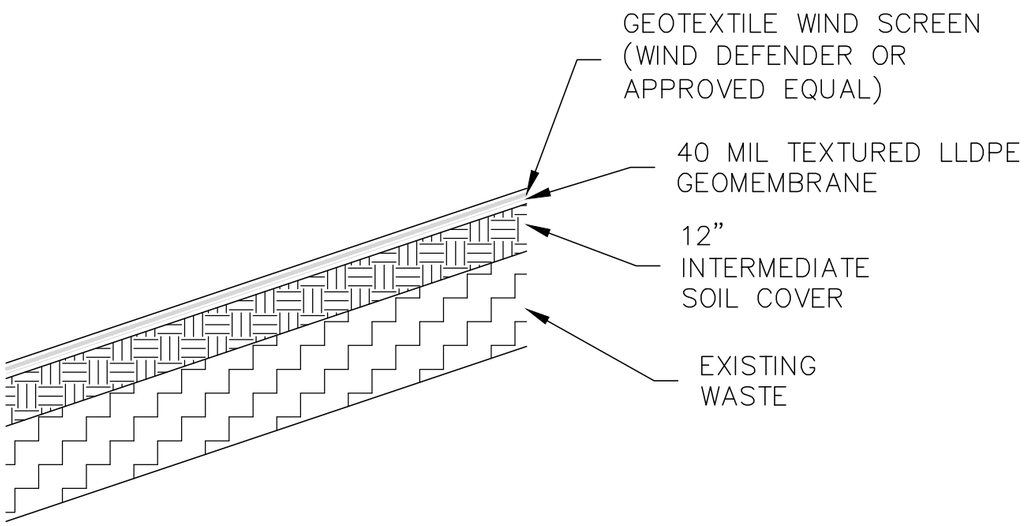
NOTES:

1. CONSTRUCT SETTLEMENT PLATES AS SHOWN; ACTUAL DIMENSIONS MAY VARY.
2. INSTALL AT SELECTED LOCATIONS AFTER COMPLETION OF INTERMEDIATE COVER CONSTRUCTION.
3. MEASURE AND RECORD HORIZONTAL COORDINATES AND VERTICAL ELEVATIONS OF STEEL RODS.
4. PROVIDE BOLLARDS OR OTHER PROTECTIVE FEATURES AROUND PVC SLEEVE.

SCS ENGINEERS

FIGURE B-3 - SETTLEMENT PLATE DETAILS

DRAWN BY: SHA DATE: 07/06/2022 FILE NAME: 02218208.05

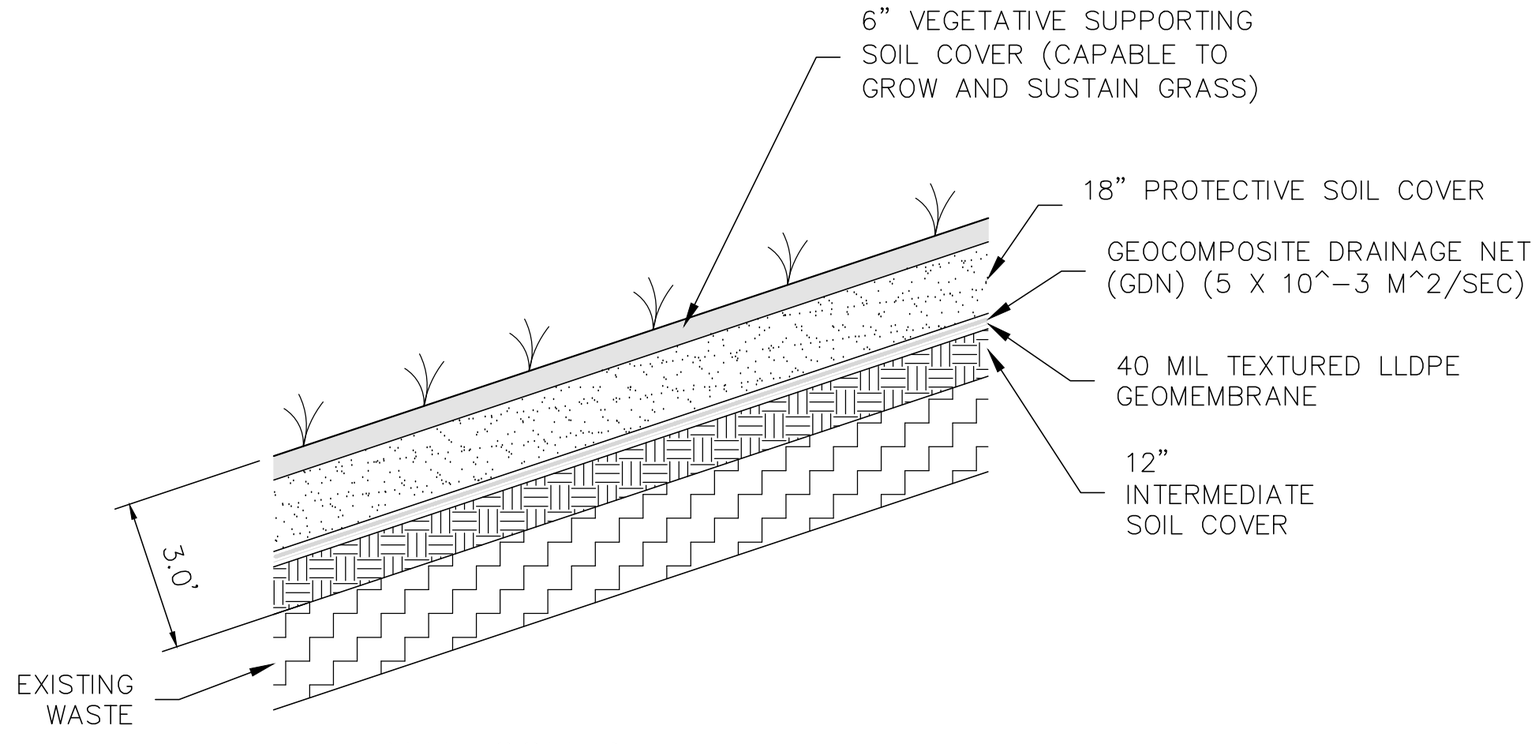


TEMPORARY COVER

NOT TO SCALE

NOTE:

1. THESE DETAILS HAVE BEEN DEVELOPED IN CONJUNCTION WITH PLANNING EFFORTS AND DEPICTS CONCEPTUAL DESIGN INFORMATION. THE ACTUAL DESIGN AND MATERIAL MAY BE MODIFIED TO ACCOMODATE FIELD CONDITIONS OR ADJUSTED BASED ON ADDITIONAL DATA OR COST IMPLICATIONS DURING ENGINEERING DESIGN ACTIVITIES AND CONSTRUCTION.
2. TEMPORARY COVER WILL BE UTILIZED OVER THE EXTENT OF THE LANDFILL IN THE SHORT TERM. IN THE EVENT THE DECISION IS MADE TO PERMANENTLY CLOSE THE LANDFILL, THE LANDFILL WILL RECEIVE FINAL COVER



FINAL COVER

NOT TO SCALE

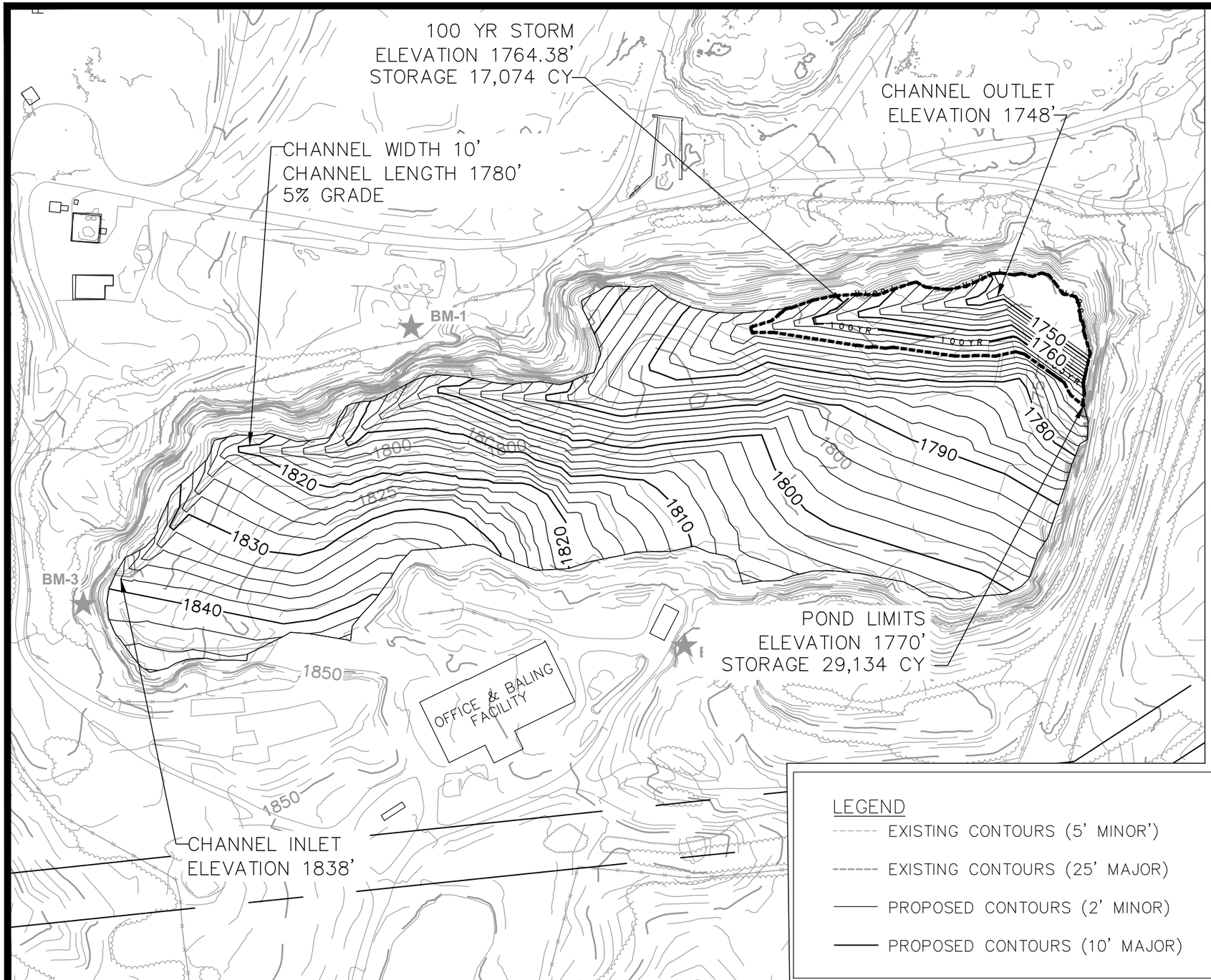
SCS ENGINEERS

FIGURE B-4 - TEMPORARY & FINAL COVER DETAILS

APPENDIX C

Stormwater and Grading Drawings

DRAWN BY: SHA DATE: 07/06/2022 FILE NAME: 02218208.05



NOTES:

1. GRADES SHOWN AS SOLID FULL-TONE CONTOUR LINES REPRESENT PROPOSED TEMPORARY GRADING FOR THE PURPOSE OF STORMWATER COLLECTION AND STORAGE.

2. GRADES SHOWN AS DASHED HALF-TONE CONTOUR LINES OUTSIDE THE PERMIT 588 BOUNDARY REPRESENT THE TOPOGRAPHY DEVELOPED FROM AERIAL PHOTOGRAPHY PROVIDED BY 3DI, EASTON, MARYLAND, DATED MARCH 21, 1997, AND AERIAL LIDAR TOPOGRAPHY PROVIDED BY THE CITY OF BRISTOL ON JUNE 25, 2019 AND TOPOGRAPHIC SURVEY PROVIDED BY THE CITY OF BRISTOL ON DECEMBER 12, 2019.

3. GRADES SHOWN AS DASHED HALF-TONE CONTOUR LINES INSIDE THE PERMIT 588 BOUNDARY REPRESENT THE TOPOGRAPHY CAPTURED ON JUNE 15, 2021 AS PROVIDED BY DRAPER ADEN ASSOCIATES

4. STORMWATER DETENTION POND WITHIN QUARRY LANDFILL TO BE EQUIPPED WITH GEOMEMBRANE LINER IN CONJUCTION WITH THE TEMPORARY COVER CONSTRUCTION.

LEGEND

- EXISTING CONTOURS (5' MINOR')
- EXISTING CONTOURS (25' MAJOR)
- PROPOSED CONTOURS (2' MINOR)
- PROPOSED CONTOURS (10' MAJOR)

N

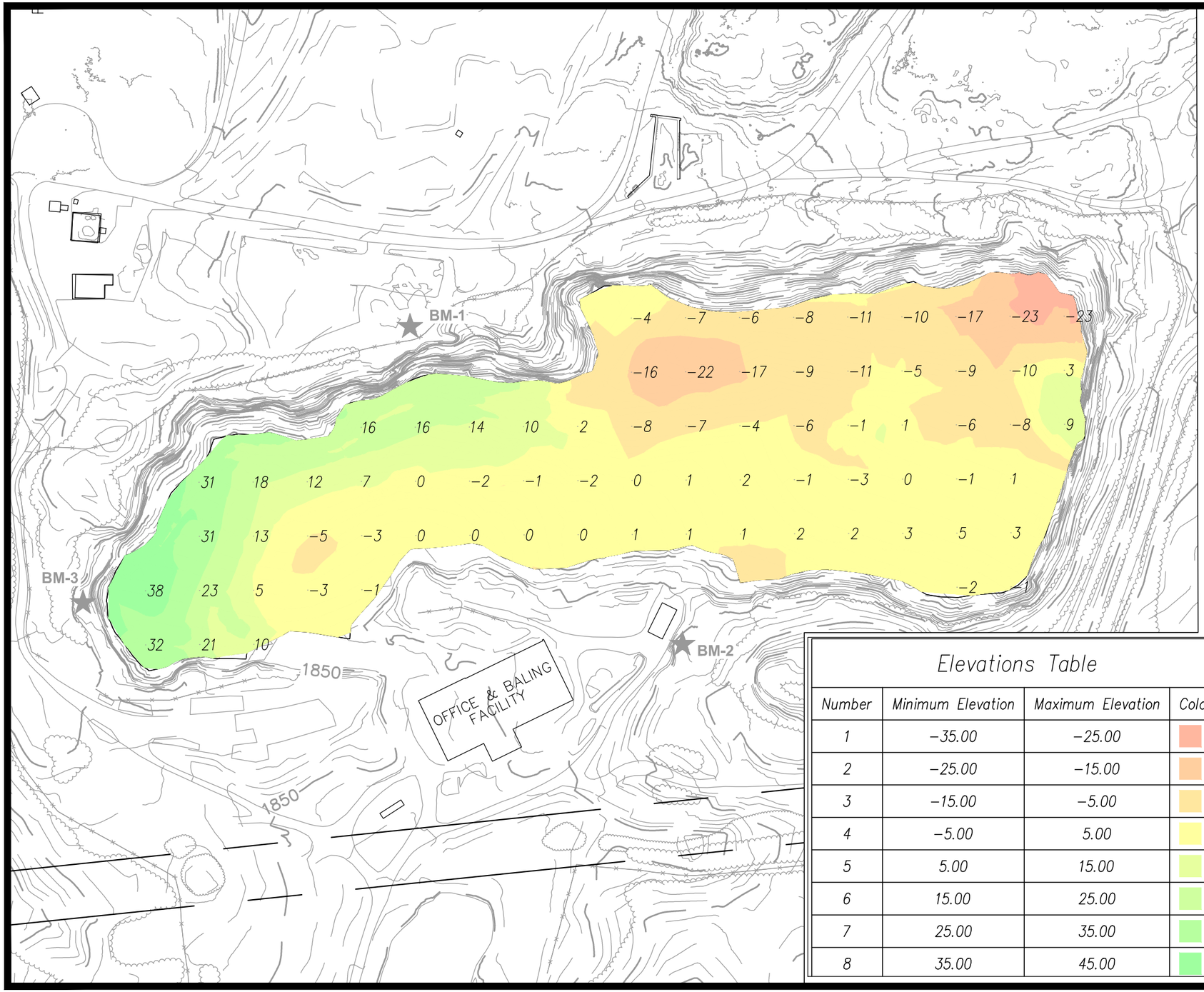
0 200 400

SCALE IN FEET

SCS ENGINEERS

FIGURE C-1 - TEMPORARY STORMWATER GRADING

DRAWN BY: SHA DATE: 07/06/2022 FILE NAME: 02218208.05



NOTES:

1. THE VOLUME MAP COMPARES THE LANDFILL TOPOGRAPHY WITHIN THE PERMIT 588 BOUNDARY PROVIDED BY DRAPER ADEN ASSOCIATES, DATED 6-15-2021 (BOTTOM SURFACE) TO THE PROPOSED GRADING (COMPARISON SURFACE).

2. POSITIVE NUMBERS INDICATED IN GREEN REPRESENT AREAS TO BE FILLED, NEGATIVE NUMBERS INDICATED IN RED REPRESENT AREAS TO BE CUT.

3. SCS ESTIMATES A FILL OF 136,050 CY AND A CUT OF 105,650 CY. THESE NUMBERS WERE CALCULATED IN CONJUNCTION WITH PLANNING EFFORTS AND ARE SUBJECT TO CHANGE BASED ON ADDITIONAL DATA, FIELD CONDITIONS, AND ENGINEERING MODIFICATIONS

Elevations Table

Number	Minimum Elevation	Maximum Elevation	Color
1	-35.00	-25.00	
2	-25.00	-15.00	
3	-15.00	-5.00	
4	-5.00	5.00	
5	5.00	15.00	
6	15.00	25.00	
7	25.00	35.00	
8	35.00	45.00	

N

0 200 400

SCALE IN FEET

SCS ENGINEERS

FIGURE C-2 - TEMPORARY STORMWATER GRADING CUT AND FILL

DRAWN BY: SHA DATE: 07/06/2022 FILE NAME: 02218208.05

NOTES:

1. CALCULATIONS ARE BASED ON INITIAL EXPOSED GEOMEMBRANE CONDITIONS AND A GEOMEMBRANE LINED CHANNEL.

Hydrology Report

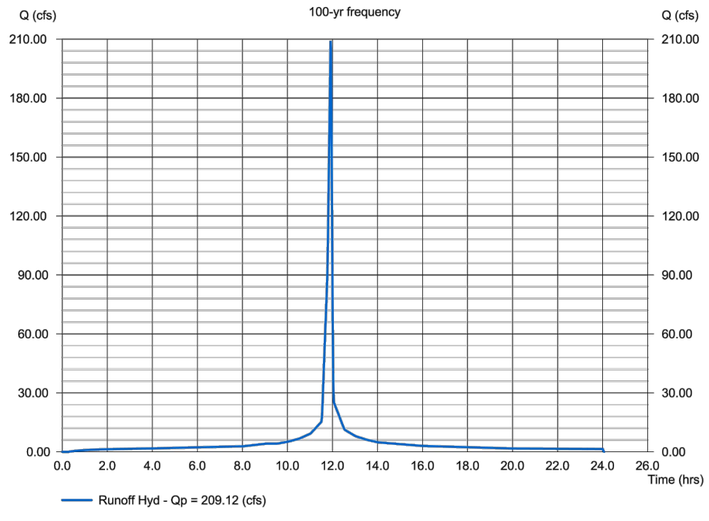
Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Jun 20 2022

Quarry Drainage Channel - 100 yr Storm

Hydrograph type	= SCS	Peak discharge (cfs)	= 209.12
Storm frequency (yrs)	= 100	Time interval (min)	= 1
Drainage area (ac)	= 17.300	Curve number (CN)	= 99
Basin Slope (%)	= *See Worksheet*	Hydraulic length (ft)	= *See Worksheet*
Tc method	= TR55	Time of conc. (min)	= 3
Total precip. (in)	= 7.95	Storm Distribution	= Type II
Storm duration (hrs)	= 24	Shape factor	= 484

Hydrograph Volume = 460,987 (cuft); 10.583 (acft)

Runoff Hydrograph



TR55 Tc Worksheet

Hydraflow Express by Intelisolve

SCS

Quarry Drainage Channel - 100 yr Storm

Description	A	B	C	Totals
Sheet Flow				
Manning's n-value	= 0.011	0.011	0.011	
Flow length (ft)	= 100.0	0.0	0.0	
Two-year 24-hr precip. ((in))	= 2.54	0.00	0.00	
Land slope (%)	= 5.00	0.00	0.00	
Travel Time (min)	**= 0.94**	**+ 0.00**	**+ 0.00**	**= 0.94**
Shallow Concentrated Flow				
Flow length (ft)	= 200.00	0.00	0.00	
Watercourse slope (%)	= 7.00	0.00	0.00	
Surface description	= Paved	Paved	Paved	
Average velocity (ft/s)	= 5.38	0.00	0.00	
Travel Time (min)	**= 0.62**	**+ 0.00**	**+ 0.00**	**= 0.62**
Channel Flow				
X sectional flow area ((sqft))	= 8.89	0.00	0.00	
Wetted perimeter ((ft))	= 14.62	0.00	0.00	
Channel slope (%)	= 5.00	0.00	0.00	
Manning's n-value	= 0.010	0.015	0.015	
Velocity (ft/s)	= 23.87	0.00	0.00	
Flow length (ft)	= 1780.0	0.0	0.0	
Travel Time (min)	**= 1.24**	**+ 0**	**= 1.24**	

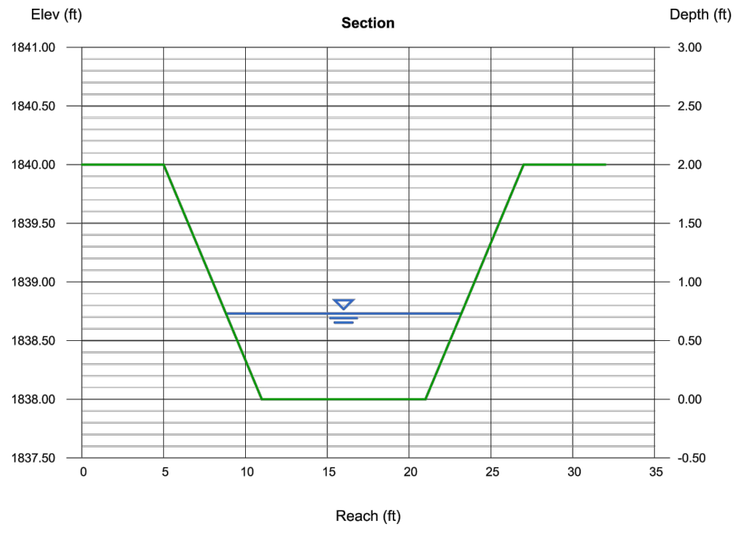
Total Travel Time, Tc ..... 3.00 min

Channel Report

Hydraflow Express Extension for Autodesk® Civil 3D® by Autodesk, Inc. Monday, Jun 20 2022

Quarry Drainage Channel - 100 yr Storm

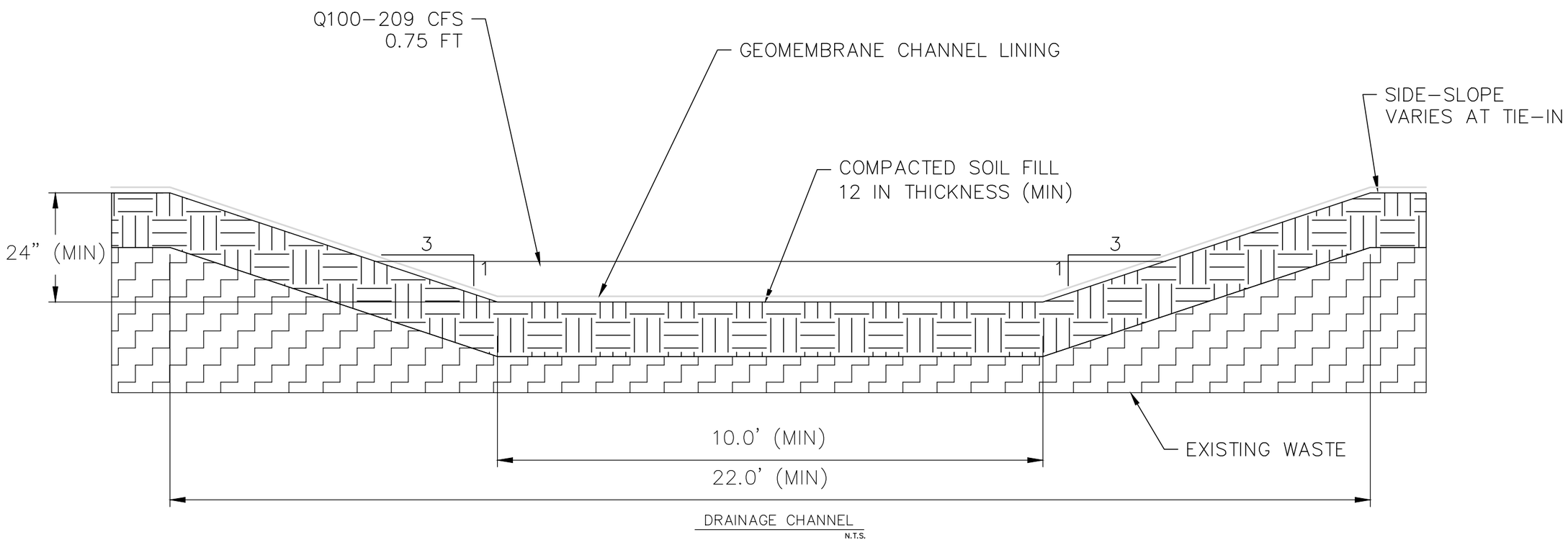
Trapezoidal		**Highlighted**	
Bottom Width (ft)	= 10.00	Depth (ft)	= 0.73
Side Slopes (z:1)	= 3.00, 3.00	Q (cfs)	= 209.12
Total Depth (ft)	= 2.00	Area (sqft)	= 8.90
Invert Elev (ft)	= 1838.00	Velocity (ft/s)	= 23.50
Slope (%)	= 5.00	Wetted Perim (ft)	= 14.62
N-Value	= 0.010	Crit Depth, Yc (ft)	= 1.95
		Top Width (ft)	= 14.38
Calculations		EGL (ft)	= 9.32
Compute by:	Known Q		
Known Q (cfs)	= 209.12		



SCS ENGINEERS

FIGURE C-3 - STORMWATER CALCULATIONS

DRAWN BY: SHA DATE: 07/06/2022 FILE NAME: 02218208.05



DRAINAGE CHANNEL
N.T.S.

NOTES:

1. CHANNEL SLOPE IS APPROXIMATELY 5%. THE 100-YR FLOW DEPTH IS APPROX. 0.75 FT.

FIGURE C-4 - DRAINAGE CHANNEL DETAILS

APPENDIX D

Odor Mitigation System Drawings

DRAWN BY: LLH DATE: 07/06/2022 FILE NAME: 02218208.05 – Action Plan

1. THIS DRAWING HAS BEEN DEVELOPED IN CONJUNCTION WITH PLANNING EFFORTS AND DEPICTS CONCEPTUAL DESIGN INFORMATION. THE ACTUAL NUMBER, LOCATION, ALIGNMENT, CONFIGURATION, AND FUNCTION OF PROPOSED FEATURES AND INFRASTRUCTURE MAY BE MODIFIED TO ACCOMMODATE FIELD CONDITIONS OR ADJUSTED BASED ON ADDITIONAL DATA OR COST IMPLICATIONS DURING ENGINEERING DESIGN ACTIVITIES AND CONSTRUCTION.

PILOT SECTION OF SIDEWALL ODOR MITIGATION SYSTEM APPROXIMATE LOCATION

INSTALL WELLHEAD TO HORIZONTAL COLLECTOR SEGMENT

UTILIZE COLLECTION PIPING AS PROVISION TO EXISTING SIDEWALL BLOWER AND FLARE

EXTEND EXISTING LFG LATERAL PIPING TO WELLHEAD TO SUPPLY VACUUM TO HORIZONTAL COLLECTOR.

EXTEND EXISTING FORCEMAIN AND AIRLINE TO ACCESS RISER AS PROVISION FOR LIQUIDS EXTRACTION AND CONVEYANCE.

LEGEND

- PROPOSED SIDEWALL ODOR MITIGATION SYSTEM PILOT DEMONSTRATION SECTION
- EXISTING 2" AIR LINE
- 2" AIR LINE
- EXISTING 4" FORCE MAIN
- PROPOSED 4" FORCE MAIN
- EXISTING LFG HEADER
- PROPOSED LFG HEADER
- 4G EXISTING 4" LFG HEADER
- 6G EXISTING 6" LFG HEADER
- 12G EXISTING 12" LFG HEADER
- BUILDING
- WASTE MANAGEMENT BOUNDARY
- EXISTING WELLHEAD
- EXISTING ISOLATION VALVE

N

0 150 300

SCALE IN FEET

SCS ENGINEERS

FIGURE D-1: PILOT ODOR MITIGATION SYSTEM

DRAWN BY: LLH DATE: 07/06/2022 FILE NAME: 02218208.05 – Action Plan

1. THIS DRAWING HAS BEEN DEVELOPED IN CONJUNCTION WITH PLANNING EFFORTS AND DEPICTS CONCEPTUAL DESIGN INFORMATION. THE ACTUAL NUMBER, LOCATION, ALIGNMENT, CONFIGURATION, AND FUNCTION OF PROPOSED FEATURES AND INFRASTRUCTURE MAY BE MODIFIED TO ACCOMMODATE FIELD CONDITIONS OR ADJUSTED BASED ON ADDITIONAL DATA OR COST IMPLICATIONS DURING ENGINEERING DESIGN ACTIVITIES AND CONSTRUCTION.

HEADER PIPING TO EXISTING LFG SYSTEM

SIDEWALL ODOR MITIGATION SYSTEM

FORCEMAIN AND AIRLINE

CONDENSATE SUMP

LFG HEADER PIPE TO TREATMENT STATION W/ CONNECTIONS AT APPROX. 100' O.C.

SIDEWALL ODOR MITIGATION SYSTEM BLOWER/TREATMENT STATION (IF SEPARATE STATION IS WARRANTED)

SE SIDEWALL MONITORING POINT (APPROX.)

DISCHARGE LINE FROM U-TRAP TO SUMP

ROAD CROSSING

1800

1775

LEGEND

- PROPOSED HORIZONTAL COLLECTOR
- EXISTING 2" AIR LINE
- PROPOPSED 2" AIR LINE
- EXISTING 4" FORCE MAIN
- PROPOSED 4" FORCE MAIN
- EXISTING LFG HEADER
- PROPOSED LFG HEADER
- 4G — EXISTING 4" LFG HEADER
- 6G — EXISTING 6" LFG HEADER
- 12G — EXISTING 12" LFG HEADER
- BUILDING
- WASTE MANAGEMENT BOUNDARY
- EXISTING WELLHEAD
- EXISTING ISOLATION VALVE

N

0 150 300

SCALE IN FEET

SCS ENGINEERS

FIGURE D-2: LARGE NETWORK SIDEWALL ODOR MITIGATION SYSTEM

APPENDIX E

Temperature Sensor Drawing

DRAWN BY: LLH DATE: 07/06/2022 FILE NAME: 02218208.05 – Action Plan

LEGEND

- EXISTING LFG WELLHEAD– VINTAGE 2021
- EXISTING LFG WELLHEAD– VINTAGE 2017
- PROPOSED TEMPERATURE MONITORING PROBE
- EXISTING AIR RELEASE VALVE
- EXISTING ISOLATION VALVE
- EXISTING CONDENSATE PUMP STATION
- EXISTING HORIZONTAL COLLECTOR SUMP
- EXISTING LFG LIQUIDS CONTAINMENT TANK
- EXISTING HORIZONTAL COLLECTOR
- EXISTING LFG HEADER
- 12G — EXISTING 12" LFG HEADER
- BUILDING
- WASTE MANAGEMENT BOUNDARY

NOTES

1. GRADES SHOWN AS DASHED HALF–TONE CONTOUR LINES OUTSIDE THE PERMIT 588 BOUNDARY REPRESENT THE TOPOGRAPHY DEVELOPED FROM AERIAL PHOTOGRAPHY PROVIDED BY 3DI, EASTON, MARYLAND, DATED MARCH 21, 1997, AND AERIAL LIDAR TOPOGRAPHY PROVIDED BY THE CITY OF BRISTOL ON JUNE 25, 2019 AND TOPOGRAPHIC SURVEY PROVIDED BY THE CITY OF BRISTOL ON DECEMBER 12, 2019.

2. GRADES SHOWN AS DASHED HALF–TONE CONTOUR LINES INSIDE THE PERMIT 588 BOUNDARY REPRESENT THE TOPOGRAPHY CAPTURED ON JUNE 15, 2021 AS PROVIDED BY DRAPER ADEN ASSOCIATES

3. THIS DRAWING HAS BEEN DEVELOPED IN CONJUNCTION WITH PLANNING EFFORTS AND DEPICTS CONCEPTUAL DESIGN INFORMATION. THE ACTUAL NUMBER, LOCATION, ALIGNMENT, CONFIGURATION, AND FUNCTION OF PROPOSED FEATURES AND INFRASTRUCTURE MAY BE MODIFIED TO ACCOMMODATE FIELD CONDITIONS OR ADJUSTED BASED ON ADDITIONAL DATA OR COST IMPLICATIONS DURING ENGINEERING DESIGN ACTIVITIES AND CONSTRUCTION.

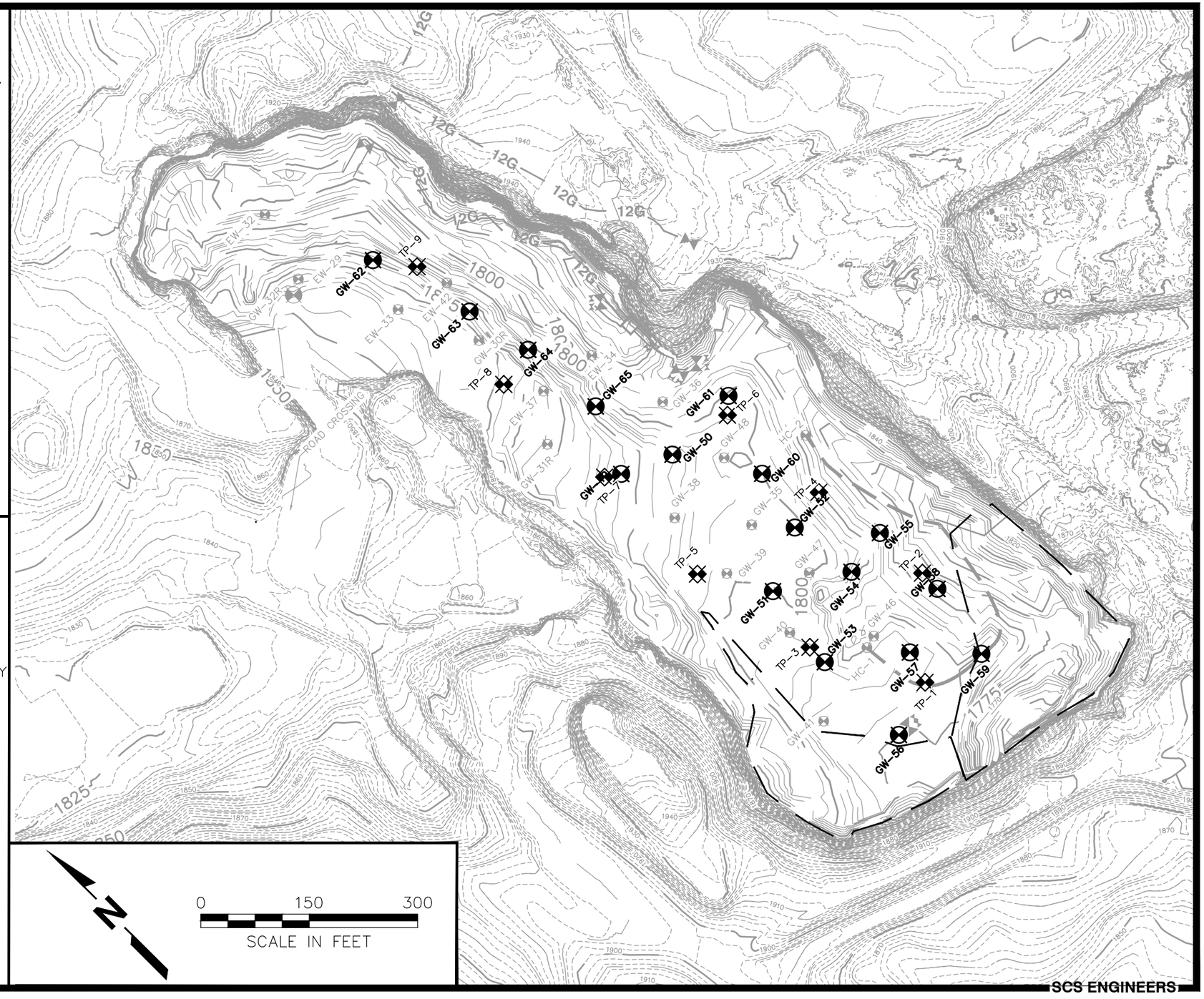


FIGURE E-1: CONCEPTUAL TEMPERATURE MONITORING PROBE LAYOUT