

The Narragansett Bay Commission

Phase III CSO Program

Pawtucket Tunnel Construction Spoils Reuse - Bucklin Point North & South Landfills

Design Basis Report

Date: February 18, 2022

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Revisions

Revision History

Date	Version	Description	Author(s)	Reviewer(s)	Date of Review(s)
2-18-2022	0.1	DRAFT Report			

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List of Abbreviations and Acronyms

AASHTO	American Association of State Highway and Transportation Officials
BVDC	Blackstone Valley District Commission
CMP	Corrugated Metal Pipe
CRMC	Coastal Resources Management Council
CSO	Combined Sewer Overflow
FHWA	Federal Highway Administration
GEP	Geotechnical Exploration Program
IDF	Intensity-Duration-Frequency
MSL	Mean Sea Level
NBC	Narragansett Bay Commission
NGVD 29	National Geodetic Vertical Datum of 1929
OA	Order of Approval
RIDEM	Rhode Island Department of Environmental Management
SESC	Soil Erosion and Sediment Control
TBM	Tunnel Boring Machine
TST	Temporary Sediment Trap
WWTF	Wastewater Treatment Facility

Executive Summary

The Narragansett Bay Commission (NBC) has embarked on the design and construction of Phase IIIA of its Phase III CSO Program. The Pawtucket Tunnel is the largest part of the Program, to be constructed using a tunnel boring machine (TBM) that will generate upwards of 600,000 cubic yards of crushed up rock that will need to be managed during construction, requiring offsite disposal or reuse. NBC proposes to use approximately 160,000 cubic yards of it as fill material on top of two closed sludge landfills, herein referred to as the North and South Landfills, at the Bucklin Point Wastewater Treatment Facility (WWTF). The reuse of this material at the landfills will lower construction costs and reduce schedule risk by diverting it from offsite disposal. The work will be performed on contiguous properties owned and controlled by NBC. The material excavated during construction of the Pawtucket Tunnel is suitable for the proposed activity and the proposed work is consistent with other goals NBC has for the landfill sites.

No proposed slope shall exceed maximum 3H:1V side slope, unless it is stabilized with riprap (to a maximum slope of 2H:1V) or retained with gabion retaining walls. Existing slopes at the North Landfill that are currently steeper than this are not proposed to be disturbed, and appear to be stabilized by existing deep-rooted vegetation. The minimum slope at the top of both landfills will be 3% to promote stormwater runoff. A new gravel access road is proposed on top of the North Landfill to maintain access to the WWTF when improvements are made to the existing paved access road along the east side of the landfill. The proposed final grades at the North Landfill are supportive of multiple potential future uses, including renewable energy (e.g., ground mounted solar) and passive recreation. While these uses are being considered, there are currently no plans for future uses of the site and it will be restored and stabilized in accordance with RIDEM and CRMC requirements at the end of this project. Any future use would be designed and permitted separately, at a future date.

Hydraulic calculations were performed to design improvements to stormwater controls at both landfill sites. The existing paved access road along the east of the North Landfill will be improved to address ongoing problems where stormwater runs onto the road and does not properly drain off of it. A slope stability analysis was performed which demonstrates that the proposed grading as designed will be stable, and this work will not further destabilize the existing landfill slope. Finally, a passive gas venting system is proposed at the North Landfill to intercept potential landfill gases that may be prone to migrate offsite due to the changes proposed at the site.

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Section 1.0

Introduction

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1.0 Introduction

The Narragansett Bay Commission (NBC) has embarked on the design and construction of Phase IIIA of its Phase III CSO Program. The Pawtucket Tunnel Design Build project is the largest and most significant project in the Program, currently undergoing final design and construction by the team of CBNA-Barletta Phase IIIA Joint Venture (CB3A). The tunnel will have a 30-foot finished inside diameter and it will be approximately 11,600 feet long once completed in 2025. It is designed for a 58.5 MG storage capacity for the estimated combined sewer flow from the 3-month, 6-hour rainfall.

The tunnel will be constructed using a tunnel boring machine (TBM) that will be lowered to the elevation of the tunnel through a 60-foot diameter tunnel launch shaft at its downgradient end. Tunnel construction spoils will be removed through this launch shaft by a conveyer belt system. The TBM will then be removed from a tunnel receiving shaft at its upgradient end once tunneling is complete. An 80-foot diameter shaft will also be constructed for the tunnel pump station, and four (4) vortex-style drop shafts will be constructed to convey flow from the surface down into the tunnel. Figure 1-1 shows the alignment of the tunnel and the locations of the proposed shafts. Tunnel construction will displace upwards of 600,000 cubic yards of crushed up rock that will need to be managed during construction, requiring reuse or offsite disposal.

1.1 Purpose

One of the measures proposed for managing displaced tunnel construction material is to use some of it in shaping and grading on top of the North and South Landfills at the Bucklin Point Wastewater Treatment Facility (WWTF). It is estimated that approximately 160,000 cubic yards of this tunnel construction material can be used at the two landfills. Both landfills are located at the Bucklin Point Wastewater Treatment Facility (WWTF), as shown on Figure 1-2.

1.2 Objectives

This report presents the feasibility and design basis for meeting the NBC’s stated objectives for the project, which are as follows:

- Maximize the use of displaced tunnel construction material to reduce the amount that otherwise requires offsite disposal. This will lower project costs and reduce schedule risk by providing an Owner-controlled site for displaced tunnel construction material.
- Provide final grades that support potential future site uses. No future uses have been decided on at this time, but options under consideration include passive recreation and renewable energy (e.g., ground mounted solar).
- Provide final grades with stabilized vegetated slopes that promote stormwater runoff in a non-erosive manner.
- Provide final grades that have minimal impact on stakeholders by limiting the final height of each landfill and minimizing encroachment toward property lines.
- Incorporate stormwater controls into the proposed final grades to prevent erosion and reduce nuisance flooding.
- Add controls to vent methane to the surface, to mitigate potential offsite migration.

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Figure 1-1 Pawtucket Tunnel

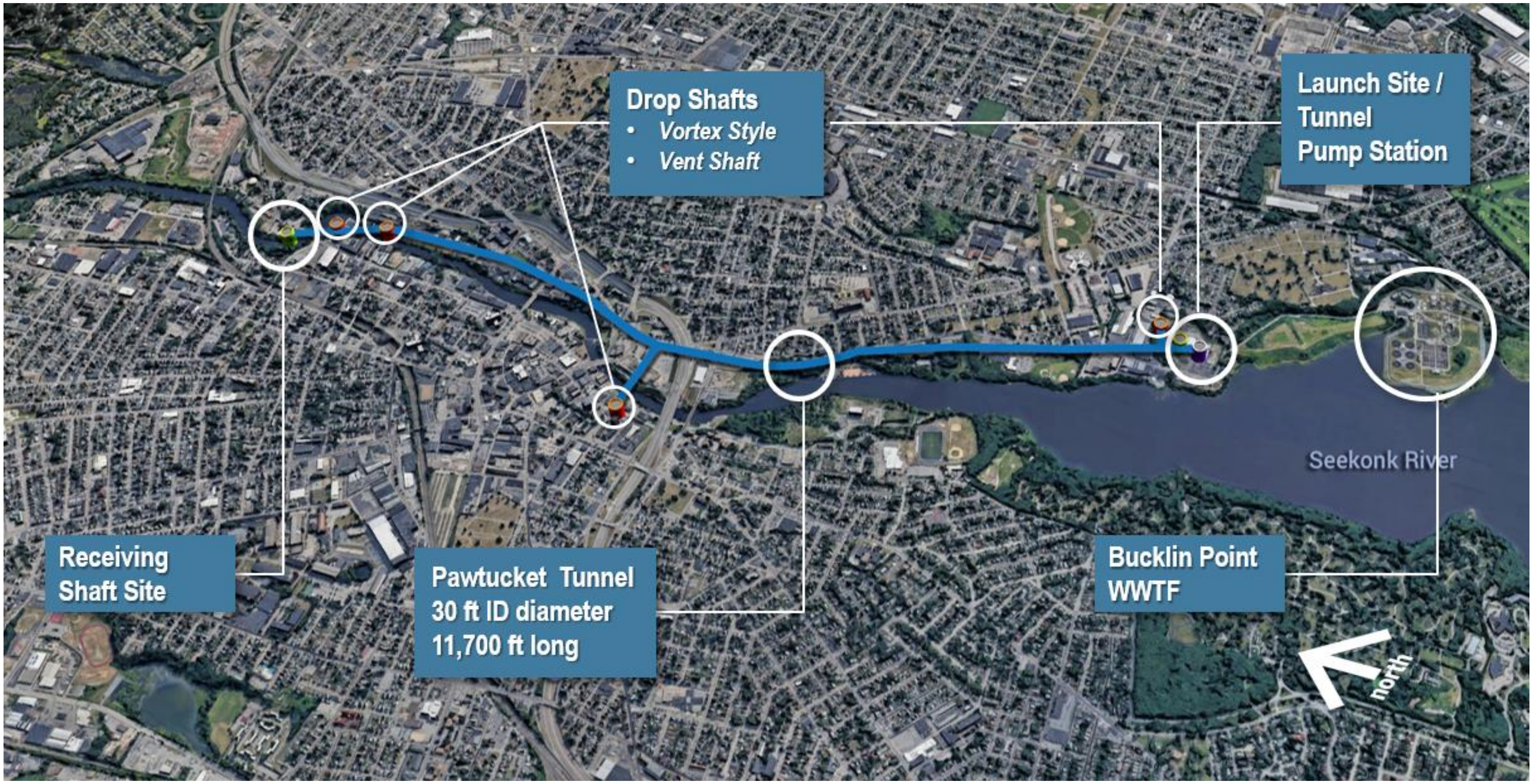

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Figure 1-2 Bucklin Point North and South Landfills

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Section 2.0

Existing Conditions

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2.0 Existing Conditions

Much of the background information provided in this section is based on information provided by NBC or files reviewed at the RIDEM Office of Water Resources. The Bucklin Point WWTF was operated by the Blackstone Valley District Commission (BVDC) until its merger with the Narragansett Bay Water Quality Management District Commission, which later became the Narragansett Bay Commission. This merger went into effect on January 1, 1992.

2.1 Bucklin Point North Landfill

Development of the BVDC Sludge Landfill (now referred to as the North Landfill) dates to the early 1980s, following RIDEM approval (via RIDEM Order of Approval No. 492) of plans entitled "Additions and Modifications to Existing Wastewater Facilities, Sludge Landfill – Plan" prepared by Metcalf & Eddy, Inc. (M&E) and dated February 1980. Prior to this, historical aerial images and shoreline change maps from CRMC show that the river once extended under large parts of the North Landfill, but that the area was filled gradually over time. It appears much of this work was conducted in the 1950s through 1970s.

In the 1980s, the landfill site was prepared for landfilling the sludge from operations at the Bucklin Point WWTF by preparing subgrade, installing perimeter drainage, and constructing a dike along the shoreline. This dike has generally become the shoreline edge of a perimeter access road along the western toe of the present-day North Landfill. Other records suggest that the dike was constructed to approximately 10 feet high above the shoreline, which topographic survey generally corroborates. Once established, waste sludge from the Bucklin Point WWTF, and intermittently from the Fields Point WWTF, was being buried at the North Landfill with gravel cover material.

A paved road provides access for trucks and delivery vehicles to the Bucklin Point WWTF from an entrance at Nassau Street. This road travels alongside the eastern toe of the North Landfill and into the Bucklin Point WWTF. The other entrance to the site, from Campbell Avenue, is the main entrance and is used by passenger vehicles because of truck restrictions in the residential neighborhood east of site. An entrance to the southern limit of the site, off of Roger Williams Avenue, is gated and not typically used. Three paths provide access to the top of the North Landfill from the paved access road – a gravel access road travels to the top of the landfill at the approximate midpoint while grass roads lead to the top at the far north and south ends. A grass access road along the western toe of the landfill is also maintained by NBC. NBC mows the top of the landfill while brush and woody vegetation has grown along the side slopes. An osprey nest roost located on top of the North Landfill is being removed by NBC in advance of the proposed work of this application. Several birdhouses at the northern end of the landfill will be removed and replaced during the proposed filling activities.

A closed drainage system was constructed when the landfill was developed in the 1980s. This system collects surface drainage from both the site and offsite areas from the east that drain to the site, and an underdrain constructed along the east side of the paved access road. Record drawings show that this underdrain consists of 12-inch perforated corrugated metal pipe (CMP) and is upwards of 20 feet below grade in some areas. The surface drainage system consists of drainage manholes and other structures, piping up to 36 inches in diameter, and culverts crossing beneath the paved access road. The surface drainage and underdrain systems discharge to the river at outfalls to the northwest and southwest of the landfill. A 60-inch CSO outfall from the North Diversion Structure, identified by NBC as OF-002, also discharges combined sewer overflows during wet weather events to the southwest of the landfill. Other outfalls along the western toe of the slope are believed to be inactive.

Borings were performed at the North Landfill in late 2017 as part of the Phase III CSO Geotechnical Exploration Program (GEP). These borings were identified as B17-1 and B17-2A and are shown on the drawings. Another boring, B17-2, was started but abandoned and grouted closed before it was completed due to the discovery of high levels of methane. Both B17-1 and B17-2A were converted to monitoring wells and groundwater was monitored periodically for following their installation. Boring logs and groundwater monitoring results are provided in Appendix A.

A visual impact assessment was conducted for the North Landfill in March 2021 to assess potential impacts to sight lines from abutting or nearby properties. The analysis consisted of flying 4-foot diameter weather balloons from various locations on the existing landfill, which were raised to the proposed final height of the landfill following filling and grading to represent final site conditions. Five weather balloons were used. Observations were made from several vantage points around the site and recorded by taking photographs looking out toward the landfill. The vantage points used were all publicly accessible, and no private properties were entered. Views of the balloons in the surrounding neighborhoods were generally limited and it was concluded that the current proposed height of the landfill would not likely have a significant visual impact on the residents in the surrounding area. This work was done in early Spring before foliage was in bloom so that sight lines were not obscured by tree canopy. A memorandum summarizing this assessment is included as Appendix B.

Closure of the landfill began in 1996 upon the site reaching its capacity in accordance with a Closure Plan prepared by NBC in 1995. Prior to its closure, waste sludge from the Bucklin Point WWTF, and intermittently from the Fields Point WWTF, was being buried at the landfill with gravel cover material. RIDEM issued Order of Approval No. 1268 accepting modifications to sludge handling and management at the Bucklin Point WWTF, including the landfill closure. Similarly, CRMC issued an Assent approving the closure of the Bucklin Point North Landfill upon RIDEM’s approval.

A report by NBC entitled “Bucklin Point North Landfill Closure Plan”, dated August 1995 and revised in November 1995, described the planned closure of the landfill. The maximum allowable elevation of the landfill at closure was 145 feet in the Pawtucket Datum, or 47.3 feet above MSL in NGVD 1929. An exception to this is in the northern plateau where the existing top of landfill had already exceeded this elevation. It appears this area was allowed to stay at its current height to avoid excavation and relocation of buried sludge. This part of the landfill is at a maximum elevation of approximately 58 feet MSL (NGVD 1929). Otherwise, the remainder of the landfill is at or below 47.3 feet MSL (NGVD 1929).

The closure was performed by regrading slopes with imported gravel, covering with loam and compost, and hydroseeding to stabilize the site and limit erosion. Landfill side slopes would be graded to a maximum slope of 3 horizonal to 1 vertical (e.g., 3H:1V) unless steeper slopes were already stable whereas regrading might destabilize them. The minimum top slope was set to 3% to promote runoff. Closure was completed in late 1996, as reported by NBC.

2.2 Bucklin Point South Landfill

The Bucklin Point South Landfill is located directly south of the Bucklin Point WWTF. Based on file information reviewed at the RIDEM, this site was used as a borrow area and for stockpiling and disposal before it was established as a sludge landfill in the early 1990s. Historic deposition of iron slag and concrete reportedly formed a berm along the shoreward side of the site. Aerial images also suggest that portions of the river were filled in this area in the 1950s.

The Seekonk River surrounds this site to the north, west, and southwest. The shoreline feature was flagged and mapped by Pare Corporation personnel. There is a 50-foot setback and 200-foot contiguous area offset from the shoreline feature. Salt marsh areas were mapped in the river, to the north and west of this site. In addition, an area of emergent plant community was identified near the northwest corner of the site and there is an isolated freshwater wetland to the north. Neither of these areas have established regulatory setbacks. The landfill is bordered by a grass access road to the east, which travels from the Bucklin Point WWTF to Roger Williams Way to the south. The 48-inch East Providence Interceptor (EPI) flows to the Bucklin Point WWTF beneath this access road. According to City of East Providence tax assessor mapping, an easement borders this site directly to the south and the property beyond this easement is reportedly owned by Merrymeeting Realty LLC.

The South Landfill was created by relocating and burying sludge and cover soils excavated from the Bucklin Point North Landfill as part of a project referred to as the “Rejuvenation of the BVDC Sludge Disposal Facilities”. RIDEM Order of Approval No. 953 authorized the excavation of the material from the North Landfill, as proposed by drawings entitled “Rejuvenation of the Blackstone Valley District Commission Sludge Disposal Facilities”, dated October 1990 and prepared by BETA Group, Inc. RIDEM Order of Approval No. 954 authorized modified plans for the creation of the South Landfill, based on plans prepared by BETA Group, Inc. and dated December 1990. CRMC issued Assent B90-9-15 authorizing the proposed activities.

Permitting and construction bid documents suggest that on the order of 100,000 to 120,000 cubic yards of a sludge and cover soil mix were proposed to be relocated to the Bucklin Point South Landfill; however, the actual quantity of material relocated to this site has not been verified. Existing grades make it difficult to determine the actual limits of the Bucklin Point South Landfill. Borings have not been performed at the South Landfill. Since it was constructed by the relocation of sludge and gravel mixture excavated from the North Landfill, its composition may be less layered and more heterogenous than observations made in borings at the North Landfill.

The subgrade beneath the landfill is also unknown, and part of the area is known to have once been within the river before having been filled in. Nearby historical borings were used to approximate subgrade conditions in the meantime until borings can be performed at the South Landfill.

The site is relatively small in comparison to the Bucklin Point North Landfill. It is also much lower, with an existing peak elevation of about 22 feet MSL (NGVD 29). The top of the landfill is very flat, with side slopes typically about 5:1 or flatter. The site is primarily covered with grass and brush but there are coastal buffer plantings along the shoreward sides of the site. It appears that the South Landfill was closed in accordance with the requirements and stipulations of the CRMC Assent and RIDEM Order of Approval sometime in the early 1990s, though the exact dates of closure are currently unknown. An osprey nest roost located on top of the South Landfill is being removed by NBC in advance of this proposed construction.

Section 3.0

Proposed Conditions

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3.0 Proposed Conditions

The design of this project is depicted on the drawing set entitled "Narragansett Bay Commission Phase III Combined Sewer Overflow Program Pawtucket Tunnel – Construction Spoils Reuse, Bucklin Point Landfills – East Providence, RI", dated February 2022.

3.1 Proposed Final Site Conditions

3.1.1 North Landfill

Proposed final site conditions for the Bucklin Point North Landfill are depicted on drawing sheets C-6 through C-23. These include the following:

- Erosion and Sedimentation Control Plans, for multiples phases of construction (C-6 – C-10),
- Key Plan and Grading Plans (C-11 – C-13), showing the proposed final grades and stormwater controls,
- Final Site Plans (C-14 – C-15), showing the proposed finished surface conditions,
- Plan and Profile sheets (C-16 – C-20), of new or reconstructed access roads at the landfill, and
- Cross Sections (C-21 – C-23).

Filling and grading of the North Landfill will be done in phases to minimize disturbance during construction. Based on the landfill size and configuration, four phases are planned. Drawing sheet C-6 (Key Plan) and sheets C-7 through C-10 (Phases 1 – 4) are color coded drawings showing how the work is currently planned to be phased. Phasing is anticipated to begin in the lower, southern end of the landfill (Phase 1) with the work progressing northerly, toward higher areas of the landfill in Phases 2 and 3. The phasing plans show the conditions anticipated at the end of each phase of the work.

Side slopes will be graded at maximum slope of 3H:1V, transitioning to a flatter top plateau with a minimum slope of 3%. The proposed peak elevation of the Bucklin Point South Landfill is approximately 65 feet MSL (NGVD 1929). This is higher than the permitted peak elevation at landfill closure; however, the final grades have been planned to minimize visual impact to abutters while sacrificing the fill volume that could be accommodated at the site. The proposed final grades also allow for future uses that are being considered by NBC, including renewable energy (e.g., ground solar array) or recreation. A one-foot clean soil cover underlain by nonwoven geotextile will be spread over the entire landfill to cover the tunnel construction debris. Accounting for this soil cover, approximately 95,000 cubic yards of tunnel muck is anticipated to be used in the proposed grading at the North Landfill. Plateau areas and moderately sloped areas will be seeded with RIDOT seed mix to prepare the site for future use. NBC will maintain these areas by periodically mowing them. Steeper side slope areas up to 3H:1V will be seeded with low-maintenance wildflower mix to create the appearance of naturalized buffers. Areas along the toe of the landfill and along the east side of the paved access road where slopes steeper than 3H:1V are required in some areas will be stabilized with R-4 riprap up to 2:1 slope. Gabion walls have been proposed where conditions require that retaining walls be used to tie into existing grades. Drawing sheets C-14 and C-15 provide color-coded hatching to demonstrate the proposed final surfaces throughout the site.

3.1.2 South Landfill

Proposed final site conditions for the Bucklin Point South Landfill are depicted on drawing sheets C-25 through C-28. These include an Erosion and Sedimentation Control Plan (C-25), Final Site Plan (C-26), Plan and Profile (C-27), and Cross Sections (C-28).

Prior to construction, erosion and sedimentation controls will be established in accordance with the approved Soil Erosion and Sediment Control (SESC) Plan and the Erosion and Sedimentation Control Plan (sheet C-25). Once controls are established, the site will be filled with tunnel construction spoils in uniform lifts based on the contractor's means and methods. Given the size of this landfill with total disturbance of approximately 5 acres, this work will be conducted in one phase. Stormwater controls during filling and grading activities will include temporary swales and conveyances to direct stormwater to temporary sediment traps (TSTs). Three TSTs are planned, as shown on drawing sheet C-25. These controls will be used until the site is stabilized with loam and seed.

Side slopes will be graded at maximum slope of 3H:1V, transitioning to a flatter top plateau with a minimum slope of 5%. The proposed peak elevation of the Bucklin Point South Landfill is approximately 47.5 feet MSL (NGVD 1929). It is unknown if a peak elevation was established at the time of its closure. A one-foot clean soil cover underlain by nonwoven geotextile will be spread over the entire landfill to cover the tunnel construction debris. Accounting for this soil cover, approximately 65,000 cubic yards of tunnel muck is anticipated to be used in the proposed grading at the South Landfill. The plateau area will be seeded with RIDOT seed mix and side slopes will be seeded with low-maintenance wildflower mix.

The existing grass access road along the eastern side of the landfill will be raised in areas to promote stormwater runoff and returned to its existing condition. This road is infrequently used so a grass surface, like the existing condition, is suitable. This includes widening it to a 24-foot width to allow two-way trick traffic and elevating it in some areas to increase its slope for improved stormwater runoff conveyance. A new access road will also be constructed to the top of landfill in the final site condition to provide future access for maintenance activities. Because this access road is intended for maintenance activities which will be done by smaller vehicles and infrequently, it has been limited to 10 feet wide. Both access roads will be provided with a 2% cross slope to direct stormwater toward new roadside swales. These swales, and additional swales around the toe of the landfill, will be 2-feet wide and 2-feet deep with riprap bottom and side slopes in accordance with the project details. These swales will drain toward one of two culvert sections, generally at the northeast and southwest corners of the landfill.

3.2 Stormwater Hydraulics

Stormwater will be controlled using riprap drainage swales and diversion benches in the final proposed conditions at both landfills. Post-construction watershed limits in the project area will be unchanged from existing conditions. However, proposed conditions represent an increase in peak runoff, despite land cover remaining largely unchanged, due to an increase in steep slopes and the addition of the new gravel access roads. Because stormwater discharge is to the Seekonk River (a 4th Order or larger stream) peak flow control is not required. As such, a detailed hydrologic analysis comparing pre-construction and post-construction rates of runoff has not been performed. Also, since only a negligible increase in the runoff volume to the existing drainage piping at the North Landfill site is anticipated, calculations have not been performed to verify its capacity. Proposed stormwater controls represent an improvement from existing conditions where stormwater is allowed to run onto and across the existing paved access road, so no reduction in level of service is anticipated.

Temporary swales/diversions and temporary sediment traps (TSTs) are anticipated to be used to control stormwater during construction. Each TST was sized in accordance with the Rhode Island Soil Erosion and Sediment Control Handbook to control 1 inch of runoff from its contributing area. These calculations have been provided in the SESC Plan for this project, and TST dimensions are included on the project details.

Peak rates of runoff to proposed final stormwater controls were estimated for each sub-watershed area using the Rational method. Rainfall intensity was estimated to be 6.4 in/hour, based on a 25-year return period design storm and the Intensity-Duration-Frequency (IDF) curve for the Providence, RI area. Drainage swales and diversion benches were designed with consistent width and depth, so the capacity of each conveyance was estimated at its most critical section (e.g., section of flattest slope). Regardless of stormwater flow, all swales were designed with a trapezoidal cross section with 2:1 side slopes, a minimum depth of 2 feet, and minimum width of 2 feet.

Catch basins have been proposed at the North Landfill to intercept runoff in drainage swales, where grate capacity is sufficient to accept the estimated runoff from the 25-year design storm without excessive ponding. Catch basin outlets connect to existing and/or new drainage manholes on the existing closed drainage piping at the site. New pipes have been sized using AutoCAD Civil3d package Storm Sewers Hydraflow v10.30. Where catch basin grate capacity will be exceeded, culverts have been proposed instead. Culvert design was performed using the HY-8 Culvert Hydraulic Analysis Program developed by the Federal Highway Administration (FHWA).

There is no existing closed drainage system at the South Landfill. As such, drainage swales will flow to new culverts, which will discharge toward the river at the northwest and southwest of the landfill. These culverts have also been designed using the FHWA HY-8 software.

Appendix C includes hydraulic calculations performed to support the design of proposed stormwater conveyances.

3.3 Slope Stability Analysis

A slope stability analysis was performed for both the North and South Landfills. The objective of this analysis was to evaluate the stability of each landfill after the addition of the proposed tunnel construction material. The analysis was done using proprietary software, SLOPE/W 2021 R2 software by GeoSlope, to check that the modeled stability meets or exceeds industry standard factors of safety for the proposed grading. Slope stability analyses were modeled using the Morgenstern-Price method. A minimum factor of safety ranging from 1.3 to 1.5 is recommended per American Association of State Highway and Transportation Officials (AASHTO).

A profile of the material within the existing North Landfill used for this analysis was based on two borings performed in 2017. Borings have not been performed at the South Landfill, but conditions were assumed to be like that of the North Landfill. Assumed soil parameters for the tunnel construction material proposed to be used in filling and grading operations were based in part on geotechnical testing of samples collected from stockpiles of similar material generated during NBC's Providence Tunnel project (stockpiles located at Smithfield Peat Co. in Smithfield, RI). Additional parameters were selected based on assumptions of the Design Builder's means and methods in carrying out the filling at both landfills.

Memoranda summarizing the results of this analyses is provided in Appendix D. Slope failure is not expected though the model predicts that some existing side slopes do not meet the minimum factor of safety recommended by AASHTO. These areas are on the existing landfill side slopes, where existing slopes steeper than 3H:1V are present. It does not appear that the proposed filling worsens this condition or further reduces the factor of safety against slope failure. These existing slopes are likely further stabilized by existing deep-rooted vegetation, which the model does not account for in its analysis. There is no evidence that these slopes currently fail. Regardless, should slope failure occur in these areas, it would be localized and could be easily repaired.

3.4 Passive Gas Venting

A passive gas venting system has been proposed for the Bucklin Point North Landfill because of the discovery of methane during subsurface investigations as part of the Phase III CSO Program Geotechnical Exploration Program. When drilling boring B17-2, elevated concentrations of methane were detected with a handheld four-gas meter once the boring advanced to approximately 44 feet below grade (surface grade is about 50 feet MSL at this location). Methane levels were monitored and found to approach the lower explosive limit. As such, drilling was abandoned and the boring was grouted closed. A new boring, B17-2A, was completed at an alternate, nearby location on the landfill. High levels of methane were not detected during drilling of this boring, nor were they detected when drilling B17-1 in the southern part of the North Landfill.

The proposed passive gas venting system consists of a gravel trench of crushed stone and perforated PVC pipe at the eastern toe of the landfill, buried beneath the surface alongside new swales between the landfill and paved access road. The intent of this trench is to intercept landfill gases that may want to migrate away from the landfill in this direction. This location and alignment has been chosen because the landfill is otherwise surrounded by the river to the west and southwest. A layer of polyethylene sheet will be placed on top of the trench, beneath the one-foot clean soil cover, to discourage stormwater from infiltrating and filling the gravel trench since it is proposed along the toe of the slope. Vertical pipe risers will be connected to the perforated pipe at approximately 200 feet on center to allow landfill gas that collects in the trench to vent to the surface. This system is shown on site plans and detailed in the permit drawing set.

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Appendix A

Boring Logs and Groundwater Monitoring Results

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COASTAL RESOURCES MANAGEMENT COUNCIL

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BORING LOGS

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3/4/2022
COASTAL RESOURCES
MANAGEMENT COUNCIL

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Pare Corporation
10 Lincoln Road, Suite 210
Foxboro, MA 02035
T: 508-543-1755
F: 508-543-1881

BORING NUMBER B17-1

TEST BORING REPORT

PROJECT NAME Narragansett Bay Commission Phase III CSO Program
CLIENT NBC/Stantec
CONTRACTOR New England Boring Contractors, Inc.

PROJECT NO. 13:308.00D/14106.02
START 10/10/2017
FINISH 11/28/2017
DRILLER NEBC
LOGGED BY MLP/JMC
CHECKED BY SJM

ELEVATION 39.3 **NORTHING** 280773.193
DATUM NGVD 1929 **EASTING** 363864.134
LOCATION NBC Landfill Bucklin Point (South End)

	CASING	SAMPLER	BARREL
Type	Steel	Split Spoon	HQ2
Inside Diameter (in.)	5	1 3/8	2.5
Hammer Weight (lb.)	140	140	N/A
Hammer Fall (in.)	30	30	N/A

DRILLING EQUIPMENT & PROCEDURES
Rig Make & Model: Diedrich D-120
Bit Type: 4 7/8" Tricone
Drill Fluid: Water
Casing: 5"
Hoist/Hammer: Automatic Hammer/Safety

DEPTH (ft)	ELEVATION (ft)	CASING BLOWS	SPT	SAMPLE NO.	REC (in) / PEN (in)	SAMPLE DEPTH (ft)	USCS SYMBOL	GRAPHIC LOG	VISUAL-MANUAL IDENTIFICATION & DESCRIPTION (Density/consistency, color, max. particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	DRILLING NOTES
0	39.3									
		14 35	6-23-30-23 (53)	S-1	24 / 24	0 - 2	SM		Upper 9": Moist, very dense, tan, fine to medium SAND, some silt, trace coarse sand. Lower 15": Gray, fine to medium SAND, some silt, little fine gravel, trace coarse sand. (FILL)	PID = 0.5 ppm Automatic hammer used. Composite environmental sample taken (0'-1'). (1) 8 oz. Amber, (1) VOA PID = 3.6 ppm (0'-2')
		40 35	30-23-16-12 (39)	S-2	15 / 24	2 - 4	SM		Moist, dense, dark gray, fine to medium SAND, little silt, some fine to coarse gravel, trace coarse sand, trace wood. (FILL)	PID = 3.6 ppm Environmental sample taken (2'-4'). (1) 8 oz. Amber (1'-10'), (1) VOA (6'-8')
5	34.3	20 24	8-8-7-5 (15)	S-3	10 / 24	4 - 6	SM		Wet, medium dense, dark gray, fine to medium SAND, some silt, little fine to coarse gravel, trace coarse sand. (FILL)	PID = 3.1 ppm (4'-6')
		17 10	7-6-4-3 (10)	S-4	6 / 24	6 - 8	SM		Wet, medium dense, dark gray, fine to medium SAND, some silt, trace coarse sand, trace fine gravel. (FILL)	PID = 5.7 ppm (6'-8')
10	29.3	7 16	25-30-26-22 (56)	S-5	14 / 24	8 - 10	SM		Wet, very dense, dark gray, fine to medium SAND, little silt, trace fine to coarse gravel, trace coarse sand, odor. (FILL)	Rollerbit through possible boulder @ 9'-10'. PID = 6.5 ppm (8'-10')
		46 6	21-23-28-17 (51)	S-6	5 / 24	10 - 12	SM		Wet, very dense, dark gray, fine to coarse SAND and SILT, trace fine gravel, odor. (FILL)	Switched to safety hammer. 15"+/- of wash in spoon. PID = 9.9 ppm
		4 33	29-18-17-60 (35)	S-7	12 / 24	12 - 14	SM		Wet, dense, gray, fine to medium SAND, some silt, little fine to coarse gravel, trace coarse sand, odor. (FILL)	PID = 34 ppm
15	24.3	27 13	5-2-3-9 (5)	S-8	11 / 24	14 - 16	SW		A: Wet, loose, bluish gray, fine to coarse SAND, some silt. (FILL) B: Wet, loose, bluish gray, SILT, trace fine sand, odor. (FILL)	PID = 149.5 ppm Composite environmental sample taken (14'-16'). (1) 8 oz. Amber (14'-18'), (1) VOA (17')
		15 28	15-21-33-30 (54)	S-9	9 / 24	16 - 18	SW		A: Wet, very dense, brown, medium to coarse SAND. (FILL) B: Wet, very dense, bluish gray, fine to medium SAND, some silt, some fine to coarse gravel, odor. (FILL)	PID = 205.6 ppm
20	19.3	27 72	4-3-2-25 (5)	S-10	12 / 24	18 - 20	ML		Wet, loose, dark gray SILT, odor. (FILL)	PID = 228.9 ppm (1) 8 oz. Amber (16'-20')
		X X	2-10-5-6 (15)	S-11	12 / 24	20 - 22	SM		Wet, medium dense, gray, fine to coarse SAND and fine to coarse GRAVEL, little silt, odor. (FILL)	PID = 142 ppm
		X X	4-6-4-47 (10)	S-12	9 / 24	22 - 24	SM		Wet, loose, gray, fine to coarse SAND, some fine gravel, little silt, odor. (FILL)	PID = 21.9 ppm
25	14.3	40	5-4-12-		19	24				

WATER LEVEL DATA

DATE/TIME	DEPTH (ft.) TO: BOTTOM OF CASING	BOTTOM OF HOLE	WATER
10/11/2017	24	26	10.9
10/12/2017 7:15:00 AM	52	54	14.8

SAMPLE IDENTIFICATION
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

REMARKS:
1. Samples for possible environmental testing taken at 0-4" (VOA), composite (0'-1'), 3' (VOA), composite (1'-10'), 6'-8' (VOA).
2. "X" within casing blows indicates that blows were not counted at that interval.

(Continued Next Page)

Pare Corporation
10 Lincoln Road, Suite 210
Foxboro, MA 02035
T: 508-543-1755
F: 508-543-1881

BORING NUMBER B17-1

TEST BORING REPORT

DEPTH (ft)	ELEVATION (ft)	CASING BLOWS	SPT	SAMPLE NO.	REC (in) / PEN (in)	SAMPLE DEPTH (ft)	USCS SYMBOL	GRAPHIC LOG	VISUAL-MANUAL IDENTIFICATION & DESCRIPTION (Density/consistency, color, max. particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	DRILLING NOTES
25	14.3	88	18 (16)	S-13	/ 24	- 26	SP		A: Wet, medium dense, gray and dark gray, fine to coarse SAND, little silt. (FILL) B: Wet, medium dense, dark gray, fine to medium SAND, some silt, little coarse sand, odor. (FILL) *(continued)*	PID = 38 ppm
		91 168	1-1-18-80 (19)	S-14	7 / 24	26 - 28	SM		Wet, medium dense, gray, fine to coarse SAND, some fine gravel, some silt, odor. (FILL)	Reverted to the automatic hammer. PID = 121.1 ppm
30	9.3	43 127	7-12-18-35 (30)	S-15	8 / 24	28 - 30	SM		Wet, dense, gray, fine to coarse SAND, some fine gravel, little silt, trace brick. (FILL)	Possible boulder from 28'-29'. PID = 22.1 ppm
		50 61	7-13-11-15 (24)	S-16	3 / 24	30 - 32	SP		Wet, medium dense, gray/tan, coarse SAND and coarse GRAVEL, trace metal (slag). (FILL)	PID = 24.7 ppm
		77 38	11-22-26-31 (48)	S-17	6 / 24	32 - 34	SP		Wet, dense, gray/tan, fine to coarse SAND, little silt, odor. (FILL)	PID = 20.9 ppm
35	4.3	70 81	14-19-30-17 (49)	S-18	10 / 24	34 - 36	ML		Wet, dense SILT, some fine to coarse sand, trace fine to coarse gravel, trace metal (slag), odor.	PID = 7.5 ppm
		104 39	13-14-13-15 (27)	S-19	6 / 24	36 - 38	ML		Wet, medium dense, gray SILT, some fine sand, trace fine gravel.	PID = 1.5 ppm
40	-0.7	70 50	4-5-7-11 (12)	S-20	9 / 24	38 - 40	ML		Wet, medium dense, gray/tan SILT, trace fine to coarse sand, trace fine gravel.	PID = 0.3 ppm Environmental sample taken. (1) 8 oz. Amber, (1) VOA
		42 57	2-7-10-9 (17)	S-21	0 / 24	40 - 42			No Recovery.	
		59 34	7-9-9-9 (18)	S-22	0 / 24	42 - 44	ML		Wet, medium dense, gray SILT, trace fine sand.	PID = 0.5 ppm
45	-5.7	52 30	10-9-7-4 (16)	S-23	7 / 24	44 - 46	ML		Wet, medium dense, gray SILT, trace fine sand.	PID = 0.1 ppm
		40 73	6-6-7-10 (13)	S-24	9 / 24	46 - 48	ML		Wet, medium dense, gray SILT, little fine gravel, trace fine sand.	Orange/red stain @47'-48'. Roller bit through possible boulders @ 47'-51'. PID = 0.1 ppm
50	-10.7	26 59	14-23-35-33 (58)	S-25	12 / 24	48 - 50	SM		Wet, very dense, gray, fine SAND, some silt, some fine to coarse gravel, little medium to coarse sand.	PID = 0.3 ppm
		93 99	61-46-37-28 (83)	S-26	12 / 24	50 - 52	SM		Wet, very dense, gray, fine to coarse SAND, some fine gravel, some silt.	PID = 0.3 ppm
		80 96	15-20-92/5"	S-27	8 / 17	52 - 53.42	GW		Wet, very dense, gray, fine to coarse GRAVEL, some fine to coarse sand, little silt.	PID = 0.3 ppm
55	-15.7	513			/	53.42 - 55				Spoon refusal on possible boulder, Driller roller bit to 55'.
		513 142	14-15-25-33 (40)	S-28	11 / 24	55 - 57	SM		Wet, dense, gray, fine to coarse SAND and fine GRAVEL, some silt.	PID = 0.5 ppm
		325	17-18-20-29	S-29	8 / 24	57 - 59	SP-SM		Wet, dense, gray, medium to coarse SAND, some fine to coarse gravel, little fine sand, little silt.	Recovery 20". 12" appears to be wash. PID = 2.7 ppm

(Continued Next Page)

Pare Corporation
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BORING NUMBER B17-1

TEST BORING REPORT

DEPTH (ft)	ELEVATION (ft)	CASING BLOWS	SPT	SAMPLE NO.	REC (in) / PEN (in)	SAMPLE DEPTH (ft)	USCS SYMBOL	GRAPHIC LOG	VISUAL-MANUAL IDENTIFICATION & DESCRIPTION (Density/consistency, color, max. particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	DRILLING NOTES
		217	(38)							
			72-100/3"	S-30	7 / 9	59 - 59.75			Wet, very dense, gray, weathered SHALY MUDSTONE recovered as fine to coarse SAND and fine to coarse GRAVEL, little silt.	Weathered rock in tip. Bottom of casing 59'9". PID = 0.5 ppm

Bottom of borehole at 59.75 feet.

Pare Corporation
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BORING NUMBER B17-2A

TEST BORING REPORT

PROJECT NAME Narragansett Bay Commission Phase III CSO Program
CLIENT NBC/Stantec
CONTRACTOR New England Boring Contractors, Inc.

PROJECT NO. 13:308.00D/14106.02
START 10/19/2017
FINISH 11/7/2017
DRILLER NEBC
LOGGED BY MLP/JMC
CHECKED BY SJM
ELEVATION 56.9 **NORTHING** 281462.136
DATUM NGVD 1929 **EASTING** 363245.077
LOCATION NBC Landfill Bucklin Point (North End)

	CASING	SAMPLER	BARREL
Type	Steel	Split Spoon	HQ2
Inside Diameter (in.)	4/5	1 3/8	2.5
Hammer Weight (lb.)	140	140	N/A
Hammer Fall (in.)	30	30	N/A

DRILLING EQUIPMENT & PROCEDURES
Rig Make & Model: Diedrich D-120 (Soil), Mobile B-53 (Core)
Bit Type: 4 7/8" Tricone / 3 7/8" Tricone
Drill Fluid: Water
Casing: 5 inches (20') 4" (Remaining)
Hoist/Hammer: Automatic Hammer

DEPTH (ft)	ELEVATION (ft)	CASING BLOWS	SPT	SAMPLE NO.	REC (in) / PEN (in)	SAMPLE DEPTH (ft)	USCS SYMBOL	GRAPHIC LOG	VISUAL-MANUAL IDENTIFICATION & DESCRIPTION (Density/consistency, color, max. particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	DRILLING NOTES
0	56.9									
		30 54	5-19-18-16 (37)	S-1	16 / 24	0 - 2	SM		A: Moist, dense, brown SILT and fine to coarse SAND, trace fine gravel. (FILL) B: Moist, dense, gray, fine to coarse SAND, some fine gravel, trace silt. (FILL)	PID = 4.0 ppm Environmental sample taken (1'-2'). (1) 8 oz. Amber, (1) VOA.
		15 9	13-10-3-4 (13)	S-2	16 / 24	2 - 4	SM		Moist, medium dense, fine to medium SAND and SILT, trace coarse sand, trace fine gravel. (FILL)	PID = 1.7 ppm
5	51.9	6 X	6-2-2-1 (4)	S-3	3 / 24	4 - 6	SW		Wet, loose, gray/black, fine to coarse SAND, trace silt. (FILL)	PID = 2.5 ppm
		X 16	20-12-9-5 (21)	S-4	18 / 24	6 - 8	GC		A: Wet, medium dense, black, fine GRAVEL, some fine to medium sand, some silt, trace coarse sand, sewage-like odor. (FILL) B: Wet, medium dense, gray/reddish, sewage-like odor. (FILL)	Environmental sample taken (6'-7'). (1) 8 oz. Amber, (1) VOA. PID = 21.9 ppm (4A), PID = 6.9 ppm (4B)
10	46.9	32 78	0-23-25-28 (48)	S-5	24 / 24	8 - 10	SM		A: Wet, dense, black SILT, trace fine to coarse SAND, sewage-like odor. (FILL) B: Wet, dense, fine to coarse SAND and SILT, some fine gravel. (FILL)	Wash water turned black 6'-8'. Spoon dropped 6" into soil (soft layer). PID = 17.5 ppm Composite environmental sample taken. (1) 8 oz. Amber (10'-14'), (1) VOA (12'-14').
		X 85	18-9-33-25 (42)	S-6	12 / 24	10 - 12	SP-SM		Wet, dense, gray, fine to coarse SAND and fine to coarse GRAVEL, some silt, sewage-like odor. (FILL)	PID = 7.6 ppm
		31 16	13-10-6-4 (16)	S-7	10 / 24	12 - 14	SM		Wet, medium dense, gray, fine to medium SAND, some fine gravel, some silt, little coarse sand. (FILL)	PID = 21.4 ppm
15	41.9	9 9	4-1-2-1 (3)	S-8	0 / 24	14 - 16			No Recovery.	
		12 16	9-3-2-15 (5)	S-9	0 / 24	16 - 18	GP		Wet, loose, gray, coarse GRAVEL, little fine to coarse sand, little silt, sewage-like odor. (FILL)	No Recovery. Retrieved sample using 3 1/8" spoon. Rollerbit through possible boulder at 17'. PID = 2.2 ppm
20	36.9	X X							No Recovery. Possible gravel layer, rollerbit to 20'. Advanced with 4" casing.	
		11 32	6-6-5-4 (11)	S-10	0 / 24	20 - 22	SP		Wet, medium dense, gray, medium to coarse SAND and fine GRAVEL, trace fine sand, trace silt, sewage-like odor. (FILL)	No Recovery. Retrieved sample using 3 1/8" spoon. PID = 0.7 ppm
		56 28	19-37-22-25 (59)	S-11	8 / 24	22 - 24	SM		Wet, very dense, gray, fine to medium SAND and fine to coarse GRAVEL, some silt, trace coarse sand, sewage-like odor. (FILL)	PID = 8.0 ppm
25	31.9	24	35-33-		16	24			Wet, very dense, gray, fine to medium SAND, some silt, little fine gravel, little fine sand, sewage-like odor. (FILL)	

WATER LEVEL DATA

DATE/TIME	DEPTH (ft.) TO: BOTTOM OF CASING	BOTTOM OF HOLE	WATER
10/20/2017 7:15:00 AM	12.5	16	5.7
10/23/2017 1:45:00 PM	63	68	17.1
10/24/2017 7:15:00 AM	68	74	18.2
10/25/2017 7:10:00 AM	88	96	48.8
10/27/2017 7:20:00 AM	108	108	53.6
10/30/2017 7:10:00 AM	115	118.8	49
10/30/2017 2:30:00 PM	118	119	51
11/2/2017 7:30:00 AM	117.5	120.3	51

SAMPLE IDENTIFICATION
O Open End Rod
T Thin Wall Tube
U Undisturbed Sample
S Split Spoon
G Geoprobe

REMARKS:
1. "X" within casing blows indicates that blows were not counted at that interval.
2. At 20 ft., the driller installed 4" diameter casing due to gravel layer.

(Continued Next Page)

Pare Corporation
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T: 508-543-1755
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BORING NUMBER B17-2A

TEST BORING REPORT

DEPTH (ft)	ELEVATION (ft)	CASING BLOWS	SPT	SAMPLE NO.	REC (in) / PEN (in)	SAMPLE DEPTH (ft)	USCS SYMBOL	GRAPHIC LOG	VISUAL-MANUAL IDENTIFICATION & DESCRIPTION (Density/consistency, color, max. particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	DRILLING NOTES
25	31.9									
		16	23-19 (56)	S-12	/ 24	- 26	SM			PID = 10.1 ppm
		30 49	13-8-9-7 (17)	S-13	5 / 24	26 - 28	SM		Wet, medium dense, gray, fine to coarse SAND and fine to coarse GRAVEL, some silt, trace coarse sand, sewage-like odor. (FILL)	PID = 17.1 ppm
30	26.9	X X	6-3-3-23 (6)	S-14	4 / 24	28 - 30	SM		Wet, loose, gray/brown, fine to coarse SAND and fine to coarse GRAVEL, some silt, sewage-like odor. (FILL)	PID = 5.0 ppm
		X X	20-14-14-11 (28)	S-15	9 / 24	30 - 32	SW		Wet, medium dense, black, fine to coarse SAND and fine GRAVEL, trace silt. (FILL)	PID = 7.4 ppm Environmental sample taken (30'-32'). (1) 8 oz. Amber (30'-42'), (1) VOA (34'-36').
		X 12	10-4-3-4 (7)	S-16	10 / 24	32 - 34	SW-SM		Wet, loose, black/white, fine to coarse SAND and SILT, some fine gravel, sewage-like odor. (FILL)	PID = 81.7 ppm
35	21.9	42 117	6-3-2-3 (5)	S-17	5 / 24	34 - 36	SM		Wet, loose, black/white, fine to medium SAND, some silt, little fine gravel, trace coarse sand, sewage-like odor. (FILL)	PID = 151.7 ppm
		89 14	15-39-40-49 (79)	S-18	16 / 24	36 - 38	SW		Wet, very dense, fine to coarse SAND and fine to coarse GRAVEL, little silt, sewage-like odor. (FILL)	PID = 32.2 ppm
40	16.9	23 19	81-95-83-59 (178)	S-19	3 / 24	38 - 40	SW		Wet, very dense, fine to coarse SAND and fine to coarse GRAVEL, little metal fragments, trace silt. (FILL)	PID = 24.6 ppm
		36 36	15-12-9-9 (21)	S-20	8 / 24	40 - 42	SM		Wet, medium dense, black, fine to coarse SAND and fine to coarse GRAVEL, some silt. (FILL)	PID = 22.8 ppm
		40 24	12-8-6-11 (14)	S-21	3 / 24	42 - 44	SP		Wet, medium dense, black, coarse SAND, trace fine to medium sand, trace silt, trace metal fragments, trace fine brick. (FILL)	PID = 23.1 ppm
45	11.9	39 30	8-5-11-11 (16)	S-22	7 / 24	44 - 46	SP-SM		Wet, medium dense, black, fine to coarse SAND, some fine to coarse gravel, trace silt, little metal fragments, trace plastic, trace wood, petroleum odor. (FILL)	PID = 27.1 ppm
		54 82	11-13-10-10 (23)	S-23	8 / 24	46 - 48	ML		Wet, medium dense, black SILT and fine to coarse SAND, some fine brick, trace metal fragments, petroleum odor.	PID = 30.0 ppm
50	6.9	32 35	6-7-12-20 (19)	S-24	16 / 24	48 - 50	OH		Wet, medium dense, black SILT, trace fine to coarse sand, trace fine gravel, trace wood, oily sheen, petroleum odor.	PID = 43.6 ppm
		37 24	35-15-10-10 (25)	S-25	18 / 24	50 - 52	SW		A: Wet, medium dense, gray/black, fine to coarse SAND, trace metal fragments, trace silt, sewage-like odor. B: Wet, medium dense, black SILT, sewage-like odor.	PID = 36.1 ppm
		32 48	17-4-9-16 (13)	S-26	16 / 24	52 - 54	ML		Wet, medium dense, black SILT, little fine to coarse sand, trace fine gravel, trace wood.	PID = 55.9 ppm
55	1.9	80 74	12-6-12-19 (18)	S-27	8 / 24	54 - 56	SM		A: Wet, medium dense, black, medium to coarse SAND, trace wood, some silt, sewage-like odor. B: Wet, medium dense, brown, fine to medium SAND, trace roots, sewage-like odor.	PID = 45.9 ppm
		90 105	44-33-26-24 (59)	S-28	0 / 24	56 - 58	GM		Wet, very dense, black, fine to coarse GRAVEL and fine to coarse SAND, little silt, trace wood, sewage-like odor.	No recovery with standards size spoon, retrieved sample using 3 1/8" spoon. PID = 27.4 ppm

(Continued Next Page)

Pare Corporation
10 Lincoln Road, Suite 210
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T: 508-543-1755
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BORING NUMBER B17-2A

TEST BORING REPORT

DEPTH (ft)	ELEVATION (ft)	CASING BLOWS	SPT	SAMPLE NO.	REC (in) / PEN (in)	SAMPLE DEPTH (ft)	USCS SYMBOL	GRAPHIC LOG	VISUAL-MANUAL IDENTIFICATION & DESCRIPTION (Density/consistency, color, max. particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	DRILLING NOTES
60	-3.1	60 47	13-9-14-13 (23)	S-29	11 / 24	58 - 60	SW		Wet, medium dense, brown, fine to medium SAND, trace silt, trace organics. *(continued)*	PID = 14.3 ppm
		37 43	5-10-20-16 (30)	S-30	12 / 24	60 - 62	ML		A: Wet, medium dense, black SILT, trace fine to coarse sand, sewage-like odor. B: Wet, medium dense, brown, fine to medium SAND, sewage-like odor.	PID = 23.5 ppm
		55 X	14-19-20-18 (39)	S-31	12 / 24	62 - 64	SW		Wet, dense, brown/black, fine to medium SAND, little silt, sewage-like odor.	PID = 15.2 ppm
65	-8.1	X 33	13-5-8-12 (13)	S-32	18 / 24	64 - 66	SP		Wet, medium dense, dark brown/gray, fine SAND, trace silt, trace coarse sand, trace roots.	PID = 11.9 ppm
		128 110	10-10-8-10 (18)	S-33	24 / 24	66 - 68	SM		Wet, medium dense, dark brown/gray, fine SAND and SILT, trace medium to coarse sand.	PID = 7.9 ppm
70	-13.1	211 170	15-10-9-7 (19)	S-34	20 / 24	68 - 70	ML		Wet, medium dense, gray SILT, some medium sand, trace coarse gravel, trace coarse sand.	PID = 0.9 ppm
		161 235	10-7-7-9 (14)	S-35	20 / 24	70 - 72	ML		Wet, medium dense, gray SILT and fine to medium SAND, trace wood.	PID = 0.3 ppm
		273 X	7-8-10-9 (18)	S-36	24 / 24	72 - 74	ML		Wet, medium dense, gray SILT and fine to medium SAND.	PID = 0.8 ppm
75	-18.1	153 143	8-6-7-7 (13)	S-37	24 / 24	74 - 76	OL		Wet, medium dense, gray SILT, some fine to medium sand.	PID = 1.5 ppm
		245 334	10-8-7-9 (15)	S-38	20 / 24	76 - 78	ML		Wet, medium dense, gray SILT, trace fine to coarse sand, trace metal fragments.	PID = 0.6 ppm
80	-23.1	121 116	45-33-27-31 (60)	S-39	20 / 24	78 - 80	ML SW		A: Wet, very dense, gray SILT, trace fine to coarse sand, trace wood. B: Wet, very dense, brown, fine to coarse SAND, trace fine gravel, trace silt.	PID = 1.2 ppm
		X 99	18-29-21-19 (50)	S-40	21 / 24	80 - 82	ML SW		A: Wet, very dense, gray SILT, trace fine to coarse sand. B: Wet, very dense, brown, fine to coarse sand.	PID = 0.3 ppm
		123 185	21-17-18-18 (35)	S-41	19 / 24	82 - 84	ML		Wet, dense, gray SILT, little fine to coarse sand, little fine gravel, trace metal fragments.	PID = 0.0 ppm
85	-28.1	126 116	10-8-18-21 (26)	S-42	12 / 24	84 - 86	ML		Wet, medium dense, gray SILT, little coarse gravel, trace fine to coarse sand, trace fine gravel.	PID = 1.8 ppm
		107 148	18-22-27-30 (49)	S-43	22 / 24	86 - 88	ML		Wet, dense, gray SILT, trace fine gravel, trace coarse sand.	PID = 0.2 ppm
90	-33.1	244 193	17-19-20-19 (39)	S-44	19 / 24	88 - 90	ML		Wet, dense, gray SILT, trace fine sand.	PID = 0.5 ppm
		122 117	19-23-31-30 (54)	S-45	11 / 24	90 - 92	ML		Wet, very dense, gray SILT, trace coarse sand, trace fine gravel.	PID = 1.5 ppm

(Continued Next Page)

RECEIVED
3/4/2022
COASTAL RESOURCES MANAGEMENT COUNCIL

Pare Corporation
10 Lincoln Road, Suite 210
Foxboro, MA 02035
T: 508-543-1755
F: 508-543-1881

BORING NUMBER B17-2A

TEST BORING REPORT

DEPTH (ft)	ELEVATION (ft)	CASING BLOWS	SPT	SAMPLE NO.	REC (in) / PEN (in)	SAMPLE DEPTH (ft)	USCS SYMBOL	GRAPHIC LOG	VISUAL-MANUAL IDENTIFICATION & DESCRIPTION (Density/consistency, color, max. particle size, structure, odor, moisture, optional descriptions, geologic interpretation)	DRILLING NOTES
		107 210	21-21-26-25 (47)	S-46	18 / 24	92 - 94	ML		Wet, dense, gray SILT, trace fine to coarse sand.	PID = 3.4 ppm
95	-38.1	204 246	16-16-23-21 (39)	S-47	16 / 24	94 - 96	CL-ML		Wet, dense, gray SILT, trace fine sand.	PID = 0.3 ppm
		190 245	7-6-10-19 (16)	S-48	20 / 24	96 - 98	ML		Wet, medium dense, gray SILT, trace fine sand.	PID = 0.3 ppm
100	-43.1	363 373	28-37-25-26 (62)	S-49	12 / 24	98 - 100	ML		A: Wet, very dense, gray SILT. B: Wet, very dense, gray, fine to coarse SAND and fine GRAVEL.	PID = 1.8 ppm
		232 243	19-33-30-47 (63)	S-50	6 / 24	100 - 102	GW		Wet, very dense, gray, fine to coarse GRAVEL and fine to coarse SAND, little silt.	PID = 1.4 ppm
		268 447	37-46-42-48 (88)	S-51	12 / 24	102 - 104	GM		Wet, very dense, gray, fine to coarse GRAVEL and fine to coarse SAND, little silt.	PID = 0.7 ppm
105	-48.1	X 347	26-34-31-19 (65)	S-52	9 / 24	104 - 106	GW		Wet, very dense, gray, fine to coarse GRAVEL, little fine to coarse sand, little silt.	Weathered rock in tip. PID = 5.4 ppm
		352 402	37-10-25-26 (35)	S-53	9 / 24	106 - 108			Weathered sandy MUDSTONE recovered as wet, very dense, gray, fine to coarse SAND and fine to coarse GRAVEL, trace silt.	PID = 1.5 ppm
110	-53.1	324 175	16-14-16-20 (30)	S-54	0 / 24	108 - 110			No Recovery.	
		275 265	22-19-24-24 (43)	S-55	18 / 24	110 - 112	SW		Wet, dense, gray, medium to coarse SAND and fine GRAVEL, trace fine sand, trace silt.	PID = 0.3 ppm
		341 278	17-11-15-19 (26)	S-56	8 / 24	112 - 114	GW		Wet, medium dense, gray, fine to coarse GRAVEL and fine to coarse SAND, trace silt.	PID = 0.6 ppm
115	-58.1	310 300	24-27-29-29 (56)	S-57	18 / 24	114 - 116	GP-GM		Wet, very dense, gray, fine GRAVEL and fine to coarse SAND, trace silt.	PID = 0.3 ppm
		392 421	24-33-56-70 (89)	S-58	8 / 24	116 - 118			Weathered sandy MUDSTONE recovered as wet, very dense, gray, fine to coarse GRAVEL and fine to coarse SAND, trace silt.	PID = 0.0 ppm
		X	118-150/2"	S-59	5 / 8	118 - 118.8			Weathered sandy MUDSTONE recovered as wet, very dense, gray, fine to coarse SAND and fine to coarse GRAVEL, trace silt.	Driller pushed spoon 2'± prior to taking SPT sample. PID = 1.4 ppm
120	-63.1	X	132/1"	S-60	0 / 1	118.8 - 118.9			No Recovery.	
			79/0"	S-61	0 / 0	118.9 - 119			Weathered rock in tip.	
		X X X								
			75/1"	S-62	1 / 1	123 - 123.1			Sandy MUDSTONE recovered as angular, fine to coarse GRAVEL.	

Bottom of borehole at 123.10 feet.

3. S-62: Driller advanced through weathered rock using roller-bit.

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WELL/PIEZOMETER WATER LEVEL RECORDS

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WELL/PIEZOMETER WATER LEVEL RECORD

Project Name NBC CSO Phase III **WELL/PIEZO. NO.** B17-1

Project Number 14106.02 **Sheet** 1 **of** 2

Reference(1) Ground Surface **Ref. Elev.** 39.3 NGVD 29

Foundation Sensed Soil/Rock Interface

Location Description(2) Landfill at Bucklin Point

Date	Time	Read By	Depth to Water (ft)	Elevation of Water (ft)	Remarks
11-13-17	10:30	JMC	32.7	6.6	Open Boring
01-08-18	8:15	JMC/HMS	32.0	7.3	Open Boring
01-23-18	-	JMC/HMS	32.2	7.1	Open Boring (Packer Testing)
02-01-18	8:15	JMC	29.0	10.3	Open Boring
02-06-18	9:30	HMS	33.1	6.2	Open Boring
02-20-18	8:50	JMC/HMS	30.1	9.2	Open Boring
03-07-18	8:15	SMA	33.8	5.5	Groundwater Well
04-05-18	1:30	JMC	33.8	3.9	Groundwater Well
05-18-18	3:15	HMS	35.4	5.7	Groundwater Well
05-29-18	9:50	HMS	33.6	5.7	Groundwater Well
06-12-18	10:15	HMS	34.4	4.9	Groundwater Well
07-25-18	8:20	JMC	34.4	4.9	Groundwater Well
08-22-18	2:20	HP	35.8	3.5	Groundwater Well
09-20-18	7:50	HMS	34.2	5.1	Groundwater Well
10-26-18	1:40	MLP	36.2	3.1	Groundwater Well
11-02-18	-	MM	36.5	2.8	Groundwater Well

(1) Normally, the top of protective casing. (2) Street intersection, address, etc.

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WELL/PIEZOMETER WATER LEVEL RECORD

Project Name NBC CSO Phase III

WELL/PIEZO. NO. B17-1

Project Number 14106.02

Sheet 2 **of** 2

Reference(1) Ground Surface

Ref. Elev. 39.3 NGVD

Foundation Sensed Soil/Rock Interface

Location Description(2) Landfill at Bucklin Point

Date	Time	Read By	Depth to Water (ft)	Elevation of Water (ft)	Remarks
11-28-18	1:50	MM	33.9	5.4	Groundwater Well
12-26-18	8:45	HMS	35.2	4.1	Groundwater Well
02-07-19	11:00	HMS	34.7	4.6	Groundwater Well
03-14-19	10:00	RKM	34.7	4.6	Groundwater Well
04-22-19	8:12	JPN	34.7	4.6	Groundwater Well
05-09-19	12:50	JPN	35.4	3.9	Groundwater Well
05-15-19	10:50	JPN	34.7	4.6	Groundwater Well
06-05-19	8:22	JPN	34.6	4.7	Groundwater Well
06-06-19	11:40	JMC	34.6	4.7	Groundwater Well
07-01-19	2:30	RAL	35.1	4.2	Groundwater Well; ¼-inch diameter vent installed.
07-30-19	4:25	MLP	35.5	3.8	Groundwater Well; ¼-inch diameter vent installed.
08-06-19	10:15	MTR	34.8	4.5	Groundwater Well; ¼-inch diameter vent installed.
09-03-19	2:15	JPN	34.5	4.8	Groundwater Well; ¼-inch diameter vent installed.
11-14-19	2:25	RAL	35.6	3.7	Groundwater Well; ¼-inch diameter vent installed.
12-20-19	9:42	KAD	38.3	1.0	Groundwater Well; ¼-inch diameter vent installed.

(1) Normally, the top of protective casing.

(2) Street intersection, address, etc.

WELL/PIEZOMETER WATER LEVEL RECORD

Project Name NBC CSO Phase III

WELL/PIEZO. NO. B17-1

Project Number 14106.02

Sheet 2 **of** 2

Date	Time	Read By	Depth to Water (ft)	Elevation of Water (ft)	Remarks
04-06-20	1:12	HMS	35.0	4.3	Groundwater Well; ¼-inch diameter vent installed.
06-02-20	12:00	JPN	35.6	3.7	Groundwater Well; ¼-inch diameter vent installed.
07-08-20	10:20	JPN	35.6	3.7	Groundwater Well; ¼-inch diameter vent installed.
08-11-20	12:40	JPN	35.2	4.1	Groundwater Well; ¼-inch diameter vent installed.
10-08-20	3:30	JPN	35.9	3.4	Groundwater Well; ¼-inch diameter vent installed.

WELL/PIEZOMETER WATER LEVEL RECORD

Project Name NBC CSO Phase III **WELL/PIEZO. NO.** B17-2A

Project Number 14106.02 **Sheet** 1 **of** 2

Reference(1) Ground Surface **Ref. Elev.** 56.9 NGVD 29

Foundation Sensed Bottom of Boring

Location Description(2) Landfill at Bucklin Point

Date	Time	Read By	Depth to Water (ft)	Elevation of Water (ft)	Remarks
11-13-17	10:20	JMC	51	5.9	Open Boring
01-08-18	8:00	JMC/HMS	51.4	5.5	Open Boring
01-23-18	8:10	JMC/HMS	50.9	6.0	Open Boring
02-5-18	-	JMC	50.6	6.3	Open Boring (Packer Testing)
02-20-18	8:50	JMC/HMS	51	5.9	Open Boring
03-07-18	8:45	SMA	49.6	7.3	Partially Grouted Well (Reading recorded inside casing, outside well)
04-05-18	1:25	JMC	33.8	23.1	Groundwater Well-when opened, audible venting noise was heard.
05-18-18	3:20	HMS	50.8	6.1	Groundwater Well
05-29-18	9:40	HMS	50.2	6.7	Groundwater Well
06-12-18	10:05	HMS	50.3	6.6	Groundwater Well
07-25-18	8:25	JMC	50.3	6.6	Groundwater Well
08-22-18	10:30	HP	52.4	4.5	Groundwater Well
09-20-18	8:00	HMS	50.2	6.7	Groundwater Well
10-26-18	1:45	MLP	56.4	0.5	Groundwater Well
11-2-18	-	MM	50.3	6.6	Groundwater Well
11-28-18	1:40	MM	49.5	7.4	Groundwater Well

(1) Normally, the top of protective casing. (2) Street intersection, address, etc.

WELL/PIEZOMETER WATER LEVEL RECORD

Project Name NBC CSO Phase III **WELL/PIEZO. NO.** B17-2A

Project Number 14106.02 **Sheet** 2 **of** 2

Reference(1) Ground Surface **Ref. Elev.** 56.9 NGVD

Foundation Sensed Bottom of Boring

Location Description(2) Landfill at Bucklin Point

Date	Time	Read By	Depth to Water (ft)	Elevation of Water (ft)	Remarks
12-26-18	9:05	HMS	50.1	6.8	Groundwater Well
02-07-19	10:15	HMS	50.1	6.8	Groundwater Well
03-14-19	10:20	RKM	50	6.9	Groundwater Well
04-22-19	8:15	JPN	49.9	7.0	Groundwater Well
05-09-19	12:55	JPN	50.1	6.8	Groundwater Well
05-15-19	10:50	JPN	50.1	6.8	Groundwater Well
06-05-19	12:45	JPN	50.1	6.8	Groundwater Well
06-06-19	11:45	JMC	49.9	7.0	Groundwater Well
07-01-19	2:20	RAL	50.1	6.8	Groundwater Well; ¼-inch diameter vent installed.
07-30-19	4:35	MLP	50.4	6.5	Groundwater Well; ¼-inch diameter vent installed.
09-03-19	2:18	JPN	50.1	6.8	Groundwater Well; ¼-inch diameter vent installed.
11-14-19	2:16	RAL	50.6	6.3	Groundwater Well; ¼-inch diameter vent installed.
12-24-19	7:55	KAD	52.3	4.6	Groundwater Well; ¼-inch diameter vent installed.
04-06-20	1:06	HMS	50.3	6.6	Groundwater Well; ¼-inch diameter vent installed.

(1) Normally, the top of protective casing.

(2) Street intersection, address, etc.

WELL/PIEZOMETER WATER LEVEL RECORD

Project Name NBC CSO Phase III **WELL/PIEZO. NO.** B17-2A

Project Number 14106.02 **Sheet** 2 **of** 2

Date	Time	Read By	Depth to Water (ft)	Elevation of Water (ft)	Remarks
06-02-20	12:10	JPN	50.6	6.3	Groundwater Well; ¼-inch diameter vent installed.
07-08-20	10:25	JPN	50.6	6.3	Groundwater Well; ¼-inch diameter vent installed.
08-11-20	12:50	JPN	51.4	5.5	Groundwater Well; ¼-inch diameter vent installed.
10-08-20	3:35	JPN	50.6	6.3	Groundwater Well; ¼-inch diameter vent installed.

Appendix B

Visual Impact Assessment Survey

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Phase III CSO Program
Technical Memorandum

To:	Kathryn Kelly, NBC	**Date:**	April 14, 2021
From:	Brandon Blanchard, Pare Matthew Sprague, Pare	**CC:**	Christopher Feeney, Stantec Melissa Carter, Stantec
Reviewed by:	Christopher Feeney, Stantec Melissa Carter, Stantec		
Subject:	NBC Phase III CSO Program Visual Impact Assessment Summary and Analysis – Bucklin Point North Landfill Proposed Beneficial Reuse of Tunnel Construction Debris		

This memorandum presents the findings from a visual impact assessment performed at the Bucklin Point North Landfill (the Site). During construction of Contract 308.01C Pawtucket Tunnel, an estimated 580,000 cubic yards of blast rock and tunneling debris is anticipated to be generated during shaft excavation and mining. Based on past sampling and analysis, the screened tunnel debris fines will contain naturally occurring arsenic at levels sometimes exceeding the Residential Direct Exposure Criteria (R DEC) of 7 ppm established by RIDEM for soil. RIDEM has stated they do not consider this fine material jurisdictional under the Remediation Regulations; and therefore, reporting, investigation, and cleanup is not required. However, because the fine material contains arsenic at concentrations too high for unregulated use, its handling and reuse or disposal must comply with RIDEM waste management requirements. Much of this material will require disposal unless it can be reused as fill material at appropriate offsite locations.

Background

The Site was identified as one possible location for beneficial reuse of some of the tunnel debris. This facility was used for the landfilling of wastes from industrial uses in the area and was then operated by NBC as a sludge disposal facility and sludge storage facility into the mid 1990's before it was closed in 1996. A report by NBC entitled "Bucklin Point North Landfill Closure Plan", dated August 1995 and revised November 1995, describes the planned closure of the landfill. Key components of the planned landfill closure are as follows:

- Maximum allowable elevation of the landfill is 145 feet above sea level in the Pawtucket Datum, or 47.3 feet MSL in NGVD 1929 (elevations are converted from Pawtucket Datum to NGVD 29 by subtracting 97.7 feet from elevations presented in the Pawtucket Datum).
- The top of the landfill has two plateaus, oriented north and south. The lower (south) plateau is at or below the permitted maximum elevation of about 47 feet MSL NGVD 1929.
- The upper (north) plateau of the landfill currently reaches elevation 58 feet MSL NGVD 29. This area was allowed to remain above the permitted maximum elevation to avoid excavation and offsite disposal of buried sludge.
- Landfill closure set the maximum side slope at 3:1 and minimum top slope at 3% in accordance with RIDEM requirements, except where existing steeper slopes are currently stabilized with vegetation. These slopes were to remain undisturbed and not regraded if found to be stable.
- Groundwater monitoring would be performed at seven monitoring wells around the facility for five years after closure. Methane monitoring would be performed at groundwater monitoring locations during

groundwater sampling events. Following this monitoring period, NBC would evaluate if monitoring for another 25 years is required.

- There is no leachate collection system, and an impermeable cap was not proposed; rather, the landfill was graded and covered with loam and seed as part of the landfill closure.

Reuse of the tunnel debris at an offsite location, as opposed to disposal, requires a Beneficial Use Determination (BUD) from the RIDEM because of its arsenic concentrations. A BUD request would be submitted to RIDEM in the form of a variance request from the Rhode Island Solid Waste Regulations. RIDEM participated in pre-application meetings with NBC on October 19, 2019 and June 2, 2020 at which the proposed use of tunnel debris at both the Bucklin Point North and South landfills was discussed in detail. During that meeting, RIDEM supported the concept of using tunnel debris in onsite fills at both landfills but confirmed the proposed activity would require review as part of a BUD request. This will require design drawings and an engineering analysis including slope stability analysis and proposed stormwater management to demonstrate the feasibility of the planned activity. It must undergo a public comment period that requires, at minimum, publishing a public notice in a newspaper of general circulation and holding a public hearing in the municipality in which the project is proposed. Other public notification may also be required by RIDEM. It should be assumed that RIDEM will require notification letters be sent to at least the immediate abutters to the Site. The Mayor and City Council of East Providence must also be provided notice. RIDEM requires acceptance by the municipality where the project is proposed in order to approve a BUD request. Guidance published by RIDEM is available on their website at the link provided below:

www.dem.ri.gov/programs/benviron/waste/pdf/budpol.pdf

Purpose

To determine the feasibility of using the Site to accept large quantities of tunnel debris, preliminary grading plans have been developed for NBC. Various potential final uses, including passive recreation and ground mounted solar, were laid out on these conceptual grading plans. Because the existing landfill side slopes are at or exceed maximum allowable slopes and the facility cannot be expanded laterally due to constraints along the landfill toe (i.e., the Seekonk River to west and access road and wetlands to east), grading plans focused on filling on top of the existing landfill, raising its height. Initially, preliminary grading plans presented much more filling on the top of the landfill to maximize the amount of tunnel debris that could be brought to the Site. However, these grading plans were scaled back to their current configuration based on input from NBC and to promote future uses at the landfill.

Increasing the height of the landfill will exceed the currently approved closure elevation, which will require RIDEM approval in addition to RIDEM's evaluation of other components of the BUD request. Because increasing the height of the landfill might impact views from the surrounding area, an assessment of the possible visual impacts from the proposed activity is likely to be required as part of RIDEM's review process. Possible visual impacts might also result in comments from residents and stakeholders surrounding the Site, through the required public comment process. To help evaluate this, a visual evaluation of the elevations proposed by the current conceptual grading plan was performed in March 2021 by flying large scale weather balloons at critical locations on top of the landfill and assessing their visibility from select vantage points surrounding the Site. Moreover, views of the Site from these vantage points could also help determine if the proposed grading would obscure views of the Seekonk River, beyond the landfill. Observations were made from these vantage points to compare existing and proposed conditions and to document these observations with photographs.

Methodology

Five (5) locations were chosen to fly balloons to best represent the change in height between existing conditions and proposed finished grades. These points corresponded to the existing landfill peak, the proposed peak elevation, and locations surrounding the proposed peak that generally reflect the shape of the conceptual filling plan. These locations were verified in the field by GPS. Five balloons were selected so that they could represent the shape of the proposed landfill grading while being spaced far enough apart so they could be differentiated from each other from various offsite vantage points.

The balloon height evaluation was planned for late winter so that there was limited vegetation on the trees surrounding the Site, maximizing visibility of the landfill and the balloons. Weather reports were monitored in advance to ensure that the height evaluation would be conducted during favorable weather conditions. The evaluation was performed on Thursday, March 18, 2021 because winds were low, and no precipitation was forecasted for the majority of the day. Federal Flight Administration regulations were reviewed in advance to verify that the balloon heights would not be within regulated airspace where special permission would have been required.

On the flight day, a helium tank was placed in a central location on top of the landfill where each balloon was prepped, filled, and tied before being walked out to their corresponding location. Each balloon was secured to stakes using a 3/16” tether rope and fishing line (slightly longer than the tether) was added as a fail-safe. The primary stakes used had a corkscrew design, which allowed them to be held securely in the ground. Two additional wooden stakes were used to provide additional support. These measures were taken to ensure the balloons remained secure and stable and minimized the risk of any balloon flying away. Large, 4-foot diameter weather balloons were used so that they would be visible from the vantage points surrounding the Site, be stable in light winds, and manageable in the field. Once the balloons were secured at the desired elevations, the height of each balloon was confirmed using a stadia rod and documented by photograph. Photographs were then taken from the various predetermined vantage points around the Site. Once complete, the balloons were retrieved and safely depleted of helium.

Discussion

Figure 1 shows the exact location of each balloon relative to the current proposed grading concept. This grading is conceptual and presents a gradual north to south slope that can support a multitude of potential future uses including passive recreation and ground mounted solar. Figure 2 shows the locations of each balloon against a birds-eye aerial view of the Site. The elevation and height of each balloon relative to existing and proposed grades is presented. In most instances, the bottom of the balloon was set to represent the proposed elevation at that location reflected by the conceptual grading plan. This allows the 4-foot diameter of the balloon to represent higher elevations in the event the proposed grading is increased slightly in the final design when final site used, and stormwater controls are considered. An inset showing how each balloon height was measured against a stadia rod is included on Figure 2.

Figure 3 presents a GIS map of the Site and surrounding area east of the Seekonk River, which was used to help identify locations where views of the landfill might be present. Grading provided on this figure shows that there is a valley between the landfill and both the residential neighborhood and the Mount Saint Mary’s Cemetery directly abutting the Site. Grades rise steeply along the Bucklin Point WWTF before leveling off and rising only moderately to the Pawtucket Avenue/Pleasant Street (RI Route 114) corridor. Because of this topography and the density of the residential neighborhood, only those residential properties that abut or are in close proximity to the landfill will have unobstructed views of the Site.

Figure 4 shows the location of each vantage point and the angle used to photograph the Site during the balloon height evaluation. A photo log is included as Appendix A, which when paired with this figure, represents the findings of this assessment. The approximate coordinates and orientation of each photograph was noted using a smart phone GPS and compass.

Nineteen vantage points were used in the surrounding area to observe and photograph the Site during the field evaluation. Several of these vantage points were predetermined in advance but other locations were added based on observations made during the field evaluation. The vantage points are characterized as follows:

- One was located at the Bucklin Point WWTF to the south of the landfill, to represent the proposed finished shape of the landfill relative to its current height because all five balloons were readily visible from this location;
- Two were in the Swan Point Cemetery (SPC) in Providence, across the Seekonk River to the east and southeast of the Site to reflect the finished height of the landfill against the tree canopy that backdrops the view from this location;
- Nine locations were in the residential neighborhood to the north and northeast of the landfill; and
- Seven were in the Mount Saint Mary's Cemetery to the west and northwest of the landfill.

For the selected vantage points, at least one balloon was visible at 14 of the 19 locations and five of these were from the residential neighborhood. Table 1 presents balloon visibility at each location.

Table 1: Balloon Visibility per Location (March 18, 2021)

Location ID	Geographical Location	Balloon 1	Balloon 2	Balloon 3	Balloon 4	Balloon 5
1	Nassau Street	✓	✓	X	X	X
2	Nassau Street	✓	✓	X	X	X
3	Charlton Avenue	X	X	X	X	X
4	Bishop Street	✓	X	X	X	X
5	Nassau Street	✓	✓	X	X	X
6	Mt. St. Mary's Cemetery	✓	✓	✓	✓	X
7	Mt. St. Mary's Cemetery	X	✓	✓	✓	✓
8	Mt. St. Mary's Cemetery	X	X	X	X	X
9	Mt. St. Mary's Cemetery	X	X	X	X	X
10	Mt. St. Mary's Cemetery	X	X	X	X	X
11	Mt. St. Mary's Cemetery	X	X	X	X	X
12	Bucklin Point WWTF	✓	✓	✓	✓	✓
13	Nassau Street	✓	✓	X	X	X
14	Nassau Street	✓	✓	X	X	X
15	Bishop Street	✓	X	X	X	X
16	Nassau Street	✓	✓	X	X	X
17	Mt. St. Mary's Cemetery	X	✓	✓	X	X
18	Swan Point Cemetery	✓	✓	✓	✓	X
19	Swan Point Cemetery	✓	✓	X	X	X

The key observations made during this evaluation are summarized below:

- All five balloons, representing the most complete view of the proposed grading at the landfill, were visible from the Bucklin Point WWTF (Location 12). This vantage point reflects the relative height of the balloons in comparison to the existing landfill surface. From this vantage point it is easy to see that the proposed grading represents a relatively insignificant increase in the total height of the landfill.
- Vantage points in the Swan Point Cemetery to the west across the river (photo locations 18 and 19) help further demonstrate the observations made from the Bucklin Point WWTF because most of the balloon were visible. These locations are approximately a half mile from the Site. Though this distance compromises photograph quality, they too show that the proposed grading represents a relatively modest increase in the height of the landfill.
- Vantage points at former residences on Nassau Street (locations 1 and 13) provide a view of only balloons 1 and 2 in the northern part of the landfill, through light foliage. It is understood that NBC is considering redevelopment of these parcels into a public park once the Pawtucket Tunnel and Pump Station construction is complete. Proposed landfill grading will not detract views from these vantage points as there is little view beyond the landfill from this location.
- Multiple vantage points were selected in the residential neighborhood to the north, directly abutting Bucklin Point WWTF property (locations 2, 5, 14 and 16). The landfill is visible at each location as were some of the balloons, but only through thick foliage (it is noted that these views would further diminish once the foliage is in bloom). There are limited views of the river over the existing landfill that may be further obscured by proposed grading. These views are not widespread and unimpeded because of the dense tree line along the Bucklin Point WWTF property line abutting these offsite properties.
- An additional set of vantage points (locations 3, 4 and 15) are located deeper into the neighborhood to the north of the Site to document the views of other residents beyond the immediate abutters. Structures and dense foliage further obstruct views from these locations and there are limited views of the landfill. The balloons were very difficult to discern from these vantage points. There does not appear to be views of the river beyond the landfill from these vantage points. The proposed filling is not anticipated to detract views from these locations.
- The landfill and balloons were much easier to discern from vantage points directly abutting the Site in the Mount Saint Mary's cemetery (locations 6 and 7). These locations closely abut the Site and while the views were obstructed by light foliage, there are currently views of the river over the lower (southern) part of the landfill. While filling on top of the landfill will obstruct these views, this is not anticipated to be a critical issue given that this property is a cemetery with transient use.
- Vantage points along the southern border of Mount Saint Mary's cemetery (locations 8 and 11) do not have a view of the Site or the balloons. Dense foliage, topography and the distance from the Site to these viewpoints all obstruct views of the Site.
- One vantage point in the approximate center of the Mount Saint Mary's Cemetery (location 17) was added because two of the balloons were partially visible during this evaluation. While the balloons were visible, the existing landfill could not be discerned through the foliage. The river was not visible in the distance beyond the landfill.
- Vantage points selected in the eastern part of Mount Saint Mary's cemetery (locations 9 and 10) reflect the potential views of the Site from Prospect Street/Pawtucket Avenue. From both vantage points, neither the Site nor any of the balloons are visible. The distance from the Site, visual obstructions (headstones and other structures), topography, and dense foliage all contribute to this.

Conclusions

This study was performed to evaluate potential visual impacts to nearby residents and stakeholders from proposed filling and grading atop the Bucklin Point North Landfill using tunnel debris from Pawtucket Tunnel construction. A balloon height evaluation was chosen because multiple balloons could be deployed to represent the change in grades at various locations on top of the landfill, while providing visual evidence from several nearby vantage points.

Based on this evaluation, it does not appear that significant visual impacts are likely. No unimpeded, widespread views of the Seekonk River over the existing landfill were observed during this evaluation that would be significantly compromised by the grading as planned. This evaluation was performed in late winter before the foliage is in bloom, and the visibility of the Site at other times of the year will be even less than that observed during this evaluation. There are limited views of the river from some locations in the neighborhood near the Site, but these are not widespread due in large part to the dense tree line along the property line of the Site. There are also views of the river from some vantage points in the Mount Saint Mary's Cemetery directly abutting the Site, but this is not considered critical due to the cemetery's transient use.

Limitations to this evaluation are as follows:

- Visual observations and photographs were made from ground level, so it is unknown if a view from a second story elevation would change any of these findings.
- We did not attempt to enter buildings or private property to make observations or take photographs from other vantage points not identified herein. As such, residential properties in the nearby neighborhood along Arbor Street in East Providence were inaccessible to us during this evaluation. These properties may have views of the Site and of the river over the landfill, but only through the dense tree line along the Site property line and therefore limited and not widespread.

Despite these limitations, it is not anticipated that visual impacts from raising the height of the landfill as currently planned is a significant concern to the viability of this project. It is also unknown to what degree comments from residents and stakeholders will be taken into account by RIDEM when evaluating the proposed activity. As such, it is recommended that design and permitting of the Bucklin Point North Landfill filling continues as planned. As stated before, this will require RIDEM approval of a Beneficial Use Determination (BUD). The benefits to this plan which should be presented in the BUD request are:

- Tunnel debris used in filling and grading at the Bucklin Point landfill represents a potential cost savings when compared to the likely alternative of offsite disposal, due to the site's proximity to construction and the lack of disposal tipping fees.
- It reduces construction risk and the potential costs associated with those risks, such as contractor downtime, because the Site provides an Owner-controlled facility for tunnel debris acceptance.
- Grading with tunnel debris can support future site uses. Future uses being considered include a new park and renewable energy in the form of ground mounted solar.
- Grading with tunnel debris can direct stormwater runoff to areas around the landfill where it can be better managed than under current conditions. Stormwater runoff to the east, which is currently allowed to flow across the paved access road, can also be reduced by the currently proposed grading concept.
- Tunnel debris is less permeable than existing cap material atop the landfill. This would lower infiltration into the landfill which in turn reduces leachate generation.

We believe the required next steps are as follows:

- Stantec/Pare to complete methane sampling field work and report the results in a separate technical memorandum. This was started concurrent to this balloon height evaluation.
- NBC, Stantec/Pare, and ESS to attend a pre-application meeting with CRMC to review permitting requirements for Bucklin Point Landfill and Bishop Cove Wetland Restoration projects.
- NBC to identify their proposed final use of the Bucklin Point North Landfill so that final grades and facilities can be designed accordingly.
- Stantec/Pare to prepare final design package suitable for permitting as well as construction, anticipated to include drawings, specifications, and an engineering analysis with stormwater design and slope stability analysis.
- NBC to submit a BUD request to RIDEM for the proposed activity and undertake the public comment period, including notification and public hearing, during the RIDEM review of the BUD request.

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Figure 1

Balloon Locations

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BY: MATTHEW SPRAGUE

DWG FILE: Z:\JOBS\14 Jobs\14106.03 NBC Phase III CSO CER-RI\Task 19E-Bucklin Point Landfills\DWGS\C1.X Ballon Test Locations.dwg DATE: Wednesday, April 7, 2021 11:56:58 AM

REV	DATE	BY	DESCRIPTION

SCALE 1"=60'

WARNING 0 ½ 1 IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

DESIGNED M. SPRAGUE
DRAWN M. SPRAGUE
CHECKED B. BLANCHARD

ANY PRINTS NOT BEARING THIS STAMP MAY HAVE BEEN PRINTED PRIOR TO ADVERTISING AND CANNOT BE CONSIDERED AS BID DOCUMENTS

NARRAGANSETT BAY COMMISSION
PHASE III COMBINED SEWER OVERFLOW PROGRAM

NBC CONTRACT NO 308.13C
CIVIL
TUNNEL MUCK RELOACTION AND SITE EVALUATION
PAWTUCKET AND EAST PROVIDENCE, RI
VISUAL IMPACT ASSESSMENT - BALLOON LOCATIONS

SHEET 1
195130227

Figure 2
Balloon Height and Elevation

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MEASUREMENT OF BALLOON HEIGHT WITH STADIA ROD. TYPICAL PROCESS DURING PLACEMENT OF ALL BALLOONS.

TITLE:

SIMULATED AERIAL VIEW OF BALLOONS

PROPOSED BISHOP COVE REDEVELOPMENT
BUCKLIN POINT
EAST PROVIDENCE, RI

REFERENCE(S): BING, 2021. URL: https://www.bing.com/maps/aerial, Bing Bird's Eye Oblique Image

Legend

Approximate Balloon Survey Location

NOTE: NOT TO SCALE DUE TO OBLIQUE IMAGE USED

★ SITE LOCATION

PARE PROJECT NO.: 14106.08
DATE: APRIL 2021

FIGURE: 2

Figure 3

Existing Site Grades and Surrounding Topography

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TITLE:

NEIGHBORHOOD OVERVIEW

PROPOSED BISHOP COVE REDEVELOPMENT
BUCKLIN POINT
EAST PROVIDENCE, RI

REFERENCE(S): RIGIS, 2021. URL: http://www.rigis.org,
Rhode Island Geographic Information System (RIGIS) Data Distribution System.
Environmental Data Center, University of Rhode Island, Kingston, RI.

Legend

- Balloon Survey Locations
- Municipal Boundaries
- Tree Line (approx.)

0 125 250 500 Feet

N W E S

2-Foot Contour Intervals
Elevation above Mean Sea Level
≥ 2'
increasing
≤ 100'

SITE LOCATION

PARE PROJECT NO.: 14106.03
DATE: APRIL 2021

The Narragansett Bay Commission

Stantec

PARE CORPORATION

FIGURE: 3

Figure 4

Balloon Height Survey Vantage Points

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TITLE:

BALLOON STUDY OVERVIEW PLAN

PROPOSED BISHOP COVE REDEVELOPMENT
BUCKLIN POINT
EAST PROVIDENCE, RI

REFERENCE(S): RIGIS, 2021. URL: http://www.rigis.org, Rhode Island Geographic Information System (RIGIS) Data Distribution System. Environmental Data Center, University of Rhode Island, Kingston, RI.

PARE PROJECT NO.: 14106.03
DATE: APRIL 2021

Stantec
PARE CORPORATION
The Narragansett Bay Commission

FIGURE: 4

Appendix A

Photo Log

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Vantage Point 1, Photograph 1 (Nassau Street)
Two balloons visible through light foliage

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Vantage Point 1, Photograph 2 (Nassau Street)
Closeup of balloons

Vantage Point 2, Photograph 1 (Near 60 Nassau Street)
Two balloons visible through foliage.

Vantage Point 3, Photograph 1 (Charlton Ave at Bishop Street)
No view of landfill or balloons.

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Vantage Point 4 (Bishop Street)
Photograph 1 (Wideview) and Photograph 2 (Closeup)
View of one balloon between structures and through foliage.

Vantage Point 5, Photograph 1 (End of Nassau Street)
Existing landfill and two balloons visible through foliage.

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MANAGEMENT COUNCIL

Vantage Point 5, Photograph 2 (End of Nassau Street)
Closeup view of landfill and two balloons visible through foliage.

Vantage Point 6, Photograph 1 (Mt. St. Mary's Cemetery)
View of landfill and 3 balloons visible through foliage, looking southwest.

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COASTAL RESOURCES
MANAGEMENT COUNCIL

Vantage Point 6, Photograph 2 (Mt. St. Mary's Cemetery)
View of landfill and balloon visible through foliage, looking west.

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COASTAL RESOURCES
MANAGEMENT COUNCIL

Vantage Point 7, Photograph 1 (Mt. St. Mary's Cemetery)
View of landfill and balloons through foliage.

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COASTAL RESOURCES
MANAGEMENT COUNCIL

Vantage Point 7, Photograph 2 (Mt. St. Mary's Cemetery)
Closeup view of landfill and balloons through foliage, looking west.

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MANAGEMENT COUNCIL

Vantage Point 7, Photograph 3 (Mt. St. Mary's Cemetery)
Closeup view of landfill and balloons through foliage, looking southwest.

Vantage Point 8, Photograph 1 (Mt. St. Mary's Cemetery)
No view of landfill or balloons.

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Vantage Point 9, Photograph 1 (Mt. St. Mary's Cemetery)
No view of landfill or balloons.

Vantage Point 10, Photograph 1 (Mt. St. Mary’s Cemetery)
No view of landfill or balloons.

Vantage Point 11 Photograph 1 (Mt. St. Mary's Cemetery)
No view of landfill or balloons.

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Vantage Point 12, Photograph 1 (Bucklin Point WWTF)
View of entire landfill and all 5 balloons.

Vantage Point 13, Photograph 1 (12 Nassau Street)
View of landfill and balloons from possible future park.

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COASTAL RESOURCES
MANAGEMENT COUNCIL

Vantage Point 13, Photograph 3 (12 Nassau Street)
Closeup view of landfill and balloons from possible future park.

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COASTAL RESOURCES
MANAGEMENT COUNCIL

Vantage Point 14, Photograph 1 (Nassau Street near BPWWTF Delivery Entrance)
View of landfill and 1 balloon.

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COASTAL RESOURCES
MANAGEMENT COUNCIL

Vantage Point 14, Photograph 2 (Nassau Street near BPWWTF Delivery Entrance)
Closeup view of landfill and 2 balloons.

Vantage Point 15, Photograph 1 (Bishop Street, west of Charlton Ave)
View of 1 balloon in distance, no view of landfill.

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Vantage Point 15, Photograph 2 (Bishop Street, west of Charlton Ave)
Closeup view of 1 balloon with no view of landfill or river beyond.

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MANAGEMENT COUNCIL

Vantage Point 16, Photograph 1 (Bishop Street, west of Charlton Ave)
View of landfill and balloons with limited view of river in distance.

Vantage Point 16, Photograph 2 (Bishop Street, west of Charlton Ave)
View of landfill and balloons through trees and foliage.

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Vantage Point 17, Photograph 1 (Mt. St. Mary's Cemetery)
Long range view of balloons without view of landfill or river beyond.

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Vantage Point 18, Photograph 1 (Swan Point Cemetery)
Long range view of landfill and balloons.

Vantage Point 18, Photograph 2 (Swan Point Cemetery)
Closeup view of landfill and balloons.

Vantage Point 19, Photograph 1 (Swan Point Cemetery)
Long range view of landfill and balloons.

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3/4/2022
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Vantage Point 19, Photograph 2 (Swan Point Cemetery)
Closeup view of landfill and balloons.

RECEIVED
3/4/2022
COASTAL RESOURCES
MANAGEMENT COUNCIL

Phase III CSO Program
Memorandum

To: Brandon Blanchard, P.E.

CC:

Date: February 9, 2022

From: Simon McGrath, P.G., P.E.
My Linh Pham, E.I.T.

Reviewed by: Brandon Blanchard, P.E.

Subject: Pawtucket Tunnel Construction Debris
Bucklin Point North Landfill & Grading
Slope Stability Modeling

This memorandum summarizes analyses performed for the Bucklin Point North Landfill to model the slope stability of the landfill after increasing the height from proposed filling and grading with tunnel construction debris. Existing conditions mapping is based on topographic survey by Bryant Associates and proposed grades were developed by Stantec and Pare Corporation. The objective was to perform an analysis of the stability of the landfill after the addition of the proposed tunnel construction material. The analysis was done using proprietary software, SLOPE/W 2021 R2 software by GeoSlope, to check that the modeled stability meets or exceeds industry standard factors of safety for the proposed grading. Outlined herein is a description of the approach and presentation of the findings.

Proposed Conditions

It is proposed to reuse material from the tunnel boring operations for the CSO Phase III project, which will increase the height of the landfill. We understand that the proposed grades of the North Landfill following the planned filling and grading with tunnel construction debris result in a maximum height of approximately 15 feet measured from the existing landfill surface. The length of the area is approximately 1,600 feet, roughly northwest to southeast based on the current orientation of the landfill parallel to the Seekonk River. The fill areas will have side slopes of 3H:1V except where they transition to a minimum 3% slope at the top plateau.

The slope stability of a cross section of the landfill following proposed filling and grading was modeled. For this study, three cross sections were taken along the east-side (land) and three cross sections were taken along the west-side (river). Details of Alignments 1 to 6 are as follows:

Table 1: Alignments Information

Alignment No.	Location	Length (ft)	Muck pile height (ft)
1	Eastern slope (land-side)	180	8.0
2	Eastern slope (land-side)	330	14.6
3	Eastern slope (land-side)	185	4.3
4	Western slope (River-side)	465	7.0
5	Western slope (River-side)	400	12.1
6	Western slope (River-side)	260	6.1

See attached figures SK-1 and SK-2 for more information on the cross sections.

Soil Parameters

Soil parameters used in the GeoSlope models were determined from Standard Penetration Test (SPT) blow counts and sample descriptions of borings B17-1 and B17-2A performed at Bucklin Point North Landfill during the CSO Phase III Geotechnical Exploration Program. In general, the model consists of approximately 1 to 14 feet of tunnel muck, overlying approximately 27 to 45 feet of landfill material consisting of Sand and Silt, overlying Glacial Deposits. Sandstone bedrock was encountered in borings B17-1 and B17-2A at a depth of 59.75 (El. -20.45 ft) feet and 118.8 feet (El. -61.9 ft), respectively. The slope stability models for alignments 2, 3, and 6 used the boring data from B17-1; and the models for alignments 1, 4 and 5 used the boring data from boring B17-2. The boring logs are included in the attachments.

The Tunnel construction debris soil (Tunnel Muck) is anticipated to be a ground-up mixture of various particle sizes of the bedrock strata from the TBM, and also to contain a considerable amount of water from the tunneling process. Samples of the tunnel muck from the Providence Tunnel were taken from stockpiles at Smithfield Peat Co. in 2019 for geotechnical testing. Geotesting Express performed the geotechnical testing, which included Proctor Compaction and Direct Shear tests. The compaction testing gave results of about 5-8% Optimum Moisture Content with a maximum Dry Density of about 133-141 PCF, and the Direct Shear Test indicated on an angle of friction of the material of 37°. For the slope stability modeling, lower values for the angle of friction and material density were assumed in comparison to the laboratory test data, because the dumped material is anticipated to not be compacted to the same degree as soil stockpiles at Smithfield Peak. It is assumed that material dumped in filling operations at the landfill will be compacted only by the tracking action of the dozer. It is also assumed that it will have considerably higher moisture content than during in samples from Smithfield Peat, hence will be a lower density and a lower angle of friction.

Soil parameters used in the slope stability analyses are presented in Table 2.

Table 2: Soil Parameters

Material	Unit Weight, γ (pcf)	Friction Angle, ϕ (deg.)	Effective Cohesion (psf)
Tunnel construction debris soil (Tunnel Muck)	120	30	0
Capping (underlain by woven geotextile)	125	30	500
Landfill Material (Silt)	115	28	0
Landfill Material (Sand 1)	120	30	0
Landfill Material (Sand 2)	125	30	0
Silt	115	28	500
Sand 1	120	30	0
Sand 2	120	30	0
Gravel	135	36	0
Engineered Fill	147	37	0
Bedrock	Not Applicable*	Not Applicable*	Not Applicable*

*The model assumes that slope failure through bedrock will not occur.

Slope Stability

- The stability of representative cross-sections through the landfill (shown on the attached figure) were evaluated using SLOPE/W 2021 R2 software by GeoSlope.

- Slope stability analyses were modeled using the Morgenstern-Price method and Mohr-Coulomb material model. A minimum slip surface depth of 4 feet was used, and the grid and radius of the slip surfaces were specified in the model.

- Records of ground water level readings from the monitoring wells installed in borings B17-2A and B17-1 as part of the Phase III Geotechnical Exploration Program were referenced. Readings have been taken from the monitoring wells from November 2017 to October 2020, and the highest ground water elevation was used in the analyses. For more groundwater reading information, see Attachment 2: Well/Piezometer Water Level Record.

Table 3: Groundwater Table

Boring No.	Depth to Water (ft)	Elevation of Water (ft)
B17-1	33.6	5.7
B17-2A	49.5	7.4

- A minimum factor of safety ranging from 1.3 to 1.5 is recommended per American Association of State Highway and Transportation Officials.
- Slope stability modeling was performed for both the existing landfill and the proposed Tunnel construction debris soil pile.
- Figures 1 and 2 below are schematics of the models used in the analyses.

Figure 1: Slope Stability Model for the Alignment 1 (land side)

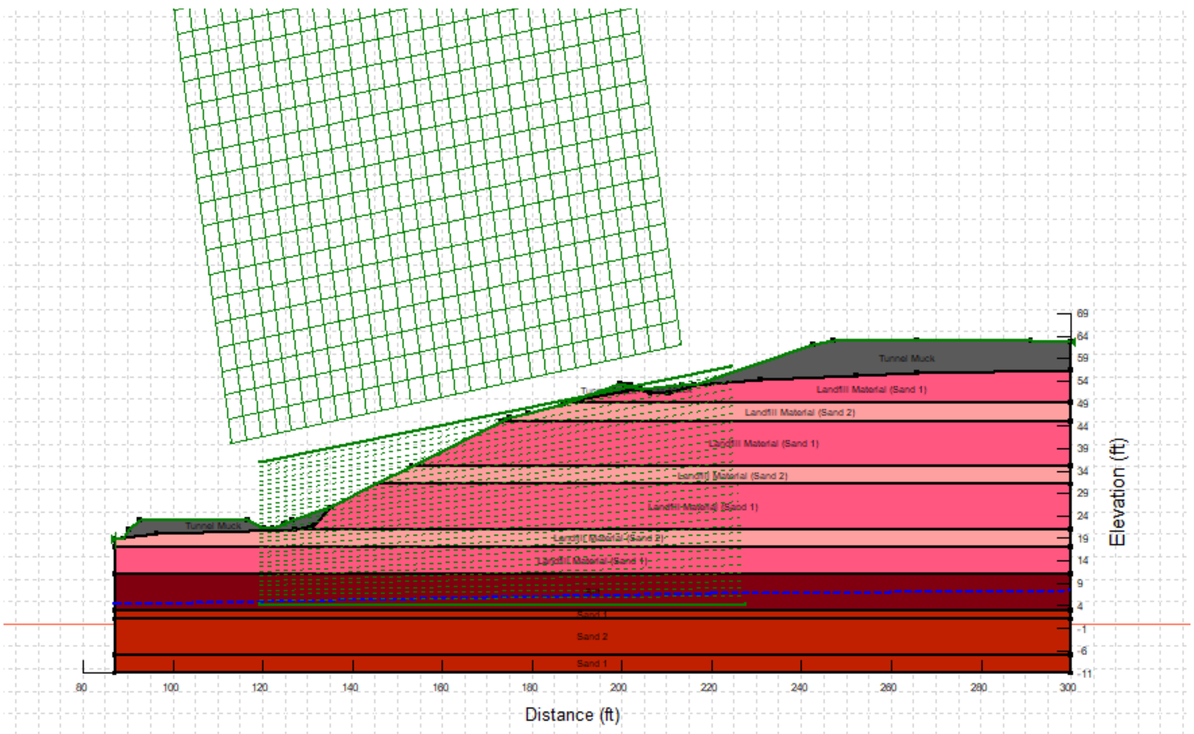
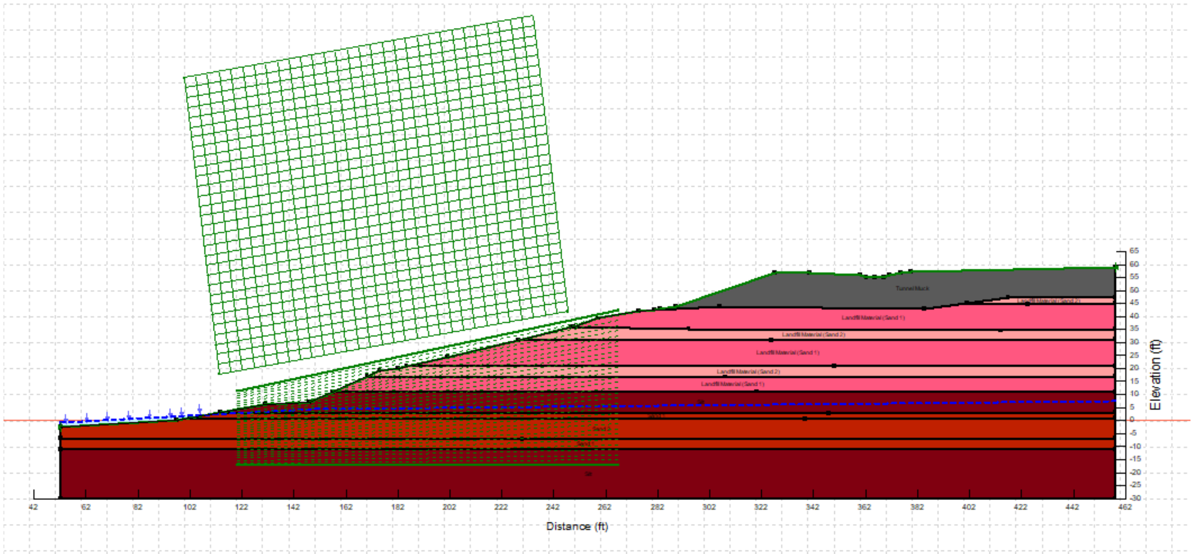


Figure 2: Slope Stability Model for the Alignment 2 (River side)



Slope Stability Results

Slope stability was evaluated for the proposed final condition for two separate zones: 1) the existing landfill side slopes that will remain undisturbed, and 2) areas of new tunnel muck fill placed above the current side slopes. These areas were evaluated separately to distinguish

Existing Landfill Side Slopes

The results of the proposed muck pile are summarized in Table 4 and the result of each alignment is included in the attached Slope Stability Results.

From these results, it may be seen that existing side slopes in modeled alignments 1 and 6 do not meet the minimum factor of safety against failure (i.e. 1.3). While the minimum factor of safety is not met for these two alignments, the results do not predict a slope failure condition because the estimated factor of safety is above 1.0. On the existing landfill slopes, a failure condition may occur where the existing side slope are steeper than those modeled, however, we are not aware of ongoing slope failures occurring on the existing landfill slopes. Given that the proposed depth of fill represents minimal additional loading on the existing landfill, the planned grading is not expected to exacerbate this condition. It should also be noted that the software does not account for the reinforcing effect of vegetation that is present on these slopes - the root mat will likely increase the stability of the slope. Finally, the modeling software also indicated that the slip circles with the lowest factor of safety were relatively shallow. A slope failure that might occur would likely be localized, relatively shallow, and easily repaired by a landscaping contractor.

Table 4 Existing Slope Results

Alignment No.	Required Minimum Factor of Safety (FOS)	Modeled Minimum FOS
1	1.5	**1.2**
2		2.2*
3		2.3*
4		1.7
5		1.7
6		**1.4**

Bold values indicate that the modeled alignment does not meet the minimum FOS
*Slip circle with the lowest factor of safety was on the proposed tunnel muck slope and existing slope

Proposed Muck Pile

Slope stability for the area of newly placed tunnel muck, above the existing landfill side slopes, was evaluated separately as previously described. These results are summarized in Table 5 and the result of each alignment is included in the attached Slope Stability Results.

Table 5: Proposed Muck Pile Slope Stability Analyses Results

Alignment No.	Required Minimum Factor of Safety (FOS)	Modeled Minimum FOS
1	1.5	2.5
2		2.3
3		2.3
4		2.7
5		2.0
6		2.5

Slope failures within areas of placed tunnel muck are not expected based on this analysis, because the minimum factor of safety against failure is met.

Attachment:
- Boring Logs
- Well/Piezometer Water Level Record
- North Landfill/Tunnel Muck Layout and Cross-Sections
- Slope Stability Modeling Results

Phase III CSO Program Memorandum

To:	Brandon Blanchard, P.E.
CC:	My Linh Pham
Date:	February 9, 2022
From:	Simon McGrath, P.G., P.E.
Reviewed by:	Brandon Blanchard, P.E.
Subject:	Pawtucket Tunnel Construction Debris Bucklin Point South Landfill Filling & Grading Feasibility-Level Slope Stability Modeling

This memorandum summarizes feasibility-level analyses performed for the Bucklin Point South Landfill to model the slope stability of the landfill after increasing the height from proposed filling and grading with tunnel construction debris. Existing conditions mapping is based on topographic survey by Bryant Associates and proposed grades were developed by Stantec and Pare Corporation. The objective was to perform a feasibility-level analysis of the stability of the landfill after the addition of the proposed tunnel construction material. The analysis was done using proprietary software, SLOPE/W 2021 R2 software by GeoSlope, to check that the modeled stability meets or exceeds industry standard factors of safety for the proposed grading. Outlined herein is a description of the approach and presentation of the findings.

Proposed Conditions

It is proposed to reuse material from the tunnel boring operations for the CSO Phase III project, which will increase the height of the landfill. We understand that the landfill height will be increased by a maximum of approximately 28 feet with slopes of approximately 3H:1V, from elevation 20 ± to elevation 48 ± (NGVD 1929).

The slope stability of a cross section of the landfill following proposed filling and grading was modeled. The cross section analyzed is along the East-West alignment through the full height of the proposed landfill. The cross-section is shown on the attached Sheet 2.

Soil Parameters

Borings have not been performed within the landfill in performing this analysis. Records of borings performed to the north on the Bucklin Point WWTF, including historical borings 540, CDM-206, and CDM-207 were used for general information on the subsurface conditions. These boring logs are attached for reference. In the absence of site-specific information on the deposits in the immediate vicinity of the Bucklin Point South Landfill, the material parameters used in the GeoSlope models were determined based on borings in the Bucklin Point North Landfill during the Phase III CSO Geotechnical Exploration Program. Standard Penetration Test (SPT) blow counts and sample descriptions on the logs of borings B17-1 and B17-2A were used. In general, the model consists of tunnel construction debris, overlying the existing landfill material, overlying alluvium, overlying Glacial Deposits, overlying Sandstone bedrock.

Without site-specific subsurface information, the analyses presented herein should be used for preliminary information until verified from borings performed within the Bucklin Point South Landfill. The proposed filling and grading plan may require modification based on reanalysis of slope stability with site specific subsurface information, following this investigation.

Tunnel construction debris soil parameters were estimated using visual observation and geotechnical laboratory testing of similar material stored at the Smithfield Peat Co., generated from the mining of the Phase I CSO Program Tunnel in Providence. Additional soil parameters were selected based on professional judgement with assumptions made based on nearby borings and borings conducted in the Bucklin Point North Landfill. Soil parameters used in the slope stability analyses are presented in Table 1.

Table 1: Soil Parameters

Material	Unit Weight, γ (pcf)	Friction Angle, ϕ (deg.)	Effective Cohesion, (psf)
Soil Capping (underlain by nonwoven geotextile)	125	30	500
Tunnel construction debris soil (Tunnel Muck)	120	30	0
Engineered Fill	135	36	0
Existing Landfill	120	30	0
Alluvium	115	28	500
Glacial Deposits	135	36	0
Bedrock	Not Applicable*	Not Applicable*	Not Applicable*

* The model assumes that slope failure through bedrock will not occur.

The Tunnel construction debris soil (Tunnel Muck) is anticipated to be a ground-up mixture of various particle sizes of the bedrock strata from the TBM, and also to contain a considerable amount of water from the tunneling process. Samples of the tunnel muck from the Providence Tunnel taken from stockpiles at Smithfield Peat Co. in 2019 were subjected to geotechnical testing by Geotesting Express. These tests included Proctor Compaction and Direct Shear tests. The compaction testing gave results of about 5-8% Optimum Moisture Content with a maximum Dry Density of about 133-141 PCF, and the Direct Shear Test indicated on an angle of friction of the material of 37°.

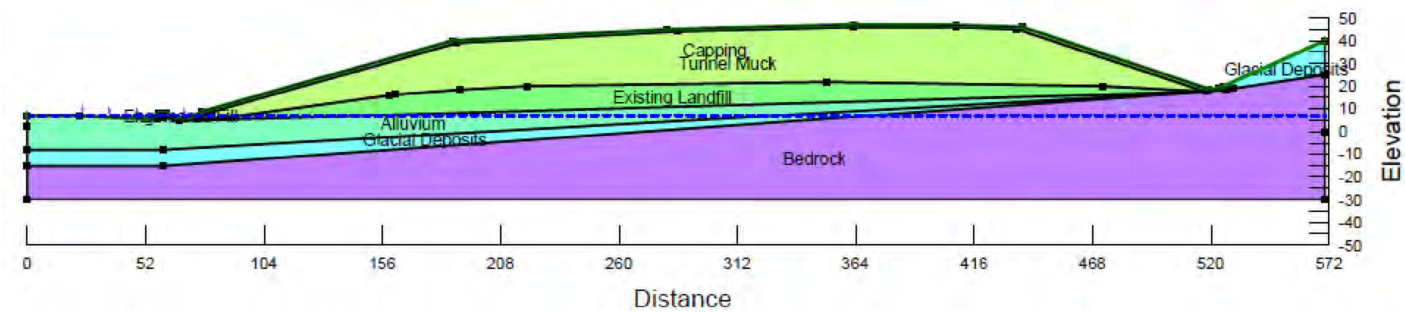
For the slope stability modeling, lower values for the angle of friction and material density were assumed as represented in Table 1. These assumptions were based in part because the dumped material is anticipated to not be compacted to the same degree as the laboratory tests. It is anticipated that the dumped material will be compacted only by the tracking action of the dozer. It also will have considerably higher moisture content than during testing in the stockpiles at Smithfield Peat, hence will be a lower density and a lower angle of friction.

<u>Slope Stability</u>

- The stability of a representative cross section through the landfill (shown as Alignment A on the attached figure) was evaluated using SLOPE/W 2021 R2 software by GeoSlope. The landfill was modeled with a maximum tunnel construction material height of approximately 28 feet and side-slopes with a maximum of 3H:1V.
- Slope stability analyses were modeled using the Morgenstern-Price method and Mohr-Coulomb material model. A minimum slip surface depth of 4 feet was used, and the grid and radius of the slip surfaces were specified in the model.
- Groundwater was modeled to be at elevation 7.4 ft. In the absence of site-specific subsurface information, the highest observed stable groundwater elevation was used from the groundwater monitoring wells installed in borings B17-1 and B17-2A in the northern landfill. This value should be verified from the site-specific subsurface geotechnical investigation. Given the setting of the Bucklin Point South Landfill, the groundwater elevation is likely lower than 7.4 feet so this represents a conservative condition for the purposes of this analysis.
- The stability of the slopes on the Western (i.e. Seekonk River) side and the Eastern (i.e. land) side were modeled.

- A minimum factor of safety ranging from 1.3 to 1.5 is recommended per American Association of State Highway and Transportation Officials.
- Figure 1 below is a schematic of the model used in the analysis.

Figure 1: Slope Stability Model



<u>Slope Stability Results</u>

The results of the slope stability analyses are summarized in Table 2.

Table 2: Slope Stability Modeling Results

Alignment	Minimum Factor of Safety (from GeoSlope modeling)	
	West (Seekonk River) Side	East (Land) Side
A	2.14	2.03

The results indicate that the landfill with the tunnel muck pile, as designed, meets or exceeds the required minimum factor of safety of 1.3 to 1.5. A graphical representation of these results is attached. These results are based on the assumptions identified herein, and should be verified using subsurface information from borings to be performed within the Bucklin Point South Landfill.

Attachment:
Historical Boring Logs
Landfill/Tunnel Muck Pile Layout and Cross Section
Slope Stability Modeling Results