APPENDIX N

GEOTECHNICAL INSTRUMENTATION AND MONITORING PLAN

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GEOTECHNICAL INSTRUMENTATION AND MONITORING PLAN

ONONDAGA LAKE SEDIMENT CONSOLIDATION AREA (SCA) FINAL DESIGN SUBMITTAL

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1. INTRODUCTION

1.1 Project Background

Onondaga Lake is a 4.6 square mile (3,000 acre) lake located in Central New York State immediately northwest of the City of Syracuse. A major component of the selected lake remedy includes the dredging and onsite consolidation of sediments removed from the lake. Honeywell evaluated potential locations for building and operating a Sediment Consolidation Area (SCA) to contain sediment removed from Onondaga Lake during the remedial action. Based on the evaluation results, Wastebed 13 was selected for building and operating the SCA. Wastebed 13 is located in the Town of Camillus and encompasses approximately 163 acres. It is bordered to the north by Ninemile Creek and the CSX Railroad tracks; to the west by an Onondaga County Garage property, a former gravel excavation owned by Honeywell, and a few residential properties; and to the east and south by Wastebeds 12 and 14, respectively. Wastebed 13 was originally designed as a settling basin for the disposal of Solvay waste (SOLW).

The purpose of the SCA is to contain dredged sediment from the Onondaga Lake remedial action. Geotextile tubes were selected as the dewatering method for the dredged sediment within the SCA. The SCA will have a maximum footprint of approximately 70 acres and will include a perimeter berm, a liner system, a gravel drainage system, stacked geotextile tubes filled with dredged sediment, and a final cap. The SCA design includes a phased construction approach to facilitate the dredging schedule, odor mitigation, underlying Solvay waste consolidation, and/or enhanced final closure.

1.2 Purpose of Instrumentation and Monitoring Program

The purpose of instrumentation and monitoring is to provide data to: (i) evaluate whether the SCA is performing as expected; and (ii) evaluate whether SCA construction and/or operations are impacting SCA and/or Wastebed 13 stability. Specifically, the scope of the Geotechnical Instrumentation and Monitoring Plan (referred to as the Plan) includes: (i) a description of the proposed instrumentation to be installed in the SCA; (ii) recommended procedures for instrument installation; (iii) requirements of instrument operation, data collection, and instrument maintenance; and (iv) recommendations on data management and analysis.

1.3 Plan Organization

The remainder of the Plan is organized as follows:

- Section 2 provides a description of the instrumentation program. It includes a summary of instrumentation to be installed in the SCA, the requirements for testing and calibration of instrument components, the recommended procedures of instrument installation, and the requirements for documentation.

- Section 3 provides a description of the monitoring program. It includes the requirements for baseline survey and monitoring prior to the SCA construction, requirements for collecting reliable data during construction, requirements for post-closure monitoring, and recommendations on data management and analysis.

- Section 4 describes the contingency plan. It includes the recommended response actions for unexpected monitoring results.

- Section 5 describes the instrumentation maintenance. It includes the requirements for maintenance of the instrumentation system during service life.

2. INSTRUMENTATION PROGRAM

2.1 Introduction

Instrumentation will be installed in the SCA and field data will be collected to assist in the evaluation of the performance of the SCA. The parameters to be monitored in the SCA include: (i) porewater pressures in the foundation SOLW at specified locations; (ii) settlement of the foundation SOLW at specified locations; and (iii) lateral movement of the foundation SOLW at specified locations near the toe of the SCA perimeter berm. In addition, porewater pressures in the Wastebed 13 dikes will be monitored.

2.2 Instrumentation Plan

A plan view of the proposed locations of instrumentation in the SCA is shown on Drawing No. 7 titled "Instrumentation and Monitoring Plan" of the Final design drawings prepared by Geosyntec Consultants. The following instruments are planned to be installed:

- Seven sets of nested vibrating wire piezometers will be installed within the footprint of the SCA. Each set of nested piezometers will consist of three piezometers at depths of 15 ft, 30 ft, and 45 ft, respectively. The piezometers will be used to monitor porewater pressures before, during, and after the SCA construction.

- Settlement profilers will be installed along five sections. The extent of the profilers to the north (i.e., into or beyond the Phase III area) will depend on whether or not construction of Phase III is required. One profile pipe will be placed in an excavated trench near the wastebed surface. The profilers will be used to monitor the settlement of the foundation SOLW under the loading from the SCA.

- Up to thirty-eight vibrating wire settlement cells will be installed within the footprint of the SCA. The installation of the nine vibrating wire settlement cells in Phase III will depend on whether construction of this phase is necessary. The settlement cells will be used to monitor the settlement of the foundation SOLW under the loading from the SCA.

- Five inclinometers will be installed. Two of them are located inside the SCA footprint near the proposed boundaries of Phase I. The other three are located outside the SCA footprint at the toe of the SCA perimeter berm. The inclinometers will be used to evaluate the amount of lateral movement of the foundation SOLW due to the SCA construction.

The SCA is expected to be constructed in phases. Installation of instrumentation in the SCA should be coordinated with the construction phasing. Specifically, the piezometers and inclinometers will be installed all at once, whereas only Phase I and II profilers and settlement cells will be installed initially. Phase III settlement cells and extensions on the profilers will only be installed if construction of Phase III is required.

In addition to the above-mentioned instruments, two vibrating wire piezometers will be installed on the side slope of the existing northern Wastebed 13 perimeter dike, as shown on Drawing No. 7 of the Final design drawings. These new piezometers, together with three nearby existing piezometers, will be used to monitor any change of porewater pressures in the existing Wastebed 13 dike due to the SCA construction.

Table 1 provides the installation and monitoring frequency information for both the piezometers installed during the pre-design investigations (PDIs) and the piezometers that will be installed as a part of SCA construction. The table also includes a list of the PDI piezometers that will be abandoned during SCA construction. Table 2 provides the monitoring frequency of the PDI piezometers during SCA filling.

2.3 Surveying and Settlement Model Calibration

In addition to the proposed instrumentation, a 50 ft by 50 ft survey grid will be set up over the footprint of the SCA. This grid will be set up as clearing progresses and will eventually include Phase I, Phase II, and the two basins. A grid in Phase III will only be set up if Phase III construction is required. Reference points or bench marks in the Phase III area and other areas within Wastebed 13 will be established so that the area outside of the SCA can be monitored as necessary. An initial survey will be performed to obtain the elevation of the existing ground. In addition, two more surveys are planned after construction of the clay liner and the gravel drainage layer, respectively, to obtain the elevations of the top of these two layers. The surveying results, together with the settlement of the foundation SOLW measured by the settlement cells and the settlement profilers, will be used to calibrate the settlement computation models. The calibrated model will be used to improve the prediction of future settlement, if needed.

2.4 Pre-Installation Acceptance Tests

The instrumentation personnel should perform pre-installation acceptance tests to ensure that the instruments and readout units are functioning properly. The U.S. Army Corps of Engineers' manual [USACE, 1995] provides a good list of items to be checked as part of pre-installation acceptance tests. According to the manual, pre-installation acceptance tests should include items from, but not limited to, the following list, as applicable:

- Examine factory calibration data to verify completeness (factory calibration and documentation should be specified).
- Examine manufacturer's quality assurance inspection check list to verify completeness (quality assurance procedures and documentation should be specified).
- Check cable length and tag numbers on instrument and cable.
- Check, by comparing with procurement documents, that the model, dimensions, materials, product performance criteria, etc. are correct.
- Bend cable back and forth at point of connection to the instrument while reading the instrument to verify connection integrity.
- Check water pressure or humidity test components as appropriate for the service entity to identify leaks.
- Verify that instrument reading as required compares favorably with factory reading.
- Perform resistance and insulation testing, in accordance with criteria provided by the instrument manufacturer.
- Verify that all components fit together in the correct configuration.

- Check all components for signs of damage in transit.
- Check that quantities received correspond to quantities ordered.

These pre-installation acceptance tests will be made available to the NYSDEC PM as they are completed.

2.5 Instrumentation Installation

General installation procedures for vibrating wire piezometers, settlement profilers, vibrating wire settlement cells, and inclinometers are presented in Attachments A through D of this Plan, respectively.

2.6 Post-Installation Acceptance Tests

The installation personnel should demonstrate that the instrument was correctly installed and is functioning properly. A minimum of three readings should be made during a short span of time to demonstrate that the instrument reading can be repeated. The installation may have an effect on the parameter which is to be measured; therefore, the instrument should be allowed to stabilize and the acceptance test repeated.

2.7 Documentation

An installation report will be prepared after completion of the installation of all instruments for each phase. The report should include a minimum of the following items [USACE, 1995]:

- Description of instruments, readout units, and other related equipment.
- Plan(s) to show as-built locations of installed instruments, cables, and tubing.
- Information of subsurface stratigraphy from boring.
- Instrument calibration and maintenance procedures.
- Instrumentation and automation documentation from manufacturers, including calibration data and warranty information.
- Pre-installation acceptance test results.

- A record of instrument installation.
- Post-installation acceptance test results.
- Names, addresses, and phone numbers of maintenance and repair sources.

The installation report should be maintained on file at the project site.

2.8 Care and Handling

All instruments should be handled carefully in accordance with manufactures' instructions to ensure satisfactory performance. Cables and tubes should be protected from nicking, bending, and kinking. Instruments installed outside the SCA footprint should be protected with a protective housing that is provided with a vented locking cap. Protective housings should be grouted into place not only to secure the cap but also to prevent surface water from flowing into the instrument. Locations of instruments, cables, and tubes should be staked with warning flags. Care should be taken by contractors during the SCA construction to prevent the damage of the system by excavation, if any, and construction traffic.

3. MONITORING PROGRAM

3.1 Introduction

The performance of the SCA will be monitored during the construction and operations and for a limited period of time after closure as determined by the Design Engineer based on monitoring results. Geotechnical data to be collected include porewater pressures and vertical and horizontal displacements. This section addresses the procedures and requirements for monitoring. Tables 1 to 5 provide the frequencies for baseline, during construction, and during operation monitoring of the SCA.

3.2 Baseline Survey

As mentioned previously, a 50 ft by 50 ft survey grid will be set up over the footprint of the SCA (i.e., Phase I, Phase II, and the basins initially and Phase III only if needed). Prior to the SCA construction of a phase (i.e., before the construction of perimeter berm and the liner system), an initial survey will be performed to obtain the northing, easting, and elevation of the existing ground within that phase.

3.3 Baseline Monitoring

Baseline values will be established from the instruments installed in the SCA. The following baseline monitoring will be performed prior to the SCA construction:

- The piezometers will be monitored frequently until the installation-induced pore pressures have dissipated and the steady-state is reached. Piezometers may take a significant amount of time to stabilize after installation due to drilling effects, lag time, or temperature. The "datum" reading (i.e., field zero) should not be taken until after dissipation of installation-induced pore pressures.

- Initial readings will be taken from the settlement profilers, inclinometers, and settlement cells before the construction of the SCA commences.

3.4 Monitoring during Construction and Operations

3.4.1 Measurement of Settlement

Settlement of the foundation SOLW due to loading from the SCA will be monitored by the settlement profilers and the settlement cells. The total settlement of the foundation SOLW due to the liner system and the gravel drainage layer will be measured by surveying.

The procedure of measuring the settlement using the profiler is presented in Attachment B of this Plan. The process can be carried out as a two-man operation with one pulling the draw cord and the other booking the readings. The settlement profilers will be read twice per week during the construction and operation of the SCA. Under the direction of the Design Engineer, profiler readings may only need to be performed in the areas that are undergoing active filling or have been filled during the last few weeks. In addition, the Design Engineer may adjust the monitoring frequency based on the observed readings. Modifications to monitoring frequencies will be in consultation with and approved by NYSDEC.

The settlement cells will be read automatically with a data logger. Data will be retrieved remotely from the logger using electrical cables or wireless options. The automated monitoring provides a real-time continuous observation of the performance of the SCA during construction and operations and enables a quick response to any unexpected monitoring results, if they occur.

Survey will be performed at the following stages of SCA construction and operations: (i) before and after the construction of the perimeter berm and the clay liner; (ii) after the construction of the gravel drainage layer; and (iii) before and after the placement of final cover. By comparing the measurements, the thickness of each layer can be determined, using a procedure described in Attachment E. Additionally, by comparing the measurement at different times, the total and incremental settlement of the foundation SOLW and the dredge material can be determined. Attachment E includes a figure and sample calculation to illustrate the use of survey data to determine the total and incremental settlement. Seventeen reference points/benchmarks outside of the SCA will also be monitored.

After calculation of the total and incremental settlement of the foundation SOLW and dredge material, the calculated settlements can be combined with the known elevations from the preconstruction survey to calculate the current elevations at settlement cell locations and along the settlement profilers and verify that positive drainage is maintained. If drainage reversal is observed during filling, geotextile tube sequencing or other remedial actions will be taken, as discussed in Section 4.

3.4.2 Measurement of Porewater Pressure

Piezometers will be used to monitor the porewater pressures in the foundation SOLW and to confirm the dissipation of excess porewater pressures that are developed as a result of the SCA construction. The on-site weather station will continue to operate as long as porewater pressure monitoring is ongoing, to allow correlation of measured porewater pressures and other data with on-site rainfall. Potential change of porewater pressures in the existing Wastebed 13 perimeter dike will also be monitored by piezometers. Similar to the settlement cells, the new piezometers installed during SCA construction will be monitored automatically using remote techniques during SCA construction and operation. The PDI piezometers will be monitored as specified in Tables 1 and 2.

3.4.3 Measurement of Lateral Movement

Lateral movement of the foundation SOLW will be monitored by the inclinometers. Readings will be taken manually using a portable inclinometer probe and a portable readout two times a week during SCA construction and operation. At inclinometer location SI-G3, two boreholes will be drilled, and an inclinometer casing will be installed in each one. One of them will be continually monitored using a Measurand ShapeAccelArray (SAA), and the other one will be manually monitored with a portable inclinometer probe. The SAA-type inclinometer is proposed for one of the locations as a method for potentially reducing the amount of labor required for monitoring, since this system automatically collects the data. This location was selected because it is one of the permanent inclinometer locations and is a critical area for stability. If appropriate, future consideration will be given to installing additional SAAs.

The Design Engineer may adjust the monitoring frequency based on the observed readings. It is recommended that the same probe and control cable be used for each survey for consistency. If the inclinometer data indicates unacceptable movement, the geotextile tube sequencing will be altered or other remedial actions will be taken, as discussed in Section 4.

The two inclinometers inside the SCA footprint near the proposed boundaries of Phase I will be abandoned during the construction of Phases II and III liner systems, as directed by the Design Engineer.

3.5 Post-Closure Monitoring

Monitoring requirements and frequencies will be different after closure of the SCA. Post-closure monitoring will be addressed in a separate document and agreed upon in consultation with the Design Engineer and NYSDEC.

3.6 Data Management and Analysis

The management of data consists of data collection, reduction and processing, and presentation. The instrumentation manufacturers usually provide tools (i.e., hardware and software) to automatically retrieve the data from a data logger or a portable readout, interpret the data, and plot the data graphically as a function of time. For the measurement of settlement using the profiler, the data should be recorded and saved electronically (i.e., in Excel® spreadsheets) for analysis. Settlement cell data will be presented as a contour map of the top of liner elevations, and the settlement profiler data will be presented as cross-sections of the top of liner elevations. The Design Engineer will remotely monitor data on a daily basis and provide verbal updates to the construction team and NYSDEC on a weekly basis; however, if unexpected conditions are identified at any time, the construction team and NYSDEC will be notified within 24 hours. The contour maps and cross sections will be provided to NYSDEC on a monthly basis. Based on a review of the data, the Design Engineer may request more frequent measurements or additional instruments. The Design Engineer will notify Honeywell and the contractor immediately if an unexpected condition occurs that may affect the stability of the SCA. Unexpected conditions include: (i) excessive lateral or vertical movement in a relatively short period; (ii) rapid increase of porewater pressures associated with shear movement; and (iii) significant reversal of the base liner grades.

Unacceptable values for the monitored parameters are not defined at this time because what is considered unacceptable for a particular parameter depends on the overall performance of the SCA and the Solvay waste based on data obtained from a combination of sources including, but not limited to, piezometers, settlement cells, profilers, inclinometers, survey data, and general field observations. Data from all of these sources will be evaluated by the Design Engineer during SCA construction and operation. This instrumentation data will be shared with NYSDEC, as requested. If deemed necessary by the Design Engineer, contingency measures presented in Section 4, such as altering the geotextile tube filling sequence, will be implemented.

4. CONTINGENCY PLAN

The steps outlined below should be followed when an unexpected condition occurs that will affect the stability or performance of the SCA.

In the event of stability issues:

- Temporarily suspend the SCA construction or operation in the affected area to allow the underlying SOLW to consolidate and gain strength.

- Visually inspect the SCA for any sign of cracks or bulges on the ground or on top of the SCA.

- Ensure that all monitoring equipment is working properly. Additional instruments may be installed nearby if data collected from the existing instruments is determined to be questionable due to defective equipment or installation procedures.

- Increase the frequency of readings to monitor and provide data to further evaluate the situation.

- Should excessive movement rate continue after construction work has ceased, consider constructing a compacted soil berm adjacent to the toe of the SCA perimeter berm.

- Execute the solution with concurrence of Honeywell, the NYSDEC, and the Design Engineer.

In the event of significant grade reversal of the base liner that will adversely affect the flow of liquid in the drainage layer:

- Temporarily suspend the SCA construction or operation in the affected area.

- Ensure that the profilers and the settlement cells are working properly.

- Modify geotextile tube fill sequence to correct the grade reversal.

- Increase the frequency of readings to monitor and provide data to further evaluate the situation.

- Consider installation of temporary sumps/pumps in affected areas with grade reversal, to the extent practicable.

- Execute the solution with concurrence of Honeywell, the NYSDEC, and the Design Engineer.

In the event of instrument failure before sediment placement:

- Troubleshooting will be performed to identify the causes and remediate the problem prior to sediment placement.

- If repair of the instrumentation is not possible, additional or alternate instruments will be installed before sediment placement, if practical.

- The solution will be executed with concurrence of Honeywell, the NYSDEC, and the Design Engineer.

In the event of instrument failure during sediment placement:

- Troubleshooting will be performed to identify the causes and remediate the problem, if practical.

- Design Engineer will conduct a review of the impact of the failed component on the overall performance of the monitoring system and SCA performance. It is noted that the instrumentation system has been designed with multiple instrument types and redundancy. Therefore, the failure of one component or measurement will not result in failure of the entire system.

- The solution will be executed with concurrence of Honeywell, the NYSDEC, and the Design Engineer.

5. INSTRUMENTATION MAINTENANCE

Regular maintenance should be performed to ensure that the instrumentation systems remain in a satisfactory operating condition during their service lives. The instrumentation personnel should follow the manufacturer's maintenance schedules during the SCA construction and operations. After the SCA closure, the instrument components will be inspected as part of the quarterly final cover inspections.

The maintenance should be performed in accordance with the manufacturer's procedures. General requirements for the maintenance of the major components of the instrumentation system are discussed below:

- *Portable readout units*: Portable readout units should be protected from mishandling. The units should be kept clean and dry and checked routinely for connection and damaged parts. Batteries should be replaced as needed. In addition, the units should be recalibrated regularly following the manufacturer's instructions or sent to manufacture for calibration, adjustment, or repair.

- *Retrievable components*: Retrievable components, including wires, tubes, cables, data loggers, data controllers, and communications systems should be protected from rodents, vandals, and transient voltage surges. All plugs, caps, and covers should be maintained in good condition. Reservoirs for the settlement cells should be checked periodically and refilled as necessary in accordance with the manufacturer's instructions.

- *Embedded components*: Embedded components are normally inaccessible and maintenance is not possible. Embedded components that are accessible, such as inclinometer casings, can be inspected by downhole video cameras to determine if maintenance is required. Such video camera investigation will be performed on the profiler post-construction of the liner system if camera access is possible, regardless, post-construction profiler readings from all profilers will be obtained prior to operation to establish baseline readings and verify working condition of all the profilers.

Any maintenance, recalibration, or replacement should be documented and reported to the Engineer. Follow-up checks should be made to verify success of maintenance.

6. REFERENCES

U.S. Army Corps of Engineers (USACE). "*Instrumentation of Embankment Dams and Levees*", Engineering Manual 1110-2-1908, Washington DC, 30 June 1995.

TABLES

Table 1: Piezometer Monitoring Frequency

Piezometer Name	Serial Number	Date Installed	Type	Ground Surface Elevation	Piezometer Tip Elevation	Piezometer Depth (ft bgs)	Proposed Monitoring Frequency	Baseline Monitoring	Additional comments
Wastebed Piezometers (installed during Phase II PDI)									
SB915-PZ13-01S	06-20309	11/10/2006	Geokon VW	430.89	411.39	19.5	Quarterly (min.)[1]	Quarterly	Near proposed SCA East Basin
SB915-PZ13-01D	06-19784	11/10/2006	Geokon VW	430.89	391.39	39.5	Quarterly (min.)[1]	Quarterly	Near proposed SCA East Basin
SB915-PZ13-01N	06-19773	11/9/2006	Geokon VW	430.89	367.39	63.5	Quarterly (min.)[1]	Quarterly	Near proposed SCA East Basin
SB915-PZ13-02I	06-20310	11/8/2006	Geokon VW	430.34	410.44	19.9	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-02D	06-20305	11/8/2006	Geokon VW	430.34	393.84	36.5	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-02N	06-19778	11/7/2006	Geokon VW	430.34	380.34	50.0	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-03S	06-20308	11/14/2006	Geokon VW	429.17	408.67	20.5	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-03I	06-19786	11/13/2006	Geokon VW	429.17	388.97	40.2	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-03D	06-19775	11/13/2006	Geokon VW	429.17	369.67	59.5	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-04S	06-19781	11/20/2006	Geokon VW	419.10	403.60	15.5	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-04I	06-19774	11/20/2006	Geokon VW	419.10	383.60	35.5	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-04D	06-19776	11/17/2006	Geokon VW	419.10	366.60	52.5	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-04N	N/A	11/16/2006	Standpipe	418.62	305.62	113.0	N/A	N/A	Removed as part of SCA construction
SB915-PZ13-05S	06-20311	11/6/2006	Geokon VW	432.94	418.14	14.8	Quarterly (min.)[1]	Quarterly	West of proposed SCA West Basin
SB915-PZ13-05I	06-19785	11/3/2006	Geokon VW	432.94	397.94	35.0	Quarterly (min.)[1]	Quarterly	West of proposed SCA West Basin
SB915-PZ13-05N	06-19772	11/3/2006	Geokon VW	432.94	376.94	56.0	Quarterly (min.)[1]	Quarterly	West of proposed SCA West Basin
SB915-PZ13-06S	06-20307	11/7/2006	Geokon VW	428.67	410.50	19.5	Quarterly (min.)[1]	Quarterly	West of SCA Phase II
SB915-PZ13-06I	06-20306	11/6/2006	Geokon VW	428.67	395.50	34.5	Quarterly (min.)[1]	Quarterly	West of SCA Phase II
SB915-PZ13-06D	06-19771	11/6/2006	Geokon VW	428.67	380.50	49.5	Quarterly (min.)[1]	Quarterly	West of SCA Phase II
SB915-PZ13-06N	06-19769	11/3/2006	Geokon VW	428.67	366.00	64.0	Quarterly (min.)[1]	Quarterly	West of SCA Phase II
Dike Piezometers (installed during Phase II PDI)									
SB915-PZ13-07	06-19782	11/14/2006	Geokon VW	438.23	384.23	54.0	Quarterly (min.)[1]	Quarterly	Perimeter dike
SB915-PZ13-08	N/A	11/27/2006	Standpipe	431.35	391.35	40.0	Quarterly (min.)[1]	Quarterly	Perimeter dike
SB915-PZ13-09	06-19783	11/16/2006	Geokon VW	432.48	395.98	36.5	Quarterly (min.)[1]	Quarterly	Perimeter dike
SB915-PZ13-10	N/A	11/29/2006	Standpipe	397.45	365.45	32.0	Quarterly (min.)[1]	Quarterly	Perimeter dike
SB915-PZ13-11	06-19787	11/17/2006	Geokon VW	432.44	391.44	41.0	Quarterly (min.)[1]	Quarterly	Perimeter dike
SB915-PZ13-12	N/A	11/28/2006	Standpipe	431.51	406.51	25.0	Quarterly (min.)[1]	Quarterly	Perimeter dike
SB915-PZ13-13	06-19779	11/21/2006	Geokon VW	434.26	404.26	30.0	Quarterly (min.)[1]	Quarterly	Perimeter dike
SB915-PZ13-14	06-19780	11/27/2006	Geokon VW	443.67	413.67	30.0	Quarterly (min.)[1]	Quarterly	On dike between WB-13 and WB-14
SB915-PZ13-15	06-19770	11/29/2006	Geokon VW	446.56	416.56	30.0	Quarterly (min.)[1]	Quarterly	On dike between WB-13 and WB-14
SB915-PZ13-16	N/A	11/22/2006	Standpipe	441.08	411.08	30.0	Quarterly (min.)[1]	Quarterly	On dike between WB-13 and WB-12

Table 1: Piezometer Monitoring Frequency (Continued)

Piezometer Name	Serial Number	Date Installed	Type	Ground Surface Elevation	Piezometer Tip Elevation	Piezometer Depth (ft bgs)	Proposed Monitoring Frequency	Baseline Monitoring	Additional comments
SCA Piezometers (to be installed as part of SCA Construction)									
PZ-G1A		Oct-2010	ITM VW			15.0	Continuous	Quarterly	SCA Phase I, near west sump
PZ-G1B		Oct-2010	ITM VW			30.0	Continuous	Quarterly	SCA Phase I, near west sump
PZ-G1C		Oct-2010	ITM VW			45.0	Continuous	Quarterly	SCA Phase I, near west sump
PZ-G2A		Oct-2010	ITM VW			15.0	Continuous	Quarterly	SCA Phase I, near east sump
PZ-G2B		Oct-2010	ITM VW			30.0	Continuous	Quarterly	SCA Phase I, near east sump
PZ-G2C		Oct-2010	ITM VW			45.0	Continuous	Quarterly	SCA Phase I, near east sump
PZ-G3A		Oct-2010	ITM VW			15.0	Continuous	Quarterly	SCA Phase I
PZ-G3B		Oct-2010	ITM VW			30.0	Continuous	Quarterly	SCA Phase I
PZ-G3C		Oct-2010	ITM VW			45.0	Continuous	Quarterly	SCA Phase I
PZ-G4A		Oct-2010	ITM VW			15.0	Continuous	Quarterly	SCA Phase II
PZ-G4B		Oct-2010	ITM VW			30.0	Continuous	Quarterly	SCA Phase II
PZ-G4C		Oct-2010	ITM VW			45.0	Continuous	Quarterly	SCA Phase II
PZ-G5A		Oct-2010	ITM VW			15.0	Continuous	Quarterly	SCA Phase II
PZ-G5B		Oct-2010	ITM VW			30.0	Continuous	Quarterly	SCA Phase II
PZ-G5C		Oct-2010	ITM VW			45.0	Continuous	Quarterly	SCA Phase II
PZ-G6A		Oct-2010	ITM VW			15.0	Continuous	Quarterly	SCA Phase III
PZ-G6B		Oct-2010	ITM VW			30.0	Continuous	Quarterly	SCA Phase III
PZ-G6C		Oct-2010	ITM VW			45.0	Continuous	Quarterly	SCA Phase III
PZ-G7A		Oct-2010	ITM VW			15.0	Continuous	Quarterly	SCA Phase III
PZ-G7B		Oct-2010	ITM VW			30.0	Continuous	Quarterly	SCA Phase III
PZ-G7C		Oct-2010	ITM VW			45.0	Continuous	Quarterly	SCA Phase III
PZ-G8		Oct-2010	ITM VW			50.0	Continuous	Quarterly	Perimeter dike
PZ-G9		Oct-2010	ITM VW			50.0	Continuous	Quarterly	Perimeter dike

Notes:

[1]. The monitoring frequency of existing piezometers will be increased when active filling of geotextile tubes is occurring nearby, as shown in Table 2. The monitoring frequency of existing piezometers may also be increased based on the observed results. Additional readings will be taken after significant rainfall events, as determined necessary by the Project Engineer in consultation with the NYSDEC.

[2]. The baseline monitoring for SCA piezometers (i.e., PZ-G1A through PZ-G9) should begin on a continuous basis a minimum of two weeks before the start of liner construction.

[3]. After installation, the piezometers will be monitored as needed to determine the dissipation of installation-induced pore pressures under the direction of the Installation Engineer. The "datum" reading (i.e., field zero) should not be taken until after dissipation of installation-induced pore pressures.

[4]. Post closure monitoring is addressed in Section 3.5 of the Geotechnical Instrumentation and Monitoring Plan.

Table 2: Piezometer Monitoring Frequency
(based on SCA Phase being filled)

Piezometer Name	Type	Proposed Monitoring Frequency (based on SCA Phase being filled)						Location relative to SCA
		Phase I		Phase II		Phase III		
		East	West	East	West	East	West	
Wastebed Piezometers (installed during Phase II PDI)								
SB915-PZ13-01S	Geokon VW	2/month	2/month	2/month	2/month	2/month	2/month	East of Phases I and III
SB915-PZ13-01D	Geokon VW	2/month	2/month	2/month	2/month	2/month	2/month	East of Phases I and III
SB915-PZ13-01N	Geokon VW	2/month	2/month	2/month	2/month	2/month	2/month	East of Phases I and III
SB915-PZ13-05S	Geokon VW	Quarterly	2/month	Quarterly	Quarterly	Quarterly	2/month	West of Phases I and III
SB915-PZ13-05I	Geokon VW	Quarterly	2/month	Quarterly	Quarterly	Quarterly	2/month	West of Phases I and III
SB915-PZ13-05N	Geokon VW	Quarterly	2/month	Quarterly	Quarterly	Quarterly	2/month	West of Phases I and III
SB915-PZ13-06S	Geokon VW	Quarterly	2/month	Quarterly	2/month	Quarterly	Quarterly	West of Phases I and II
SB915-PZ13-06I	Geokon VW	Quarterly	2/month	Quarterly	2/month	Quarterly	Quarterly	West of Phases I and II
SB915-PZ13-06D	Geokon VW	Quarterly	2/month	Quarterly	2/month	Quarterly	Quarterly	West of Phases I and II
SB915-PZ13-06N	Geokon VW	Quarterly	2/month	Quarterly	2/month	Quarterly	Quarterly	West of Phases I and II
Dike Piezometers (installed during Phase II PDI)								
SB915-PZ13-07	Geokon VW	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Significant distance from SCA
SB915-PZ13-08	Standpipe	Quarterly	Quarterly	Quarterly	Quarterly	2/month	Quarterly	Northeast of Phase III
SB915-PZ13-09	Geokon VW	Quarterly	Quarterly	Quarterly	Quarterly	2/month	2/month	North of Phase III
SB915-PZ13-10	Standpipe	2/month	2/month	2/month	2/month	2/month	2/month	North of Phase III; near PZ-G8 and PZ-G9
SB915-PZ13-11	Geokon VW	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	2/month	Northwest of Phase III
SB915-PZ13-12	Standpipe	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Significant distance from SCA
SB915-PZ13-13	Geokon VW	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly	Significant distance from SCA
SB915-PZ13-14	Geokon VW	Quarterly	Quarterly	Quarterly	2/month	Quarterly	Quarterly	South of Phase II West
SB915-PZ13-15	Geokon VW	Quarterly	Quarterly	2/month	Quarterly	Quarterly	Quarterly	South of Phase II East
SB915-PZ13-16	Standpipe	Quarterly	Quarterly	2/month	Quarterly	Quarterly	Quarterly	East of Phase II

Notes:

[1]. This table does not include continuously monitored piezometers (PZ-G1 through PZ-G9) or piezometers which have been abandoned (SB915-PZ13-02, SB915-PZ13-03, and SB-915-PZ13-04).

[2]. The monitoring frequency follows this philosophy: (i) Monitor twice monthly when active filling is occurring nearby; (ii) Monitor quarterly when active filling is not occurring nearby; and (iii) Monitor quarterly piezometers which are a significant distance from the SCA.

[3]. SB915-PZ13-10 is located near the proposed piezometers PZ-G8 and PZ-G9. Therefore, it has been decided to monitor this piezometer at an increased frequency to serve as a calibration check for PZ-G8 and PZ-G9.

[4]. The Design Engineer may adjust the monitoring frequency of the existing piezometers based on the observed readings.

[5]. Additional readings will be taken after significant rainfall events, as determined necessary by the Project Engineer in consultation with NYSDEC.

[6]. Post closure monitoring is addressed in Section 3.5 of the Geotechnical Instrumentation and Monitoring Plan.

Table 3: Settlement Cell Monitoring Frequency

Settlement Cell Name	Date Installed	Type	Proposed Monitoring Frequency	Baseline Monitoring	Settlement Cell Location
SCA Settlement Cells (to be installed as part of SCA construction)					
SC-G1	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G2	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I, near west sump
SC-G3	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G4	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G5	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G6	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G7	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G8	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G9	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G10	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G11	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G12	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G13	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G14	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I, near east sump
SC-G15	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G16	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase I
SC-G17	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G18	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G19	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G20	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G21	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G22	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G23	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G24	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G25	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G26	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G27	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G28	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G29	Oct-2010	ITM SC	Continuous	Continuous[1]	SCA Phase II
SC-G30	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G31	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G32	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G33	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G34	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G35	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G36	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G37	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III
SC-G38	TBD	ITM SC	Continuous	Continuous[1],[3]	SCA Phase III

Notes:

[1]. The settlement cell baseline monitoring is not required to be performed immediately upon installation, however, continuous monitoring should begin a minimum of two weeks before the start of liner construction.

[2]. Post closure monitoring is addressed in Section 3.5 of the Geotechnical Instrumentation and Monitoring Plan.

[3]. Settlement cells SC-G30 through SC-G38 will only be installed and monitored if construction of Phase III is required.

Table 4: Settlement Profiler Monitoring Frequency

Profiler Name	Date Installed	Length of Profiler (ft)	Proposed Monitoring Frequency	Baseline Monitoring	Settlement Profiler Location
SCA Settlement Profilers (to be installed as part of SCA construction)					
Profiler 1	Oct-2010	1890	2/wk	Quarterly	SCA Phases I, II and III
Profiler 2	Oct-2010	1890	2/wk	Quarterly	SCA Phases I, II and III
Profiler 3	Oct-2010	2380	2/wk	Quarterly	SCA Phase I
Profiler 4	Oct-2010	1960	2/wk	Quarterly	SCA Phases I, II and III
Profiler 5	Oct-2010	1950	2/wk	Quarterly	SCA Phases I, II and III

Notes:

[1]. The settlement profiler tubing will be initially tested with a "dummy" profiler before performing baseline monitoring.

[2]. Under the direction of the Design Engineer (in consultation with and approval by NYSDEC), profiler readings may only need to be performed in the areas that are undergoing active filling or have been recently filled. In addition, the Design Engineer (in consultation with and approval by NYSDEC) may adjust the monitoring frequency based on the observed readings.

[3]. Post closure monitoring is addressed in Section 3.5 of the Geotechnical Instrumentation and Monitoring Plan.

Table 5: Inclinometer Monitoring Frequency

Inclinometer Name	Date Installed	Type	Length of Casing (ft)	Proposed Monitoring Frequency	Baseline Monitoring	Inclinometer Location
SCA Inclinometers (will be installed as part of SCA construction)						
SI-G1	Oct-2010	Manual	70.0	2/wk	Quarterly	Will be removed during Phase II construction
SI-G2	Oct-2010	Manual	70.0	2/wk	Quarterly	Will be removed during Phase III construction
SI-G3-Manual	Oct-2010	Manual	70.0	2/wk	Quarterly	West of SCA Phase I
SI-G3-SAA	Oct-2010	SAA	72.0	Continuous	Quarterly	Measurand SAA; west of SCA Phase I
SI-G4	Oct-2010	Manual	70.0	2/wk	Quarterly	North of SCA Phase III
SI-G5	Oct-2010	Manual	70.0	2/wk	Quarterly	East of SCA Phase II

Notes:

[1]. The Design Engineer, in consultation with and approval by NYSDEC, may adjust the monitoring frequency of the manual inclinometers based on the observed readings.

[2]. Additional readings of the manual inclinometers will be taken after significant rainfall events, as determined necessary by the Design Engineer in consultation with NYSDEC.

[3]. The SAA baseline monitoring should begin on a continuous basis a minimum of two weeks before the start of liner construction.

[4]. Post closure monitoring is addressed in Section 3.5 of the Geotechnical Instrumentation and Monitoring Plan.

ATTACHMENT A

INSTALLATION OF VIBRATING WIRE PIEZOMETERS

Piezometers will be installed by the grout-in method using boreholes. The installation procedures should be in accordance with the specific manufacturer's instruction and generally as follows:

1. Stake out specified installation locations, which can be performed using a hand-held GPS unit. It should be noted that the as-built locations of the installed piezometers should be obtained by a licensed surveyor. Surveying activities should be completed in accordance with the appropriate New York State rules and regulations.

2. Advance borehole to desired depth using a center hole (i.e., hollow stem) auger. During drilling, perform continuous SPT sampling over the full depth to allow characterization of the subsurface soils, if no existing borings are located within 20 ft of the borehole. Flush the borehole with water or biodegradable drilling mud.

3. Obtain pore pressure and thermistor zero readings prior to installation.

4. Saturate the filter stone with water, in accordance with manufacturer's recommendations.

5. Check pore pressure transducer calibration with the piezometer set in a bucket of water. Obtain readings for at least two different water levels.

6. Tie the piezometer to its own signal cable and lower it, with filter-end up, into the borehole to the design elevation. Nested piezometers at various depths can be installed in one borehole or separate boreholes. If multiple piezometers are installed in the same borehole, lower the deeper piezometers first. For separate borehole installation, the piezometers shall be offset from each other by about 5 ft to avoid damage to the piezometers during installation. Handle the piezometers carefully.

7. Backfill the borehole with grout specified by the manufacture. Mix cement with water first, and then add the bentonite. Adjust the amount of bentonite to produce a grout with the consistency of heavy cream. If the grout is too thin, the solids and the water will separate. If the grout is too thick, it will be difficult to pump.

8. Readings taken immediately after installation will be high, but will decrease as the grout cures. Datum (i.e., field zero) readings can be taken hours to days after installation, depending on the permeability of the soil. The lag time caused by the grout itself is measured in minutes.

9. Thread piezometer cables in a trench extending to a monitoring station, located outside the SCA footprint. The cables should be snaked to the extent possible.

ATTACHMENT B

INSTALLATION AND OPERATION OF GEOSYNTEC SETTLEMENT PROFILER SYSTEM

Settlement profile pipes will be installed in the SCA to monitor the settlement of the foundation SOLW under the loading from the SCA. Details of a profiler system are shown on Drawing No. 11 titled "Instrumentation and Monitoring Details" of the Final Design Drawings prepared by Geosyntec Consultants in January 2011.

The contractor shall stake out the specified locations for the pipes prior to installation, which can be performed using a hand-held GPS unit. It should be noted that the as-built locations of the installed settlement profile pipes should be surveyed by a licensed surveyor.

Before construction of the SCA, an approximately 1.5-ft wide by 1.33-foot deep trench will be excavated along the length of each profile line for each phase. After excavation of the trench, a 4-in deep layer of sand bedding will be placed at the bottom of the trench. A single 4-inch nominal diameter single-wall corrugated pipe manufactured by Advanced Drainage System (ADS) should be placed in the trench and the trench backfilled with sand. The ADS piping was selected due to its flexibility to facilitate the measurement of differential settlement.

To facilitate settlement measurements, a ¼-inch diameter polypropylene rope will be advanced through the entire length of each buried profile pipe. Pipe segments will be joined as necessary using ADS couplers and nylon cable ties. This rope will be used to pull the settlement profiling device through the ADS pipe. In many cases it may be advantageous to place the rope as the pipe is being installed. The ADS pipe and trench configuration discussed previously was selected such that the pipe would resist crushing due to the overburden loading of the SCA.

After the settlement pipes are installed and the trenches are backfilled, the contractor should test the pipes by pulling a "dummy" transducer through each pipe to confirm that the pipe did not get crushed during installation. The "dummy" transducer used for testing will be slightly larger than the actual settlement profiler transducer to better check for pipe crushing.

Settlements will be measured using a proprietary settlement profiling system developed by Geosyntec. This system is designed to measure relative settlements at any location along the profile pipe by using a pressure transducer to measure the hydrostatic water pressure imposed on the transducer from a stationary water supply reservoir. The pressure transducer is housed within a steel or plastic "torpedo" that is pulled through the ADS pipe using a steel cable. This transducer is connected to water-filled vinyl tubing that, in turn, is connected to the fluid reservoir maintained at a constant elevation. As the transducer and vinyl tubing are pulled through the profile pipe, any change in elevation (i.e., settlement) is recorded as a pressure change on the transducer. The relative elevation of the transducer can be converted to an absolute elevation by measuring the pressure at the transducer when it is placed on a point (i.e., survey hub) of known elevation.

Adjacent to the entrance of the profile pipe, the surveyed “hub” will need to be installed and maintained for the duration of the project. Prior to each profile survey, initial readings on the transducer will be recorded by placing the torpedo and enclosed pressure transducer on the hub. The specific components that are used to conduct a profile survey include:

- ADS profile pipe installed in a trench prior to SCA construction;
- Polypropylene rope placed in the profile pipe;
- Model 15 Wika EcoTronic pressure transducer (transducer) with a built-in direct-connect (DC) signal conditioner (or compatible alternative);
- Geosyntec-fabricated torpedo device to house the transducer;
- Bundled vinyl tubing, electrical cable, and steel cable attached to the torpedo;
- Water reservoir and settlement hub located at one end of the profile lines; and
- Palm® IIIxe handheld personal data assistant (PDA) device and a MyCorder DAS 1206 analog to digital (A/D) converter; the MyCorder is a general-purpose, six-channel, 12-bit, multirange A/D device for data acquisition.

Alternate devices for recording the settlement may be used as improvements to the system are developed. To initiate a test, an initial pressure reading is obtained when the torpedo/transducer is placed on the hub. The settlement profiler device is then pulled through the profile pipe under the SCA using the polypropylene rope. To begin testing, the profiler is then pulled backwards through the profile pipe using the steel cable while stopping at pre-selected test locations to obtain readings from the transducer.

Measurements are proposed to be obtained at approximately 5-ft linear intervals along the profile length as the torpedo/transducer is pulled back through the ADS pipe. At the end of a test, the torpedo/transducer is again placed on the hub, and the final elevation readings are established. At all times during the test, the liquid reservoir is maintained at a constant elevation.

ATTACHMENT C

INSTALLATION OF VIBRATING WIRE SETTLEMENT CELLS

The installation procedure for vibrating wire settlement cells shall be in accordance with the specific manufacturer's instructions and generally as follows:

1. Stake out specified installation locations, which can be performed using a hand-held GPS unit. It should be noted that the as-built locations of the installed settlement cells should be obtained by a licensed surveyor. Surveying activities should be completed in accordance with the appropriate New York State rules and regulations.
2. Excavate a trench approximately 6-in wide and 1-ft deep extending from the location of the settlement cell to the reservoir mounted on a post located outside the SCA footprint. Remove sharp stones and rocks, if any, and place a 4-in layer of sand on the bottom of the trench.
3. At the proposed location of the settlement cell, increase the trench size as needed to fit the settlement cell and the steel plate. The steel plate (already attached to the settlement cell) should be placed at the top of the 4-in layer of sand. The steel plate helps maintain required upright orientation of the cell.
4. Place the settlement cell in an upright (vertical) position on the steel plate.
5. Cover the settlement cell with hand-compacted sand.
6. Thread settlement cell cables and tubing along the trench extending to the reservoir and monitoring station. The cables and tubing should be "snaked" to the extent possible.
7. Backfill the trench with hand-compacted sand.
8. Test the system and obtain field-zero readings in accordance with manufacturer's instructions to ensure it is functioning properly.

ATTACHMENT D

INSTALLATION OF INCLINOMETERS

The installation procedure for inclinometers should be in accordance with the specific manufacturer's instructions. The installation procedure generally includes the following steps:

1. A borehole is first advanced to the desired depth (i.e., a minimum of 3 feet into the native material underlying the Solvay waste) using a center hole (i.e., hollow stem) auger. During drilling, it is recommended that standard penetration test (SPT) sampling be conducted at a minimum interval of 5 feet over the full depth to allow characterization of the subsurface soils, if no existing borings are located within 20 ft of the borehole. Additional sampling should be conducted if the material is suspected to be different at a particular depth during drilling. Sampling frequency may need to be increased to locate the bottom of the Solvay waste, as needed.

2. Place the bottom cap on the bottom of the lowest section of inclinometer casing pipe to keep the inside of the casing dry and to keep grout from clogging the casing. Take care not to get dirt onto the seal. Push until a "click" is heard, indicating the lock ring is properly seated.

3. Place a pipe clamp on the top of the casing, and manually lower this first section inside of the borehole. Install another pipe clamp on top of the second section of casing. Attach this casing to the top of the casing in the borehole. Remove the lower pipe clamp, and slowly lower the casing. This procedure of clamping and incrementally adding and lowering the rigid inclinometer casing inside the borehole continues until the casing rests on the bottom of the borehole.

4. Backfill the borehole with grout approved by the Engineer. The proposed grout should match the strength and deformation characteristics of the surrounding Solvay waste to the extent possible. Take measures to counter buoyancy during grouting and allow the grout to set.

5. Install a plug on the top section of inclinometer casing to keep foreign materials and water out of the casing.

ATTACHMENT E

SAMPLE THICKNESS AND SETTLEMENT CALCULATION

Sample Calculation of Layer Thickness

As discussed in 3.07 of Section 02250, thickness measurements of the low permeability soil layer will be taken at a maximum spacing of 100 ft by 100 ft in areas where the design thickness is 18 inches or less. In addition, elevations will be measured on a 50-ft grid throughout the area where the low permeability soil layer is being placed (i.e., including the area where the design thickness is greater than 18 inches). The 50-ft grid will be surveyed initially to establish the existing subgrade. It will be surveyed again immediately following installation of the low permeability soil layer. The data from the settlement cells and profilers will be combined with the survey data to calculate the thickness of the low permeability soil layer. This calculation will be performed as follows:

> *Total low permeability soil layer thickness = [Top-of-low permeability soil layer survey elevation] – [Initial subgrade survey elevation] + [Settlement measured by settlement cells and profilers (as applicable based on location)]*

Settlement of the low permeability soil layer is expected to be minimal (due to compaction) and is not considered in the calculation.

The method described above also applies to calculating the gravel drainage layer thickness. Depending on the time that elapses between placement of the low permeability soil layer and the gravel drainage layer (i.e., time to install the geomembrane and geotextile), an additional survey may be performed to establish the top of the liner system elevation prior to gravel drainage layer placement. The calculation will be performed as follows:

> *Total gravel drainage layer thickness = [Top-of-gravel drainage layer survey elevation] – [Top of liner system survey elevation] + [Settlement measured by settlement cells and profilers (as applicable based on location)]*

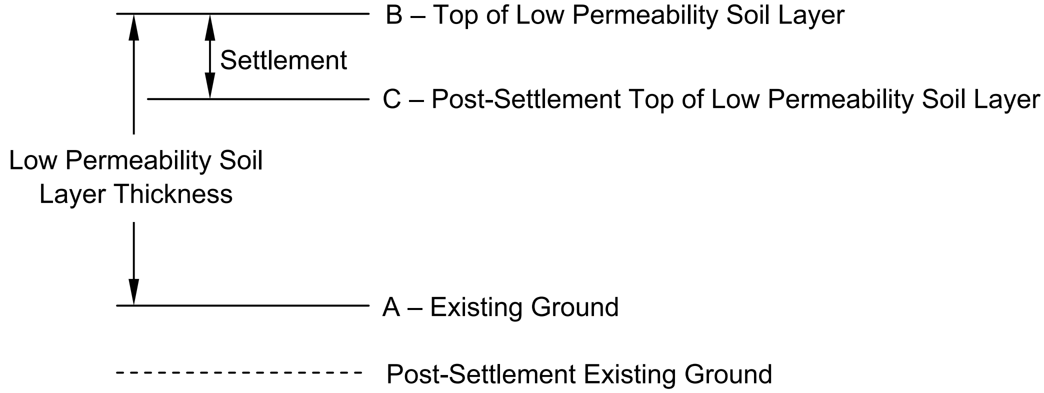
As with the low permeability soil layer thickness, settlement of the gravel drainage layer is not considered in this calculation.

Sample Calculation of Settlement

The procedure to calculate the settlement based on surveying results is illustrated below. This procedure can be repeated for every additional survey that is performed. The calculation procedure generally includes the following steps:

1. A survey of existing ground will be taken before the start of liner construction. This point is labeled “A” in the figure below.
2. The low permeability soil layer will be constructed.
3. A survey of the top of the low permeability soil layer will be taken immediately after construction of the low permeability soil layer. This point is labeled “B” in the figure.
4. The thickness of the low permeability soil layer can be calculated by subtracting the elevation at point A from the elevation at point B.
5. The geomembrane and geotextile will be installed on top of the low permeability soil layer.
6. Before construction of the gravel drainage layer, an additional survey will be performed of the top of the post-settlement low permeability soil layer. This point is labeled “C” in the figure.
7. The amount of incremental settlement that has occurred in the Solvay waste underneath the low permeability soil layer can be calculated by subtracting the elevation at point C from the elevation at point B. It is assumed that any settlement that occurs within the low permeability soil layer itself will be negligible compared to the settlement of the underlying Solvay waste. Data obtained from the settlement cells and profilers is an additional source of information that will be used to establish the amount of settlement that has occurred.
8. Additional surveys will be performed as described in Section 3.4.1, and the calculated settlement will be updated as necessary. This procedure will also be used for the gravel drainage layer.

Figure E1: Surveyed points for sample calculation



Note: Figure E1 applies specifically to the low permeability soil layer, but this method can also be used for the gravel drainage layer.