Construction Quality Assurance Project Plan

1163 | 46096

Upper Harbor Brook CQAPP
Geddes, New York

Prepared for:

Honeywell

JAMES R. HECKATHORNE, P.E., V.P.
O'BRIEN & GERE ENGINEERS, INC.

TABLE OF CONTENTS

List of Tables (in text) ii
1. Introduction 1
2. Project Organization and Responsibilities 2
2.1. Project Organization and Responsibilities 2
2.2. Personnel Qualifications 4
2.3. Lines of Communication 5
2.4. Meetings 5
3. CQA/CQC 7
3.1. Ground Water Collection System 7
3.1.1. Excavation 7
3.1.2. Geocushion 7
3.1.3. LLDPE Geomembrane 9
3.1.4. Geocomposite Drainage Layer 16
3.1.5. Structural Geogrid 18
3.1.6. Select Fill - Stone 21
3.1.7 Concrete Sand 21
3.1.8. Topsoil 23
3.1.9. Fertilization and Seeding 24
3.1.10. Electrical/Materials/Equipment 25
3.1.11. Piping and Appurtenances 25
3.2. Storm Water Drainage Facilities 26
3.2.1. Rip-rap 26
3.2.2. Geotextile Fabric 27
4. Documentation 29
4.1. Problem Identification and Corrective Measures Reports 29
4.2. Action Item List 29
4.3. Photographs 29
4.4. Record Drawings 29
4.5. Storage and Disposition of Records 29
4.6. Daily Report 29
4.7. Weekly Report 29
5. Changes and Corrections of Work 30
5.1. Procedure for Changes 30
5.2. Inspection and Correction of Work 30

LIST OF TABLES (IN TEXT)

3-1 QC of Geocushion Physical Properties by the Manufacturer at the Plant
3-2 QC of Geomembrane Physical Properties by the Manufacturer at the Plant
3-3 QC of Geomembrane Seaming by the Manufacturer at the Plant
3-4 CQC for Laboratory Testing Following Geomembrane Installation
3-5 QC of Triplanar Geonet Prior to Construction
3-6 QC of Structural Uniaxial Geogrid Prior to Construction
3-7 CQC of Stone Prior to Construction
3-8 CQC of Stone During Construction
3-9 CQC of Sand Layer Prior to Construction
3-10 CQC of Sand Layer During Construction
3-11 CQC of Topsoil Layer Prior to Construction
3-12 CQC of Topsoil Layer During Construction
3-13 CQC of Rip-Rap Prior to Construction of Storm Water Drainage Facilities
3-14 CQC of Rip-Rap During Construction of Storm Water Drainage Facilities
3-15 CQC for Geotextile Fabric Prior to Construction of Storm Water Drainage Facilities

1. INTRODUCTION

This Construction Quality Assurance Project Plan (CQAPP) has been prepared to provide guidelines and procedures for Construction Quality Assurance and Construction Quality Control (CQA/CQC) during construction of the Upper Harbor Brook Interim Remedial Measure.

CQA means a planned system of activities that provides assurance that the facility is constructed as specified in the design. CQA refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications and permits for the project. This may also include quality control for those actions taken before construction to evaluate if materials chosen and workmanship comply with agency approved engineering plans and specifications.

CQC means a planned system of inspections that are used to directly monitor and control the quality of a construction project. CQC includes those actions normally performed by the installer to achieve high quality in the constructed or installed system. CQC refers to measures taken by the installer or contractor to assess compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project.

This CQA/CQC Plan outlines the responsibilities of each of the entities associated with the project. This includes a delineation of the appropriate lines of communication between the Owner, Regulatory Agency, Contractor, inspection personnel and design personnel associated with construction activities. Also provided is a description of the required level of experience and training for the contractor and CQA/CQC inspectors in sufficient detail to document that personnel permitted to be involved with the project have the necessary qualifications to properly complete the work in accordance with the methods and procedures specified. In addition to personnel requirements, a description of the CQA/CQC protocols to be utilized for documenting construction activities and compliance with the specifications is provided.

2. PROJECT ORGANIZATION AND RESPONSIBILITIES

In this section, organizations involved in CQA/CQC for this project along with their responsibilities and qualifications are discussed. Lines of communication are presented, along with procedures for submission of CQA/CQC information.

2.1. PROJECT ORGANIZATION AND RESPONSIBILITIES

Several organizations are involved in CQA/CQC prior to, during, and following construction. These include the following:

- New York State Department of Environmental Conservation (NYSDEC) as the lead regulatory agency
- Honeywell International, Inc. (Honeywell) as the Owner
- O'Brien & Gere as the Design Engineering Firm and contractor for construction
- Testing laboratories (to be determined)
- Manufacturers and fabricators (to be determined)
- Installers (to be determined).
- The responsibilities of these organizations are delineated in the following subsections.

NYSDEC Responsibilities. As the lead regulatory agency, the NYSDEC will perform the following functions:

- Review and approve original designs
- Review project submittals for compliance with regulations
- Issue approval to construct the project once design has been approved
- Review and approve major design modifications or requests for variances from the regulatory conditions during construction.

Honeywell Responsibilities. As the Owner, Honeywell will:

- Bear responsibility for the design, construction, construction inspection and operation of the project
- Comply with NYSDEC requirements to obtain approvals and/or permits
- Bear responsibility for all communications with the NYSDEC
- Bear responsibility for providing CQA/CQC documentation to the NYSDEC that construction activities associated with the project are proceeding in accordance with the approved design (and approved design modifications)
- Select organizations charged with design, CQA/CQC, and construction activities
- Accept or reject design plans and specifications, CQA/CQC plan, reports and recommendations of the design engineer, and the materials and workmanship of the Contractor
- Bear responsibility for providing the Construction Certification Report to the NYSDEC for review and acceptance.

O'Brien & Gere Responsibilities. As the Design Engineering Firm and contractor for construction, O'Brien & Gere, will perform the following:

- Provide a project design that fulfills the performance requirements of the NYSDEC and USEPA
- Prepare this CQA/CQC Plan

- Prepare design modifications during construction, if necessitated by unexpected site conditions or required changes in construction methodology
- Retain and oversee qualified subcontractors to perform specialized components of construction
- Coordinate the review of the subcontractor, supplier, and installer shop drawing submittals
- Observe construction activities
- Confirm that regular calibration of testing equipment is properly conducted and recorded
- Confirm that testing laboratories conform to CQA requirements and procedures and sample custody procedures are followed
- Confirm that test data inspection reports are accurately recorded and maintained
- Provide the Owner with reports on testing and inspection results
- Schedule and attend project CQA/CQC meetings during construction
- Oversee the preparation of the Construction Completion Report and Record Drawings
- Provide daily on-site inspection of the work in progress to assess compliance with design plans and specifications
- Attend job meetings as required
- Construct the project in accordance with the design plans, specifications, and approved modifications using appropriate construction procedures and techniques
- Schedule and coordinate CQA/CQC inspection and testing activities
- Retain testing laboratories to provide CQC testing services

The O'Brien & Gere Construction Manager will have overall responsibility for CQA and CQC. Other related duties may include coordinating shop drawings submittals, providing required samples, and coordinating with the NYSDEC.

Testing Laboratory Responsibilities. The testing laboratory utilized will meet the following requirements:

- Have an internal CQC plan in-place to confirm that laboratory procedures conform to the appropriate American Society for Testing and Materials (ASTM) standards or other applicable standards and methods
- Follow internal CQC procedures
- Maintain sample chain-of-custody records
- Report result of testing.

The testing laboratory will be required to allow representatives of Honeywell, NYSDEC, O'Brien & Gere , and/or the Installer to observe sample preparation, testing procedures, or record-keeping procedures upon request. Honeywell, NYSDEC, O'Brien & Gere , and/or the Installer will be allowed to observe some or all tests on a particular job at any time, either announced or unannounced. It is anticipated that the laboratory required for this project will include CQC laboratory for analytical, geotechnical, and geosynthetic testing.

Manufacturer and Fabricator Responsibilities. The manufacturers and fabricators of geosynthetic components and other equipment required for construction of the project will:

- Certify that materials manufactured or fabricated meet the specifications
- Provide quality control steps taken during manufacturing or fabrication

- Allow Honeywell, NYSDEC, O'Brien & Gere , and/or the Installer to observe the manufacturing and fabrication process and QC procedures.

Installer's Responsibilities. The Installer is the contractor or subcontractor that installs manufactured and fabricated products, such as geosynthetics. The Installer's responsibilities include the following:

- Maintaining a CQC Plan in-place for handling, storing, placing, and installing materials
- Handling, storage, placement, and installation of manufactured and fabricated materials
- Following CQC procedures
- Informing the Engineer of the schedule for installation of manufactured or fabricated materials.

2.2. PERSONNEL QUALIFICATIONS

It is important that organizations and personnel involved in implementing the remedy possess suitable qualifications to perform the work. The following sections describe qualifications and minimum acceptable experience for positions identified in the CQA/CQC Plan.

Contractor. O'Brien & Gere has been selected to construct this project based upon experience in constructing projects of similar size and scope, including, but not limited to, projects requiring construction of pump stations, material excavation, construction of ground water collection trenches, and installation of LLDPE geomembrane and other geosynthetics. Specialty contractors will be retained under subcontract for construction of some components of the work. Prior to award of subcontracts, O'Brien & Gere will request evidence that each subcontractor have the necessary experience to fulfill the requirements set forth in this plan.

Contractor's CQC Manager. O'Brien & Gere's Construction Manager will serve as the CQC Manager. The CQC Manager will have a working knowledge of civil and construction engineering and soil and geosynthetic materials. The CQC Manager will be on-site during the construction period. The CQC Manager will have a thorough familiarity with the project and testing requirements. The CQC Manager will have demonstrated experience with earthwork projects, geosynthetic materials, concrete, and drainage structures.

CQC Geotechnical Laboratory. The CQC Geotechnical Laboratory will be an independent laboratory approved by O'Brien & Gere. The CQC Geotechnical Laboratory will not be owned by O'Brien & Gere or its subcontractors.

The laboratory will be qualified to perform geotechnical testing presented in the specifications and have a minimum of five years experience in testing soil properties required for the project. The laboratory will be required to submit references from three other similar projects. All laboratory test results will be certified by a Laboratory Manager with a minimum of two years of soils testing experience.

CQC Geosynthetic Laboratory. The CQC Geosynthetic Laboratory will be an independent laboratory approved by O'Brien & Gere. The CQC Geosynthetic Laboratory will not be owned by O'Brien & Gere or its subcontractors or Installers.

The laboratory will be qualified to perform geosynthetic testing presented in the specifications and have a minimum of five years experience in testing geosynthetics. All laboratory test results will be certified by a Laboratory Manager with a minimum of two years of geosynthetic testing experience.

CQC Analytical Laboratory. The CQC analytical laboratory will be an independent laboratory approved by O'Brien & Gere. The CQC analytical laboratory will not be owned by O'Brien & Gere or its subcontractors.

The laboratory will be qualified to perform analytical testing presented in the specifications and have a minimum of five years experience in the testing required for the project. The laboratory will be required to submit references from three other similar projects. All laboratory test results will be certified by a Laboratory Manager with a minimum of two years of analytical testing experience.

Manufacturers and Fabricators. Manufacturers and fabricators of the project components will be required to have experience in manufacturing or fabricating similar materials for a minimum of five completed projects. The manufacturers and fabricators will each be required to submit a list of the projects for approval by O'Brien & Gere.

Installers. Installers of specified equipment and materials will be required to demonstrate experience in projects of similar size and nature for approval by O'Brien & Gere. Installers responsible specifically for the installation of geosynthetic materials will be trained and qualified to install and test geosynthetic materials. Geosynthetic Installers will be required to demonstrate experience in installing LLDPE geomembrane for a minimum of five completed facilities. The Geosynthetic Installer will be required to submit the list of facilities for approval by O'Brien & Gere.

2.3. LINES OF COMMUNICATION

An important component to the successful completion of any project is effective communication between the parties involved. A project specific communications matrix will be developed as part of O'Brien & Gere's pre-construction project execution planning efforts.

O'Brien & Gere will notify Honeywell and the NYSDEC if deficiencies in the work are noted based on field inspections, CQA/CQC results and, if appropriate, order corrective measures or recommend work stoppage. Formal communications related to submittals and changes or modifications of work shall be made in accordance with the Contract Documents and this CQAPP.

2.4. MEETINGS

To enhance communications and maintain the progress of the work in an orderly and efficient manner, scheduled on-site construction and project management meetings will be held prior to and throughout the course of construction.

Pre-Construction Meeting. After award of the contract, a Pre-Construction meeting will be held. Attendees at this meeting may include:

- Regulatory representatives (NYSDEC and NYSDOH)
- O'Brien & Gere and select subcontractors
- Representatives of Honeywell

The meeting will cover scheduling and construction details. Important objectives of the meeting directly related to construction quality will be to:

- Provide each organization with all relevant CQA/CQC documents and supporting information
- Familiarize all entities with this CQAPP and its role relative to the plans and specifications
- Evaluate changes to the CQAPP that may be needed to monitor that the Project will be constructed to meet or exceed the specified design
- Review the responsibilities of each organization
- Review lines of authority and communication
- Discuss the established procedures or protocol for observations and tests including sampling strategies
- Discuss CQC proposed by O'Brien & Gere and Installers
- Discuss established procedures or protocol for handling construction deficiencies, repairs, and retesting
- Review methods for documenting and reporting inspection data
- Review methods for distributing and storing documents and reports

- Review work area security and safety protocols
- Discuss procedures for the location, storage, and protection of construction materials and for the prevention of damage to the materials from inclement weather or other adverse events
- Conduct a site walk to review the project site layout, construction material and inspection equipment storage locations.

Minutes of the pre-construction meeting will be kept by O'Brien & Gere and distributed to all attendees.

Weekly Construction Meetings. Construction meetings will be held weekly to discuss project progress and scheduling. Attendees at the meeting may include the NYSDEC representative. Representatives of the Owner and various property owners may also attend. Items of discussion will include:

- The progress of the work to date
- The schedule to accomplish upcoming work tasks
- Health and safety issues
- Problems encountered or anticipated during construction
- Proposed field modifications to the design
- Work deficiencies that have been noted in the field.

O'Brien & Gere will prepare, distribute and maintain an "Action Item" list summarizing key items discussed during the weekly construction meetings.

3. CQA/CQC

This CQA/CQC Plan will provide the basis for CQA/CQC activities associated with the ground water collection system. Detailed information, including the frequency of inspection, field testing methods, sampling requirements for laboratory testing, testing procedures and equipment to be used, criteria for acceptance/failure, and a description of the corrective actions to be initiated upon test failure are also presented in the Technical Specifications, bound separately, and provided as part of the project's Contract Documents.

3.1. GROUND WATER COLLECTION SYSTEM

The ground water collection system comprises a sand-filled trench with perforated conveyance piping discharging to collection sumps. An isolation layer will be installed in Harbor Brook and selected site ditches with the primary objective to prevent the discharge of contaminated ground water into the Site Ditches and Upper Harbor Brook and subsequently to Onondaga Lake. The isolation layer will also minimize the potential for migration of contaminated sediments to Onondaga Lake, and will minimize the potential for surface water to enter the collection trench.

The collection sumps will discharge collected ground water to the Willis Avenue Ground Water Treatment Plant.

3.1.1. Excavation

Construction Quality Control. The collection trench will be constructed by excavating a 3 ft wide trench to the depths shown on the Contract Drawings. The excavation will be will be dewatered during construction activities. The bottom of the excavation will be cleaned of loose or soft material and leveled. Prior to installation of the sand and collection piping, O'Brien & Gere will be required to inspect the excavation and record the findings of the inspection. Records of excavation inspections will be kept by O'Brien & Gere.

All material excavated from the Site will be transported to and placed on Wastebed B upgradient of the barrier wall at locations shown on the Contract Drawings or designated by Honeywell. As described in the West Wall Final Design Report (Parsons 2009), this material will be stockpiled in a temporary on-site staging area. The stockpile will be covered with a low-permeability membrane or stabilized (with vegetation) to minimize contact with storm water and runoff when not in use and following completion of the project. The stockpile cover, as well as any sediment and erosion control measures will be maintained until final disposition of these materials is addressed as part of the final WBB/HB site remedy selection. In the event that grossly contaminated soil (e.g., NAPL saturated soils) is encountered during the excavation/site grading activities, this material will be staged separately on site. A plan for the temporary staging, characterization, and disposal of this material will be developed by Honeywell in consultation with the NYSDEC.

3.1.2. Geocushion

The following sections discuss CQA/CQC and procedures for installation of the geocushion.

QC of geocushion raw materials by the manufacturer at the plant. The manufacturer will be required to provide O'Brien & Gere the following documentation regarding quality control of raw materials used to manufacture the geocushion.

- Certification that the polyethylene resin is new, first quality resin manufactured in the United States from virgin, uncontaminated ingredients, and meets or exceeds the requirements specified hereinafter and is free of contaminants
- Certification that all resin is from the same manufacturer
- Origin, identification, and production date(s) of the raw materials used to manufacture the geocushion
- Quality control certificates of raw materials used to manufacture the geocushion

All compound ingredients of the geocushion material will be randomly sampled on delivery to the manufacturing plant by the manufacturer of the geocushion to document compliance with the specifications. Equivalent testing may be substituted with the prior approval of O'Brien & Gere.

Manufacturer will supply O'Brien & Gere with certified copies of the factory test results prior to the arrival of material on site.

Quality Control of Physical Properties by the Manufacturer at the Plant. The manufacturer will be required to provide O'Brien & Gere documentation regarding quality control of physical properties of the geocushion certified in accordance with the following performance standards:

Table 3-1 QC of Geocushion Physical Properties by the Manufacturer at the Plant

Mechanical Properties	Test Method	Unit	Minimum Roll Value	Average
Grab Tensile Strength	ASTM D4632	N(lbs)	1691 (380)	1691 (380)
Grab Tensile Elongation	ASTM D4632	%	50	50
Trapezoid Tear Strength	ASTM D4533	N (lbs)	623 (140)	623 (140)
CBR Puncture Strength	ASTM D6241	N (lbs)	4450 (1000)	
Apparent Opening Size (AOS)	ASTM D4751	mm (U.S. Sieve)	0.15 (100)	
Permittivity	ASTM D4491	sec^{-1}	0.54	
Flow Rate	ASTM D4491	$1/min/m^2$ ($gal/min/ft^2$)	2037 (50)	
UV Resistance (at 500 hours)	ASTM D4355	%strength	70	
Physical Properties	Test Method	Unit	Typical Value	
Weight	ASTM D5261	g/m^2 (oz/yd^2)	509 (15)	
Thickness	ASTM D5199	mm (mils)	3.2 (125)	
Roll Dimensions (width x length)	--	m (ft)	4.5 x 46 (15 x 150)	
Roll Area	--	m^2 (yd^2)	290 (250)	
Estimated Roll Weight	--	kg (lb)	109 (240)	

The geotextile cushion shall consist of a long-chain geosynthetic polymer composed of at least 94 percent by weight of propylene, ethylene, ester, amids, or vinylidene-chloride, and shall contain stabilizers and/or inhibitors added to the base plastic to make the filaments resistant to deterioration due to ultra-violet and heat

exposure. The geotextile cushion shall also be mildew and rot resistant, insect and rodent resistant, and inert to chemicals and hydrocarbons.

3.1.3. LLDPE Geomembrane

The following sections discuss CQA/CQC procedures for installation of the textured 40-mil LLDPE geomembrane.

QC of LLDPE Geomembrane Raw Materials by the Manufacturer at the Plant. The manufacturer will be required to provide O'Brien & Gere the following documentation regarding quality control of raw materials used to manufacture the LLDPE geomembrane.

- Certification that the polyethylene resin is new, first quality resin manufactured in the United States from virgin, uncontaminated ingredients, and meets or exceeds the requirements specified hereinafter and is free of contaminants
- Certification that all resin is from the same manufacturer
- Origin, identification, and production date(s) of the raw materials used to manufacture the LLDPE geomembrane
- Quality control certificates of raw materials used to manufacture the LLDPE geomembrane.

All compound ingredients of the geomembrane material will be randomly sampled on delivery to the manufacturing plant by the manufacturer of the geomembrane to document compliance with the specifications. Equivalent testing may be substituted with the prior approval of O'Brien & Gere.

Manufacturer will supply O'Brien & Gere with certified copies of the factory test results prior to the arrival of material on site.

Quality Control of Physical Properties by the Manufacturer at the Plant. The manufacturer will be required to provide O'Brien & Gere documentation regarding quality control of physical properties of the geomembrane certified in accordance with the following performance standards:

Table 3-2 QC of Geomembrane Physical Properties by the Manufacturer at the Plant

Parameter	Standard	Frequency	Criteria
Thickness, absolute minimum	ASTM D5994	every roll	36 mils
Density (minimum)	ASTM D1505	200,000 lb	0.92 g/cm^3
Minimum Tensile Properties	ASTM 6693, Type IV		
1. Tensile Strength @ Break	Dumbell, 2 ipm	20,000 lb	115 lb/in (20 N/m)
2. Elongation @ Break	G.L.=2.0 in (51 mm)		500 %
Tear Resistance	ASTM D1004	45,000 lb	22 lb (125 N)
Puncture Resistance	ASTM D4833	45,000 lb	65 lb (352 N)
Carbon Black Content	ASTM D1603*/4218	20,000 lb	2.0-3.0 %
Carbon Black Dispersion	ASTM D5596	45,000 lb	+Note 1

Asperity Height	ASTM D 7466	Second roll	18 mil (0.45 mm)
Oxidative Induction Time	ASTM D3895, 200°C; O_2, 1 atm	200,000 lb	>140
Roll Length(3) (approximate)	Standard Textured		700 ft (253 m)
Roll Width(3)			22.5 ft (6.9 m)
Roll Area			15,750 ft^2 (1,463 m^2)

Note:
1. Dispersion only applies to near spherical agglomerates are considered. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.

Source: O'Brien & Gere

The manufacturer will provide O'Brien & Gere certified copies of the factory test results and a complete stress rupture curve from the geomembrane manufacturer prior to the arrival of material on site. Equivalent testing may be substituted with the prior approval of O'Brien & Gere.

In addition, a minimum of two 24-inch by 24-inch size samples, from each roll along with appropriate identification, will be provided to the O'Brien & Gere for further testing, if necessary.

QC LLDPE Geomembrane Seaming by the Manufacturer at the Plant. The manufacturer will be required to provide O'Brien & Gere the following documentation regarding quality control of LLDPE geomembrane seaming by the manufacturer at the plant.

The LLDPE geomembrane will be visually inspected for:

- Uniformity
- Damage
- Imperfections
- Holes
- Cracks
- Thin spots
- Foreign material
- Tears
- Punctures
- Blisters.

Any imperfections, such as those noted above, will be immediately removed, repaired, and re-inspected prior to being fabricated into panels.

Non-destructive seam testing will be performed on all fabricated seams over their full length. Non-destructive seam testing will be performed using either an approved vacuum box or pressurized dual seam method.

Destructive seam testing will be performed on a minimum of two samples per LLDPE geomembrane sheet in accordance with the following requirements:

- Where possible, the samples shall be taken from extra material at the beginning or end of sheet seams such that the LLDPE geomembrane sheet is not damaged and the sheet geometry is not altered.

- The samples taken will be a minimum of 18 inches wide by 72 inches long with the seam centered lengthwise. Each sample will be cut into three pieces with one piece (18 inches by 24 inches) retained by the fabricator, one piece given to an independent laboratory, and one piece given to O'Brien & Gere for further testing, if desired, and permanent record. Each sample will be tagged to identify:
  - Manufacturer's roll number
  - Date cut
  - Panel from which cut
  - Location in panel
  - Visual inspection comments
  - Inspector's name
  - Top sheet.
- Ten 1-inch wide replicate samples will be cut from the fabricator sample. Five specimens will be tested for shear strength and five for peel adhesion. If a sample fails a destructive test, the entire length of the seam will be reconstructed or repaired, and retested using non-destructive seam testing over the full length of the seam using either the vacuum box or pressurized dual seam method. If no seams delaminate, but fail in the adjacent sheet material on either side of the seam in a film tear bond, the seam strength will be calculated. Four out of five replicates must meet the specific seam strength property requirements as follows:

Table 3-3 QC of Geomembrane Seaming by the Manufacturer at the Plant

Parameter	Standard	Criteria
Fusion Seaming		
Shear Strength (minimum)	ASTM D4437 (as modified by NSF 54)	60lb/in
Peel Adhesion (minimum)	ASTM D4437 (as modified by NSF 54)	50 lb/in
Extrusion Seaming		
Shear Strength (minimum)	ASTM D4437 (as modified by NSF 54)	60 lb/in
Peel Adhesion (minimum)	ASTM D4437 (as modified by NSF 54)	48 lb/in

Source: O'Brien & Gere

The LLDPE geomembrane manufacturer will be required to supply the following documentation to O'Brien & Gere, at a minimum, with each roll or pallet of LLDPE geomembrane manufactured:

- Name of manufacturer/fabricator
- Product type
- Product thickness
- Manufacturing batch code
- Date of manufacture
- Physical dimensions (length and width)
- Directions for unrolling or unfolding the LLDPE geomembrane.

CQC Prior to LLDPE Geomembrane Installation. Prior to placement of the LLDPE geomembrane, the Geosynthetic Installer will be required to provide a copy of his Quality Control Program Manual regarding the installation of the geomembrane. The Quality Control Program Manual shall include, at a minimum:

- Installation procedures
- Field sampling procedures
- Procedures for repair
- Documentation procedures.

O'Brien & Gere will perform laboratory friction tests using the ASTM D5321 - Direct Shear Test Method to document that a minimum factor of safety of 1.5 can be obtained between cap system components (geotextile bedding layer, textured LLDPE geomembrane, geocomposite drainage layer, structural geogrid, topsoil layer) for the steepest slopes proposed. Material not capable of meeting a factor of safety of 1.5 will not be approved for use on this project.

Friction testing will be performed with a direct shear box having minimum dimensions of 12 inches by 12 inches and applied normal stresses of 1.0, 2.0 and 4.0 psi for each cap system interface. Displacement rates will be less than 0.04 inches per minute. Cap system components will be tested in a saturated condition.

The LLDPE geomembrane will be oriented such that the shear force is parallel to the downslope orientation of the LLDPE geomembrane in the field. A minimum of one test per system interface will be performed. Additional tests will be performed if materials of construction in contact with the cap system or the materials of the cap system change from those originally tested.

The material on which the LLDPE geomembrane will be installed will be free of sharp materials and any abrupt changes in grade that could damage the LLDPE geomembrane. The supporting layer will be maintained in a smooth, uniform, and compacted condition during installation of the LLDPE geomembrane.

The Geomembrane Installer will provide O'Brien & Gere with written acceptance of the subgrade prior to LLDPE geomembrane installation. No installation of the LLDPE geomembrane will commence until the surface is accepted by the Geomembrane Installer and written acceptance is supplied to O'Brien & Gere.

The Geomembrane Installer will provide two minimum 18-inch wide by 18-inch long samples of LLDPE geomembrane for each lot number of geomembrane material that arrives at the site for fingerprinting. The samples will be provided to O'Brien & Gere for possible future testing and analysis. O'Brien & Gere will archive one sample at room temperature and in a light-free environment.

The LLDPE geomembrane will be stored in a sheltered area on-site to avoid possible damage caused by the following:

- Adverse weather
- Heavy winds
- Precipitation
- UV light
- Temperature extremes
- Vandals

The Geomembrane Installer will be required to provide a geomembrane panel layout showing the proposed locations of field seams to be installed. The Geosynthetic Installer will be required to document any changes in field seam locations. The Geomembrane Installer will be required to obtain written approval from the Owner's Representative prior to field seaming.

CQC During LLDPE Geomembrane Installation. Prior to seaming, the Geosynthetic Installer will observe the areas to be seamed to determine that they are free from dirt, dust, moisture, debris, and foreign material during seaming. No seaming will be performed when the air temperature of sheet temperature is below 32° Fahrenheit (F), when the sheet temperature exceeds 158° F, when the air temperature is above 120° F, during periods of precipitation, or when winds are in excess of 20 miles per hour.

If circumstances require that field seaming be conducted in cold weather conditions (below 32° F), the following procedures will be implemented:

- Surface temperatures of the geomembrane will be measured at least every 10 ft of seaming length
- Preheating of the seaming area under wind protection will be required if the measured surface temperature is below 32°F
- Preheating devices will be accepted by O'Brien & Gere and the Owner's Representative prior to operation
- At the discretion of O'Brien & Gere, additional destructive tests will be taken to monitor the quality of the installation
- No field sampling will be conducted, if ambient temperature is above 120°F unless the Geomembrane Installer can demonstrate to the satisfaction of O'Brien & Gere that the quality of seaming is not compromised. Additional destructive tests may be required by O'Brien & Gere for any suspect areas.

All seaming material will be of a type recommended and supplied by the manufacturer and will be delivered in the original sealed containers, each with an indelible label bearing the brand name, manufacturer's mark number, and complete directions as to proper storage.

Seams will be made double wedge welding as the primary method. Extrusion welding will be used only for patching and seaming around appurtenances. The minimum finished overlap of the panels of the geomembrane will be 6 inches maximum for wedge welding and extrusion welding.

Test seams will be made at the start of each seaming period, at O'Brien & Gere's discretion, whenever there is a change in seaming personnel or equipment, and if significant changes in geomembrane temperature are observed. The field test weld will be a minimum two-ft long by one ft wide with the seam centered lengthwise and will be made for each welding machine. Test weld samples will be labeled with:

- Date and time
- Roll/panel number
- Seam number
- Ambient temperature
- Welding apparatus
- Temperature and pressures
- Welder's initials
- Top sheet

Five test strips approximately 1-inch wide will be cut from each opposite end of test weld samples by the Installer and subjected to shear and peel tests at the site, as described in the following sections for destructive testing. If the field tests fail to meet the minimum specified seam requirements, the entire operation will be repeated. If the additional test seam fails, the seaming apparatus or seamer will not be accepted or used until the deficiencies are corrected and two consecutive successful full test seams are achieved. Remaining weld samples will be retained by the Owner for subsequent laboratory testing if required. No seaming personnel may begin work until his test weld has passed the on-site shear and peel tests as indicated by O'Brien & Gere.

CQA Prior to LLDPE Geomembrane Installation. Submittal information provided by the Installer will be reviewed.

CQA During LLDPE Geomembrane Installation. O'Brien & Gere will inspect delivery tickets and the LLDPE geomembrane manufacturer's quality control documentation to verify that the LLDPE geomembrane rolls received on-site meet the project specifications. If the LLDPE geomembrane does not meet the required specifications, the material will be rejected.

During installation of the LLDPE geomembrane, O'Brien & Gere will determine that the LLDPE geomembrane is installed in accordance with the requirements of the approved engineering plans, reports, and specifications.

O'Brien & Gere will also inspect the LLDPE geomembrane visually for the following:

- Uniformity
- Damage
- Imperfections
- Tears
- Punctures
- Nodules
- Contaminants
- Blisters

Any imperfections, such as those noted above, will be immediately repaired and reinspected.

Non-destructive tests will be performed on 100 percent of the field seams using either the vacuum test or pressurized dual seam test methods.

O'Brien & Gere will perform the following during non-destructive seam testing:

- Observe all non-destructive testing
- Record location, date, test unit number, name of tester, and results of all testing
- Inform the Geomembrane Installer of any required repairs

Destructive seam testing will be performed as the seaming work progresses and not at the completion of seam fabrication. Destructive seam testing will be performed at the locations established as follows:

- A minimum frequency of one test for every 1500 ft of seam length and for each seaming machine per day, unless a more frequent testing protocol is agreed upon by the Geomembrane Installer and O'Brien & Gere.
- Additional test locations may be determined during seaming at O'Brien & Gere's discretion. Selection of such locations may be prompted by suspicion of excess grinding, moisture, excess crystallinity, contamination, offset welds, or any other potential cause of imperfect welding.

The samples will be a minimum of 18 inches wide by 72 inches long with the seam centered lengthwise. Each sample will be cut into three pieces (18 inches x 24 inches) with one piece retained by the Geomembrane Installer, one piece given to the CQC Geosynthetic Laboratory, and the remaining piece given to O'Brien & Gere for further testing if desired and permanent record. Each sample will be tagged to identify:

- Roll/panel number
- Seam number
- Date and time cut
- Ambient temperature
- Seaming unit
- Name of seamer
- Welding apparatus temperature and pressures
- Top sheet

The Installer will cut ten 1-inch wide replicate specimens from his sample with the appropriate ASTM cutting tool. Three specimens will be tested for shear strength and three for peel adhesion. Three shear strength tests and two peel tests shall be performed on one end and two shear strength tests and three peel adhesion tests shall be performed on the opposite end. If one of the tested seams delaminates, failing in a non-film tear bond, the entire length of the seam will be reconstructed or repaired and tested using non-destructive seam testing over the full length of the seams using either the vacuum box or pressurized dual seam method. If no seams delaminate, but fail in the adjacent sheet material on either side of the seam in a film tear bond, the seam strength will be calculated. To be acceptable, two out of three replicate test specimens will be required to meet the specified property requirements. Certified test results from the Installer and independent laboratory on all seams shall be submitted prior to acceptance of the seam. If the field tests pass, testing will be performed by the CQC Geosynthetic Laboratory on duplicate samples as follows:

Table 3-4 CQC for Laboratory Testing Following Geomembrane Installation

Parameter	Standard	Criteria
Fusion Seaming		
Shear Strength (seaming)	ASTM D4437 (as modified by NSF 54)	60lb/in
Peel Adhesion (minimum)	ASTM D4437 (as modified by	50 lb/in

Table 3-4 CQC for Laboratory Testing Following Geomembrane Installation		
Parameter	**Standard**	**Criteria**
	NSF 54)	
Extrusion Seaming		
Shear Seaming (minimum)	ASTM D4437 (as modified by NSF 54)	60 lb/in
Peel Adhesion (minimum)	ASTM D4437 (as modified by NSF 54)	48lb/in
		Source: O'Brien & Gere

If the field tests fail, the seam will be reconstructed between the failed location and any passed test location. Seam reconstruction shall be achieved by cutting out the existing seam and seaming in a replacement strip or adding a cap strip. In lieu of this, the seaming path will be retraced to an intermediate location at least 10 ft in each direction from the location of the sample which failed the test. At each location a minimum 12-inch by 12-inch size sample will be taken for two additional shear strength tests and two additional peel adhesion tests using an approved field tensiometer. If these tests pass, then the remaining sample portion will be sent to the CQC geosynthetic laboratory for two shear strength and two peel adhesion tests. If these tests fail, then the process will be repeated. After reconstruction, the entire reconstructed seam will be non-destructively tested. In any case, all acceptable seams will be bounded by two passed test locations and include one test location along the reconstructed seam.

The geomembrane surface will be cleaned by the Geomembrane Installer prior to examination of all seams and non-seam areas by O'Brien & Gere. O'Brien & Gere will identify defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign materials.

Each suspect location in seam and non-seam areas will be non-destructively tested, as appropriate. Locations that fail the non-destructive testing will be documented by O'Brien & Gere and repaired by the Geosynthetic Installer according to the following methods:

- Patching will be used to repair holes, tears, blisters, undispersed raw materials, or contaminated areas by foreign materials. All patches and caps will extend a minimum of 6 inches beyond the edge of the defect and be made of the same geomembrane. Corners of patches will be rounded with a radius of approximately 3 inches. If extrusion materials are used, the surface of the geomembrane will be replaced and abraded no more than one hour prior to the repair.
- Spot welding or seaming will be used to repair small tears or other localized flaws.
- Failed seams will be reconstructed. All seams will be required to pass non-destructive testing as appropriate.

3.1.4. Geocomposite Drainage Layer

Manufacturing quality control. The manufacturer will be required to provide documentation to O'Brien & Gere regarding quality control of physical properties of the geocomposite drainage layer. The geocomposite will consist of a tri-planar geonet bonded on each side by a nonwoven, needle-punched geotextile. The geocomposite will have low compressibility to maintain high flow capacity over a wide range of confining pressures. Samples of the production run of the geocomposite will be obtained and tested and the results certified in accordance with the following minimum average roll values:

Table 3-5 QC of Triplanar Geonet Prior to Construction			
Properties	**Test Method**	**Unit**	**Value**
RESIN			
Density	ASTM D1505	g/cm^3	0.94
Melt Flow Index	ASTM D1238	g/10 min	1.0
CORE[1]			
Thickness[2]	ASTM D5199	Mil (mm)	340 (8.62)
Carbon Black Content	ASTM D4218	%	2-3
GEOTEXTILE[1]			
UV Resistance (500 hours)	ASTM G154	%	70
Serviceability Class	AASHTO M-288		Class 2
Grab Tensile Strength	ASTM D4632	lbs (N)	160 (712)
Grab Elongation	ASTM D4632	%	50
Tear Strength	ASTM D4533	lbs (N)	60 (267)
Puncture Resistance	ASTM D4833	lbs (N)	85 (378)
Apparent Opening Size (AOS)	ASTM D4751	US Sieve (mm)	70 (0.212)
Permittivity	ASTM D4491	Sec^{-1}	1.1
GEOCOMPOSITE			
Peel Adhesion - MD	ASTM D7005	lb/in (g/in)	1.0 (454)
HYDRAULIC BEHAVIOR OF GEOCOMPOSITE			
Transmissivity[2] – MD **Gradient/Load** **I = 0.33** **I = 0.10**	GRI – GC8 ASTM D4716	m^2/sec	1,000 psf (48 kPa) 4.0 x 10^{-3} 7.0 x 10^{-3}

Notes:

1. Geotextile and geonet properties listed are prior to lamination.
2. Geocomposite transmissivity measured by manufacturer per ASTM D4716 with testing boundary conditions as follows: steel plate / Ottawa sand / geocomposite / 40 mil HDPE geomembrane / Ottawa sand/ steel plate, and seating period of 100 hours according to GRI-GC8, with the flat side of the geocomposite facing the soft boundary condition as indicated with top (soil) and bottom (liner) label on the rolls. Digital indicator of hydraulic gradient is required during the transmissivity measurement at low gradients.

Table 3-5 QC of Triplanar Geonet Prior to Construction			
Properties	**Test Method**	**Unit**	**Value**
			Source: O'Brien & Gere

The clogging potential of the soil/geotextile system shall be assessed by using the proposed geotextile and soils that will be in contact with geotextile. The testing shall be performed in accordance with ASTM D5101 Test Method for Measuring the Soil-Geotextile System Clogging Potential (by the Gradient Ratio). Any geotextile with a gradient ratio test result greater than 3.0 shall not be accepted.

The manufacturer will provide O'Brien & Gere with certified copies of the factory and laboratory test results prior to arrival of the geocomposite material on-site. In addition, the manufacturer will provide certification that the geocomposite meets the chemical, physical, and manufacturing requirements.

Construction Quality Assurance. Prior to procurement of any material and during construction, O'Brien & Gere will review and verify submittal and sample information from the supplier. The information will be reviewed to evaluate if the proper information has been submitted. O'Brien & Gere will proceed with ordering the materials only after the submittals have been reviewed.

During installation of the geocomposite, O'Brien & Gere will:

- Monitor that the geocomposite is installed in accordance with the requirements of the Contract Documents and as shown on the Contract Drawings
- Take measurements to show that there are no gaps between adjacent panels of geocomposite material
- Make observations that the geonets are not damaged during the installation process.

3.1.5. Structural Geogrid

Manufacturing Quality Control. The manufacturer will be required to provide documentation to O'Brien & Gere regarding quality control of physical properties of the structural geogrid (uniaxial and biaxial). The geogrid will consist of an integrally formed grid structure manufactured of a stress resistant high-density polyethylene. The geogrid will have high resistance to loss of load capacity, loss of structural integrity, and deformation under long-term stress. Samples of the production run of the geogrid will be obtained and tested and the results certified in accordance with the following minimum average roll values:

Table 3-6 QC of Structural Uniaxial Geogrid Prior to Construction			
Property	**Test Method**	**Unit**	**Value[9]**
INTERLOCK			
Apertures[1]	I.D. Calipered[2]		
MD		in	5.70 (nom)
CMD		in	0.66 (nom)
Open area	COE Method[3]	%	60 (nom)
Thickness	ASTMD1777-64		
Ribs		in	0.030 (nom)

Table 3-6 QC of Structural Uniaxial Geogrid Prior to Construction

Property	Test Method	Unit	Value[9]
junctions		in	0.110 (nom)
REINFORCEMENT			
Creep limited strength[4]	ASTM D5262	lb/ft	1,400 (min)
Flexural rigidity	ASTM D1388-64[5]	mg/-cm	670,000
Ultimate strength - md	GRI GG1-87[6]	lb/ft	3,700
Tensile modulus - md	GRI GG1-87[7]	lb/ft	42,000
Junctions	GRI GG2-87[8]		
Strength		Lb/ft	3,330
MATERIAL			
High density polyethylene type iii/class a/grade 5	ASTM D1248	%	97 (min)
Carbon black	ASTM 4218	%	2.0 (min)
DIMENSIONS			
Roll length		ft	250
Roll width		ft	4.3
Roll weight		lb	112

Notes:

1. MD dimension is along roll length. CMD dimension is across roll width.
2. Maximum inside dimension in each principal direction in each principal direction measured by calipers.
3. Percent open area measured without magnification by Corps of Engineers method as specified in CW 02215 Civil Works Construction Guide, November 1977.
4. The long-term allowable design strength (LTADS) is determined using the method outlined in GRI-GG4 "Determination of the Long Term Design Strength of Stiff Geogrids". The GRI-GG4 method applies various partial factors of safety to account for construction damage, junction strength, connections, chemical and biological degradation.
5. ASTM D 1388-64 modified to account for wide specimen testing as described in Tensar test method TTM-5.0 "Stiffness of Geosynethtics".
6. Ultimate strength measured by GeoSynethetic Research Institute test method GG1-87 as modified by AASHTO 97 at 10% of gauge length (G.L.) per min at 8 inch minimum G.L., or the greater of 3 junctions (2 repeat units).

Table 3-6 QC of Structural Uniaxial Geogrid Prior to Construction			
Property	**Test Method**	**Unit**	**Value[9]**
7. Secant modulus at 2% elongation measured by Geosynthetic Research Institute test method GG1-87 "Geogrid Tensile Strength" as modified by AASI ITO 97 at 10% of gauge length (G.L.) per min at 8 inch minimum G.L., or the greater of 3 junctions (2 repeat units). No offset allowances are made in calculating secant modulus.			
8. Geogrid junction strength and junction efficiency measured by Geosynthetic Research Institute test method GG2-87 "Geogrid Junction Strength" as modified by AASHTD 97 at 10% of gauge length (G.L.) per min at 8 inch minimum G.L., or the greater of 3 junctions (2 repeat units).			
9. Unless indicated otherwise, values are minimum average roll values determined in accordance with ASTM D-4/59.			
Source: O'Brien & Gere			

Reports of all testing will be submitted to O'Brien & Gere for acceptance.

Construction Quality Assurance. Prior to procurement of any material and during construction, O'Brien & Gere will review and verify submittals and sample information from the supplier. The information will be reviewed to evaluate if the proper information has been submitted. O'Brien & Gere will proceed with ordering the materials only after the submittals have been reviewed.

The material delivered to the site will be visually inspected by O'Brien & Gere to check that the same materials are used during construction. If changes in material occur prior to the acceptance of the material by O'Brien & Gere the material will be tested and evaluated with respect to the requirements of the Contract Documents. Any material not meeting the requirements will be removed from the site and replaced. The material will be installed according to manufacturer's recommendations.

The manufacture shall identify all rolls of geogrid with the manufacturer's name, product identification, lot number, roll number, and roll dimensions.

The manufacturer shall furnish complete written instructions for the storage, handling, installation, and seaming of the geogrid with the conditions of this warranty.

The manufacturer shall certify the quality of the rolls of geogrid. As a minimum, the manufacturer shall provide quality control certificates for each batch of resin and each shift's production. These quality control certificates shall be signed by an officer of the manufacturer and supplied to O'Brien & Gere at least three (3) weeks prior to installation of the structural geogrid.

The quality control certificate shall include:

- Roll numbers and identification
- Sampling procedures
- Result of quality control tests, including a description of test methods used.

A qualified and experienced representative of the geogrid manufacturer or its supplier shall be on site for a minimum of two days at the start of and during installation to assist the Installer in the proper construction/installation techniques.

3.1.6. Select Fill - Stone

Construction quality control. The stone used for construction of the IRM will vary as shown on the Contract Drawings and Specifications. The stone shall be as described in Specification Section 02231-Select Fill. Prior to installation, the supplier will be required submit, to O'Brien & Gere for approval, geotechnical testing results as follows:

Table 3-7 CQC of Stone Prior to Construction

Parameter	Standards	Criteria
Particle Size Analysis	ASTM D422	See Specification Section 02231-Select Fill

Note:
(1) ASTM D422 Method for Particulate Size Analysis of Soil

Source: O'Brien & Gere

The supplier shall submit an affidavit from the owner of the source of each type of borrow material to be imported to the site stating that to the best of his knowledge, the site of the source material was never used as a dump site for chemical, toxic, hazardous or radioactive materials and it is not now, or ever has been, listed as a suspected depository for chemical, toxic, hazardous, or radioactive materials by any federal, state, or other governmental agency, department, or bureau.

During installation of select fill, material from the borrow source will be tested by the CQC Geotechnical Testing Laboratory in accordance with the following:

Table 3-8 CQC of Stone During Construction

Parameter	Standard	Minimum Frequency	Criteria
Particle Size Analysis	ASTM D422	Once per 2500 cy	See Specification Section 02231 – Select Fill

Note:
(1) ASTM D422 Method for Particulate Size Analysis of Soil

Source: O'Brien & Gere

A minimum of one (1) test for each parameter shall be performed. Results of all testing will be submitted to O'Brien & Gere for acceptance.

Construction quality assurance. Prior to procurement of any material and during construction, O'Brien & Gere will review and verify submittal and sample information from the supplier. The information will be reviewed to evaluate if the proper information has been submitted. O'Brien & Gere will proceed with ordering the materials only after the submittals have been reviewed.

The material delivered to the site will be visually inspected by O'Brien & Gere to check that the same materials are used during construction. If changes in material occur prior to the acceptance of the material by O'Brien & Gere the material will be tested and evaluated with respect to the requirements of the Contract Documents. Any material not meeting the requirements will be removed from the site and replaced.

3.1.7 Concrete Sand

Construction quality control. The sand will consist of fine concrete sand installed surrounding the slotted collection pipe. The sand shall be clean, hard, durable, and dense grains containing no more than 50% carbonate material or other approved equal material free from coatings and organic matter. Prior to installation of the

sand, the supplier will be required to collect samples of the proposed sand and submit, to O'Brien & Gere for approval, geotechnical testing results as follows:

Table 3-9 CQC of Sand Layer Prior to Construction

Parameter	Standard	Criteria
Particle Size Analysis	ASTM D422	See Specification Section 02231-Select Fill

Note:
1. ASTM D422 Method for Particulate Size Analysis of Soil

Source: O'Brien & Gere

The supplier shall submit an affidavit from the owner of the source of each type of borrow material to be imported to the site stating that to the best of his knowledge, the site of the source material was never used as a dump site for chemical, toxic, hazardous or radioactive materials and it is not now, or ever has been, listed as a suspected depository for chemical, toxic, hazardous, or radioactive materials by any federal, state, or other governmental agency, department, or bureau.

The supplier shall also provide laboratory analytic data (or documentation of such data) for these sands for characteristics of hazardous waste found under Subpart C of 40 CFR 261.20 including percent solids, pH, flashpoint, reactive cyanide, and sulfide, as well as for constituents identified on Table 1 of 40 CFR 261 which identifies Maximum Concentration of Contaminant for the Toxicity Characteristics. Laboratory data (or documentation of such data) shall be submitted to O'Brien& Gere for review and acceptance prior to use of the material on-site.

In addition, sands shall either:

- Have composite samples tested for the compounds in Table 375-6.8(a) "Unrestricted Use Soil Cleanup Objectives" in NYSDEC Subpart 375. All test results shall be below the cleanup objective concentrations provided in this table, with the exception of mercury, which shall be below 0.15 mg/kg. Failure of a single compound test result shall mean that the entire material batch will be rejected unless specifically accepted on a test-by-test basis in writing by O'Brien& Gere; or
- Originate from a borrow site that has been otherwise verified as having no compounds exceeding the limits in Table 375-6.8(a) "Unrestricted Use Soil Cleanup Objectives" in NYSDEC Subpart 375.

During installation of the sand layer, material from the borrow source will be tested by the CQC Geotechnical Testing Laboratory in accordance with the following:

Table 3-10 CQC of Sand Layer During Construction

Parameter	Standard	Minimum Frequency	Criteria
Particle Size Analysis	ASTM D422	Once per 2500 cy	See Specification Section 02231-Select Fill

Note:
1. ASTM D422 Method for Particulate Size Analysis of Soil

Source: O'Brien & Gere

A minimum of one (1) test for each parameter shall be performed. Results of all testing will be submitted to O'Brien & Gere for acceptance.

Construction Quality Assurance. Prior to procurement of any material and during construction, O'Brien & Gere will review and verify submittal and sample information from the supplier. The information will be reviewed to evaluate if the proper information has been submitted. O'Brien & Gere will proceed with ordering the materials only after the submittals have been reviewed.

The material delivered to the site will be visually inspected by O'Brien & Gere to check that the same materials are used during construction. If changes in material occur prior to the acceptance of the material by O'Brien & Gere the material will be tested and evaluated with respect to the requirements of the Contract Documents. Any material not meeting the requirements will be removed from the site and replaced.

3.1.8. Topsoil

Construction quality control. Prior to installation of the topsoil, the supplier will be required to collect samples of the proposed topsoil and submit, to O'Brien & Gere for approval, geotechnical testing results as follows:

Table 3-11 CQC of Topsoil Layer Prior to Construction

Parameter	Standard	Criteria
Topsoil Grain Size	ASTM D422-63	Monitor consistency of borrow source
Topsoil pH	ASTM D4972-89	pH in the range of 5.5 to 7.6
Topsoil Organic Content	ASTM D2974-87	Not less than 6% or more than 20%

Notes:
1. ASTM D422 Method for Particulate Size Analysis of Soil
2. ASTM D2974-87 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils
3. ASTM D4972-89 Standard Test Method for pH in Soils

Source: O'Brien & Gere

Results of the testing will be submitted to O'Brien & Gere for acceptance.

The supplier shall submit an affidavit from the owner of the source of each type of borrow material to be imported to the site stating that to the best of his knowledge, the site of the source material was never used as a dump site for chemical, toxic, hazardous or radioactive materials and it is not now, or ever has been, listed as a suspected depository for chemical, toxic, hazardous, or radioactive materials by any federal, state, or other governmental agency, department, or bureau.

The supplier shall also provide laboratory analytic data (or documentation of such data) for these topsoils for characteristics of hazardous waste found under Subpart C of 40 CFR 261.20 including percent solids, pH, flashpoint, reactive cyanide, and sulfide, as well as for constituents identified on Table 1 of 40 CFR 261 which identifies Maximum Concentration of Contaminant for the Toxicity Characteristics. Laboratory data (or documentation of such data) shall be submitted to O'Brien& Gere for review and acceptance prior to use of the material on-site.

In addition, topsoil shall either:

- Have composite samples tested for the compounds in Table 375-6.8(a) "Unrestricted Use Soil Cleanup Objectives" in NYSDEC Subpart 375. All test results shall be below the cleanup objective concentrations provided in this table, with the exception of mercury, which shall be below 0.15 mg/kg. Failure of a single compound test result shall mean that the entire material batch will be rejected unless specifically accepted on a test-by-test basis in writing by O'Brien& Gere; or

- Originate from a borrow site that has been otherwise verified as having no compounds exceeding the limits in Table 375-6.8(a) "Unrestricted Use Soil Cleanup Objectives" in NYSDEC Subpart 375.

Documentation giving the location of properties from which the topsoil will be obtained, names and addresses of the owners, and depth to be stripped will be submitted to O'Brien & Gere for acceptance.

During installation of the topsoil layer, the topsoil will be tested by the CQC Geotechnical Testing Laboratory in accordance with the following:

Table 3-12 CQC of Topsoil Layer During Construction

Parameter	Standard	Minimum Frequency	Criteria
Particle Size	ASTM D422-63	Once per 2500 cy	Monitor consistency of borrow source
Topsoil pH	ASTM D4972-89	Once per 2500 cy	pH in the range of 5.5 to7.6
Topsoil Organic Content	ASTM D2974-87	Once per 2500 cy	Not less than 6% or more than 20%

Notes:

1. ASTM D422 Method for Particulate Size Analysis of Soil
2. ASTM D2974-89 Test Methods for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils.
3. ASTM D4972-89 Standard Test Method for pH of Soils.

Source: O'Brien & Gere

Results of all testing will be submitted to O'Brien & Gere for review and acceptance.

Construction Quality assurance. Prior to procurement of any material and during construction, O'Brien & Gere will review and verify submittal and sample information from the supplier. The information will be reviewed to evaluate if the proper information has been submitted. O'Brien & Gere will proceed with ordering the materials only after the submittals have been reviewed.

The material delivered to the site will be visually inspected by O'Brien & Gere to check that the same materials are used during construction. If changes in material occur prior to the acceptance of the material by O'Brien & Gere the material will be tested and evaluated with respect to the requirements of the Contract Documents. Any material not meeting the requirements will be removed from the site and replaced.

O'Brien & Gere will perform inspections to evaluate the placement of topsoil in accordance with the Contract Documents, any irregularities with respect to proposed finished grades will be corrected prior to installation of grass seed, fertilizer, and mulch.

3.1.9. Fertilization and Seeding

Construction Quality Control. As part of CQC, the suppliers will be required to submit the following information to O'Brien & Gere for acceptance prior to fertilization and seeding activities:

- Seed vendor's certified statement for the grass seed mixture required, stating common name, scientific name, percentage by weight, and percentages of purity and germination
- Fertilizer vendor's certified statement for the fertilizer required stating guaranteed statement of analysis
- Documentation giving data concerning hydroseeding equipment (if used), including all material application rates.

The grass seed will be of commercial stock of the current season's crop and will be delivered in unopened containers bearing the guaranteed analysis of the mix. The mix will be in accordance with the requirements of the approved engineering plans and specifications.

Fertilizer will be a standard quality commercial carrier of available plant food elements. Fertilizer will be a complete, prepared, and packaged material and will contain 10% nitrogen, 2% phosphoric acid, and 10% potash. Fertilizer shall be applied at a rate of 10 pounds per 1000 square feet. Each bag of fertilizer will bear the manufacturers guaranteed statement of analysis. The mulch will consist of un-rotted stalks of oats, wheat, rye or other approved crops that are free from noxious weeds, salts, mold, or other objectionable material.

Construction Quality Assurance. O'Brien & Gere will review submittals to evaluate that fertilization and seeding materials meet the requirements of the Contract Documents. If any materials fail the requirements of the Contract Documents, the materials will be rejected. O'Brien & Gere will also inspect the application rates of seed, fertilizer, and mulch with respect to the specifications.

3.1.10. Electrical/Materials/Equipment

Construction Quality Control. The electrical subcontractor will be required to perform the electrical work in accordance with the applicable codes and standards. All new electrical equipment will be listed and labeled by an acceptable organization.

The electrical subcontractor will submit shop drawings and samples to O'Brien & Gere. The electrical subcontractor will also prepare for final submission the following:

- Updated as-built shop drawings and plans, including field directed changes by O'Brien & Gere
- Wiring diagrams, including updated field directed changes by O'Brien & Gere.

Construction Quality Assurance. CQA will consist of O'Brien & Gere evaluating work and submittals for compliance with the separately bound Contact Drawings.

3.1.11. Piping and Appurtenances

Construction Quality Control. Prior to ordering any materials, the supplier shall submit, to O'Brien & Gere, the following information:

- Manufacturer's name
- Applicable codes, standards and specifications (ANSI, ASTM, *etc.*)
- Manufacturer's affidavit stating compliance with the applicable specification.

The following information on piping (in addition to the above), is an example of the information required for supplier shop drawing submittal:

- Pipe material (FRP)
- Pipe class and/or pressure rating
- Type of joints, fittings and couplings
- Linings and coatings
- Handling and storage requirements
- Drawings and manufacturer's data of the pipe, joints and fittings showing compliance with the applicable pipe specification.

Construction Quality Assurance. Prior to procurement of any material and during construction, O'Brien & Gere will review and verify submittal information from the supplier. The information will be reviewed to evaluate if the proper information has been submitted. O'Brien & Gere will proceed with ordering the materials only after the submittals have been reviewed.

The material delivered to the site will be visually inspected by O'Brien & Gere to check that the same materials are used during construction. If changes in material occur prior to the acceptance of the material by O'Brien & Gere the material will be evaluated with respect to the requirements of the Contract Documents. Any material not meeting the requirements will be removed from the site and replaced.

3.2. STORM WATER DRAINAGE FACILITIES

3.2.1. Rip-rap

Construction Quality Control. Prior to installation of the rip-rap, the supplier will be required to collect samples of proposed rip-rap and submit the samples to the CQC Geotechnical Laboratory for testing as follows:

Table 3-13 CQC of Rip-Rap Prior to Construction of Storm Water Drainage Facilities

Parameter	Standard	Criteria	
Particle Size	ASTM D422	Stone size	% of Total by Weight
Rip-Rap:			
Heavy (36 Inches)		Heavier than 600 lbs Smaller than 6 inches	50 – 100 0 – 10
Medium (24 Inches)		Heavier than 100 lbs Larger than 12 inches Larger than 18 inches Smaller than 4 inches	50 – 100 50 – 100 0 – 10 0 – 10
Light (18 Inches)		Lighter than 100 lbs Larger than 6 inches Smaller than ½ inches	90 – 100 50 – 100 0 – 10
Fine (12 Inches)		Smaller than 3 Inches Larger than 3 Inches Smaller than No. 10 Sieve	90 – 100 50 – 100 0 - 10

Notes:
Stone sizes other than weights refer to the average of the maximum and minimum dimensions of a stone particle.
(1) Materials shall contain a sufficient amount of stones smaller than the average stone size to fill the spaces between the larger stones.
(2) Materials shall contain less than 20 percent of stones with a ratio of maximum to minimum dimension greater than three.

Source: O'Brien & Gere

Results of the testing will be submitted to O'Brien & Gere for acceptance.

The supplier shall submit an affidavit from the owner of the source of each type of borrow material to be imported to the site stating that to the best of his knowledge, the site of the source material was never used as a dump site for chemical, toxic, hazardous or radioactive materials and it is not now, or ever has been, listed as a suspected depository for chemical, toxic, hazardous, or radioactive materials by any federal, state, or other governmental agency, department, or bureau.

During installation of the storm water drainage facilities, the rip-rap will be tested by the CQC Geotechnical Testing Laboratory as follows:

Table 3-14 CQC of Rip-Rap During Construction of Storm Water Drainage Facilities

Parameter	Standard	Criteria	
Particle Size	ASTM D422	Stone size	% of Total by Weight
Rip-Rap:			
Heavy (36 Inches)		Heavier than 600 lbs Smaller than 6 inches	50 – 100 0 – 10
Medium (24 Inches)		Heavier than 100 lbs Larger than 12 inches Larger than 18 inches Smaller than 4 inches	50 – 100 50 – 100 0 – 10 0 – 10
Light (18 Inches)		Lighter than 100 lbs Larger than 6 inches Smaller than ½ inches	90 – 100 50 – 100 0 – 10
Fine (12 Inches)		Smaller than 3 Inches Larger than 3 Inches Smaller than No. 10 Sieve	90 – 100 50 – 100 0 - 10
			Source: O'Brien & Gere

Results of all testing will be submitted to O'Brien & Gere for review and acceptance.

Construction Quality Assurance. O'Brien & Gere will perform inspections to evaluate the construction of the storm water drainage facilities in accordance with the Contract Documents. Any irregularities with respect to proposed drainage facilities will be corrected prior to installation of the rip-rap.

3.2.2. Geotextile Fabric

Construction Quality Control. Prior to installation of the geotextile fabric, the supplier will be required to provide documentation regarding quality control of physical properties of the geotextile fabric. The geotextile fabric shall be a woven geotextile. Samples of the production run of the geotextile material will be obtained and tested and the results certified in accordance with the following minimum average roll values:

Table 3-15 CQC for Geotextile Fabric Prior to Construction of Storm Water Drainage Facilities

Parameter	Standard	Criteria
Puncture Strength	ASTM D4833	Minimum 145 lbs.
Mullen Burst Strength	ASTM D 3786	Minimum 600 psi
Trapezoid Tear Strength	ASTM D 4533	Minimum 113 lbs

Table 3-15 CQC for Geotextile Fabric Prior to Construction of Storm Water Drainage Facilities

Parameter	Standard	Criteria
Grab Tensile Strength	ASTM D 4632	Minimum 315 lbs
Grab Tensile Elongation	ASTM D 4632	Minimum 12%
CBR Puncture Strength	ASTM D6241	Minimum 900 lbs
Apparent Opening Size	ASTM D4751	40 U.S. Sieve
Permittivity	ASTM D4491	0.05 sec^{-1}
Flow Rate	ASTM D4491	4.0 $gal/min/ft^2$
UV Resistance	ASTM D4355	70% strength retained
		Source: O'Brien & Gere

The supplier will provide O'Brien & Gere with certified copies of the factory and laboratory test results prior to arrival of material on-site. In addition, the supplier will provide the manufacturer's certification that the geotextile fabric meets the chemical, physical, and manufacturing requirements.

Construction Quality Assurance. Prior to procurement of any material and during construction, O'Brien & Gere will review and verify submittal information from the supplier. The information will be reviewed to evaluate if the proper information has been submitted. O'Brien & Gere will proceed with ordering the materials only after the submittals have been reviewed.

The material delivered to the site will be visually inspected by O'Brien & Gere to check that the same materials are used during construction. If changes in material occur prior to the acceptance of the material by O'Brien & Gere the material will be evaluated with respect to the requirements of the Contract Documents. Any material not meeting the requirements will be removed from the site and replaced.

During the installation phase, the geotextile fabric will be visually inspected for the following:

- Defects
- Rips
- Holes
- Flaws
- Deterioration
- Damage

Any imperfections, such as those noted above, will be immediately repaired by the Installer and reinspected.

O'Brien & Gere will perform inspections to evaluate the construction of the storm water drainage facilities in accordance with the Contract Documents. Any irregularities with respect to proposed drainage facilities will be corrected prior to installation of the geotextile fabric.

4. DOCUMENTATION

This section describes the recordkeeping that will be used to document the CQA/CQC activities performed during construction of this project. The documentation will comprise the final records of the project, with the results of material and installation inspections and tests.

4.1. PROBLEM IDENTIFICATION AND CORRECTIVE MEASURES REPORTS

In the event that O'Brien & Gere or others determine that material or workmanship does not meet the requirements of the plans, specifications or CQA/CQC Plan, or if an obvious defect in material or workmanship is noted and removal/replacement of work is not feasible, O'Brien & Gere will complete a problem identification and corrective measures report and present it to the NYSDEC.

4.2. ACTION ITEM LIST

O'Brien & Gere will prepare and maintain a list of "Action Items" based on the discussions during weekly meetings. The action item list will be circulated to meeting attendees and the NYSDEC to keep them apprised of the status of identified items.

4.3. PHOTOGRAPHS

All photographs taken by O'Brien & Gere will be recorded on a photo log which will include, at a minimum, the date, time, location, and description of the work.

4.4. RECORD DRAWINGS

At the completion of the project, O'Brien & Gere will transfer as-built information to a set of final record drawings to document site conditions.

4.5. STORAGE AND DISPOSITION OF RECORDS

During construction of this project, O'Brien & Gere will be responsible for all CQA/CQC documents. This includes the originals of all the data sheets and reports.

Once project construction is complete, the original document will be stored in a manner that will allow for recovery while still protecting them from damage.

4.6. DAILY REPORT

O'Brien & Gere will prepare a daily report that will provide a summary of project activities conducted that day and observations made. A copy of these reports will be maintained and available for review on site during construction.

4.7. WEEKLY REPORT

O'Brien & Gere will prepare a weekly report that will summarize the progress of work as it relates to the schedule, conditions encountered in the field and formal communications regarding the work. A copy of the weekly report will be maintained and available for review on site during construction.

5. CHANGES AND CORRECTIONS OF WORK

This section summarizes the requirements and procedures for tracking requests for information, changes to design and/or drawings, control of discrepant and non-conformant items, and tracking corrective actions.

5.1. PROCEDURE FOR CHANGES

Honeywell at any time may make changes in the Work by making alterations therein, by making additions thereto, or by omitting Work therefrom. Honeywell will not, however, make changes to the design during construction connected to the environmental remedy without first reviewing the proposed change with the NYSDEC and receiving the agency's approval to proceed.

Honeywell may authorize minor changes in the Work which do not alter the character, quantity, or cost of the Work as a whole. These changes may be accomplished by a Field Order.

5.2. INSPECTION AND CORRECTION OF WORK

O'Brien & Gere will observe the progress and quality of the executed Work to determine, in general, if the Work is proceeding in substantial compliance with the design plans and technical specifications. O'Brien & Gere may disapprove Work as failing to conform to design plans or technical specifications.

Culvert #3 Hydraulic Analysis

HONEYWELL INC.
UPPER HARBOR BROOK IRM
CULVERT #3 HYDRAULIC ANALYSIS

PURPOSE

This attachment presents the results of the hydraulic analysis performed on Harbor Brook Culvert #3 in order to compare existing to proposed conditions. Harbor Brook Culvert #3 is illustrated in plan view on **Sheet G-4** of the Contract Drawings.

PROPOSED CULVERT MODIFICATIONS

It is proposed that four 2-inch diameter pipes be placed on the invert of one of the two 78-inch culverts and be encased in 6-inches of concrete. A layer of fiberglass cured-in-place pipe (CIPP) would then be installed on the interior of the 78-inch CMP to line the culvert. The proposed 78-inch culvert cross section showing the 2-inch pipes is illustrated on **Figure 1**.

HYDRAULIC EVALUATIONS

Hydraulic calculations were performed to estimate full pipe flow capacity for existing and proposed conditions of the 78-inch culvert. Two equations were used to calculate the full pipe flow capacity including:

1. Manning's Equation (open channel flow)

   Note: Since the existing culvert has a reverse slope a minimum slope of 0.001 was used.

2. Hazen-Williams formula (pressure flow)

The table below summarizes the inputs used in the hydraulic evaluations and the resulting peak pipe flow rates.

Hydraulic Equation Inputs and Resulting Peak Flow Rates		
Parameter	**Existing 78-inch Culvert**	**Proposed Modification Culvert**
Inputs		
Size	78-inch diameter	74.5-inch diameter
Slope	0.001	0.001
Manning 'n'	0.024	0.011
Hazen-Williams 'c'	100	120
Results		
Mannings[1] Peak Flow Capacity	62.97 MGD	121.56 MGD
Hazen-Williams[1] Friction Loss	H_f = 0.43 ft	H_f = 0.39 ft

[1] Computer generated calculations attached as **Tables 1-3**

FINDINGS

As indicated in the above summary table, the hydraulic analysis shows there is an increase in flow in the modified 78-inch CMP culvert due to the lower friction factors resulting from lining the culvert with the fiberglass CIPP.

Table 1
Honeywell Inc.
Upper Harbor Brook IRM
Manning's Hydraulic Analysis (Existing Conditions)

OPEN CHANNEL FLOW
(uniform flow in circular channels using variable n)

Parameter	Value Used
Pipe Diameter (ID)	78 inches
Pipe Slope (gradient in ft./ft.)	0.001 (dimensionless)
Manning's n value (full pipe)	0.024 (dimensionless)(based on FHWA recommendations)

Flow Depth (inches)	% Full Depth	Flow Velocity (ft/sec)	Flow Rate (cfs)	Flow Rate (gpm)	Flow Rate (MGD)	n-value	Flow Area (sf)	Hydraulic Radius (ft)
0	0.0	0.00	0.00	0.00	0.00	0.023	0.00	0.00
1.95	2.5	0.44	0.10	43.71	0.06	0.024	0.22	0.11
3.9	5.0	0.67	0.42	186.76	0.27	0.025	0.62	0.21
5.85	7.5	0.85	0.96	429.29	0.62	0.026	1.13	0.31
7.8	10.0	0.99	1.71	766.78	1.10	0.026	1.73	0.41
9.75	12.5	1.11	2.66	1,194.05	1.72	0.027	2.39	0.51
11.7	15.0	1.22	3.80	1,706.14	2.46	0.028	3.12	0.60
13.65	17.5	1.31	5.12	2,298.50	3.31	0.028	3.90	0.70
15.6	20.0	1.40	6.61	2,967.13	4.27	0.029	4.72	0.78
17.55	22.5	1.48	8.26	3,708.48	5.34	0.029	5.59	0.87
19.5	25.0	1.55	10.07	4,519.42	6.51	0.029	6.49	0.95
21.45	27.5	1.62	12.03	5,397.21	7.77	0.030	7.42	1.03
23.4	30.0	1.69	14.12	6,339.39	9.13	0.030	8.37	1.11
25.35	32.5	1.75	16.36	7,343.76	10.58	0.030	9.35	1.19
27.3	35.0	1.81	18.73	8,408.31	12.11	0.030	10.35	1.26
29.25	37.5	1.87	21.24	9,531.17	13.72	0.030	11.37	1.33
31.2	40.0	1.93	23.86	10,710.55	15.42	0.030	12.39	1.39
33.15	42.5	1.98	26.61	11,944.70	17.20	0.030	13.43	1.46
35.1	45.0	2.04	29.48	13,231.86	19.05	0.030	14.48	1.52
37.05	47.5	2.09	32.46	14,570.22	20.98	0.030	15.54	1.57
39	50.0	2.14	35.55	15,957.81	22.98	0.030	16.59	1.63
40.95	52.5	2.20	38.75	17,392.53	25.05	0.030	17.65	1.68
42.9	55.0	2.25	42.05	18,871.97	27.18	0.030	18.70	1.72
44.85	57.5	2.30	45.44	20,393.46	29.37	0.030	19.75	1.77
46.8	60.0	2.35	48.91	21,953.87	31.61	0.030	20.79	1.80
48.75	62.5	2.40	52.47	23,549.57	33.91	0.029	21.82	1.84
50.7	65.0	2.46	56.09	25,176.28	36.25	0.029	22.83	1.87
52.65	67.5	2.51	59.78	26,828.92	38.63	0.029	23.83	1.90
54.6	70.0	2.56	63.50	28,501.44	41.04	0.028	24.81	1.93
56.55	72.5	2.61	67.26	30,186.54	43.47	0.028	25.77	1.95
58.5	75.0	2.66	71.02	31,875.40	45.90	0.028	26.70	1.96
60.45	77.5	2.71	74.77	33,557.21	48.32	0.027	27.59	1.97
62.4	80.0	2.76	78.47	35,218.66	50.71	0.027	28.46	1.98
64.35	82.5	2.80	82.09	36,843.03	53.05	0.026	29.28	1.98
66.3	85.0	2.85	85.58	38,408.97	55.31	0.026	30.06	1.97
68.25	87.5	2.89	88.87	39,888.38	57.44	0.025	30.79	1.96

Table 1
Honeywell Inc.
Upper Harbor Brook IRM
Manning's Hydraulic Analysis (Existing Conditions)

Flow Depth (inches)	% Full Depth	Flow Velocity (ft/sec)	Flow Rate (cfs)	Flow Rate (gpm)	Flow Rate (MGD)	n-value	Flow Area (sf)	Hydraulic Radius (ft)
70.2	90.0	2.92	91.89	41,242.69	59.39	0.025	31.46	1.94
72.15	92.5	2.95	94.50	42,415.12	61.08	0.025	32.05	1.91
74.1	95.0	2.96	96.50	43,311.47	62.37	0.024	32.56	1.86
76.05	97.5	2.96	97.43	43,730.95	62.97	0.023	32.96	1.80
78	100.0	2.83	93.84	42,119.95	60.65	0.023	33.18	1.63

Table 2
Honeywell Inc.
Upper Harbor Brook IRM
Manning's Hydraulic Analysis (Proposed Conditions)

OPEN CHANNEL FLOW
(uniform flow in circular channels using variable n)

Parameter	Value Used
Pipe Diameter (ID)	74.5 inches
Pipe Slope (gradient in ft./ft.)	0.001 (dimensionless)
Manning's n value (full pipe)	0.011 (dimensionless)(based on FHWA recommendations)

Flow Depth (inches)	% Full Depth	Flow Velocity (ft/sec)	Flow Rate (cfs)	Flow Rate (gpm)	Flow Rate (MGD)	n-value	Flow Area (sf)	Hydraulic Radius (ft)
0	0.0	0.00	0.00	0.00	0.00	0.011	0.00	0.00
1.8625	2.5	0.93	0.19	84.38	0.12	0.011	0.20	0.10
3.725	5.0	1.42	0.80	360.53	0.52	0.011	0.57	0.20
5.5875	7.5	1.79	1.85	828.70	1.19	0.012	1.03	0.30
7.45	10.0	2.09	3.30	1,480.19	2.13	0.012	1.58	0.39
9.3125	12.5	2.35	5.14	2,305.01	3.32	0.012	2.18	0.49
11.175	15.0	2.58	7.34	3,293.54	4.74	0.013	2.85	0.58
13.0375	17.5	2.78	9.89	4,437.06	6.39	0.013	3.56	0.66
14.9	20.0	2.96	12.76	5,727.79	8.25	0.013	4.31	0.75
16.7625	22.5	3.13	15.95	7,158.89	10.31	0.013	5.10	0.83
18.625	25.0	3.28	19.44	8,724.34	12.56	0.013	5.92	0.91
20.4875	27.5	3.43	23.21	10,418.83	15.00	0.014	6.77	0.99
22.35	30.0	3.57	27.27	12,237.62	17.62	0.014	7.64	1.06
24.2125	32.5	3.70	31.59	14,176.47	20.41	0.014	8.53	1.13
26.075	35.0	3.83	36.16	16,231.49	23.37	0.014	9.44	1.20
27.9375	37.5	3.95	40.99	18,399.06	26.49	0.014	10.37	1.27
29.8	40.0	4.07	46.07	20,675.75	29.77	0.014	11.31	1.33
31.6625	42.5	4.19	51.37	23,058.17	33.20	0.014	12.26	1.39
33.525	45.0	4.31	56.91	25,542.93	36.78	0.014	13.21	1.45
35.3875	47.5	4.42	62.67	28,126.50	40.50	0.014	14.17	1.50
37.25	50.0	4.53	68.63	30,805.13	44.36	0.014	15.14	1.55
39.1125	52.5	4.65	74.80	33,574.71	48.35	0.014	16.10	1.60
40.975	55.0	4.76	81.17	36,430.66	52.46	0.014	17.06	1.64
42.8375	57.5	4.87	87.71	39,367.75	56.69	0.014	18.02	1.69
44.7	60.0	4.98	94.42	42,379.98	61.03	0.014	18.96	1.72
46.5625	62.5	5.09	101.29	45,460.33	65.46	0.013	19.90	1.76
48.425	65.0	5.20	108.28	48,600.55	69.98	0.013	20.83	1.79
50.2875	67.5	5.31	115.39	51,790.83	74.58	0.013	21.74	1.82
52.15	70.0	5.42	122.58	55,019.48	79.23	0.013	22.63	1.84
54.0125	72.5	5.52	129.83	58,272.42	83.91	0.013	23.51	1.86
55.875	75.0	5.63	137.10	61,532.60	88.61	0.013	24.35	1.87
57.7375	77.5	5.73	144.33	64,779.19	93.28	0.012	25.17	1.88
59.6	80.0	5.83	151.47	67,986.47	97.90	0.012	25.96	1.89
61.4625	82.5	5.93	158.46	71,122.17	102.42	0.012	26.71	1.89
63.325	85.0	6.02	165.20	74,145.07	106.77	0.012	27.42	1.88
65.1875	87.5	6.11	171.56	77,000.94	110.88	0.012	28.09	1.87

Table 2
Honeywell Inc.
Upper Harbor Brook IRM
Manning's Hydraulic Analysis (Proposed Conditions)

Flow Depth (inches)	% Full Depth	Flow Velocity (ft/sec)	Flow Rate (cfs)	Flow Rate (gpm)	Flow Rate (MGD)	n-value	Flow Area (sf)	Hydraulic Radius (ft)
67.05	90.0	6.18	177.38	79,615.31	114.65	0.011	28.70	1.85
68.9125	92.5	6.24	182.43	81,878.60	117.91	0.011	29.24	1.82
70.775	95.0	6.27	186.28	83,608.92	120.40	0.011	29.71	1.78
72.6375	97.5	6.25	188.09	84,418.68	121.56	0.011	30.07	1.72
74.5	100.0	5.98	181.16	81,308.80	117.08	0.011	30.27	1.55

Table 3
Honeywell Inc.
Upper Harbor Brook IRM
Hazen Williams Hydraulic Analysis

Existing Conditons

Hf = (10.44)(L)((GPM^1.85)/((C^1.85)(D"^4.8655))) 0.0252

L	257.0	FT			
MGD	121.56		**GPM =**	**84,416.7**	
C	100.0		**CFS =**	**188.09**	
D	78.0	IN			
D	6.50	FT			
			A =	**33.17**	**SF**
	2,683.1	10.44 X L	**Q =**	**AV**	
			V =	**5.67**	**FPS**

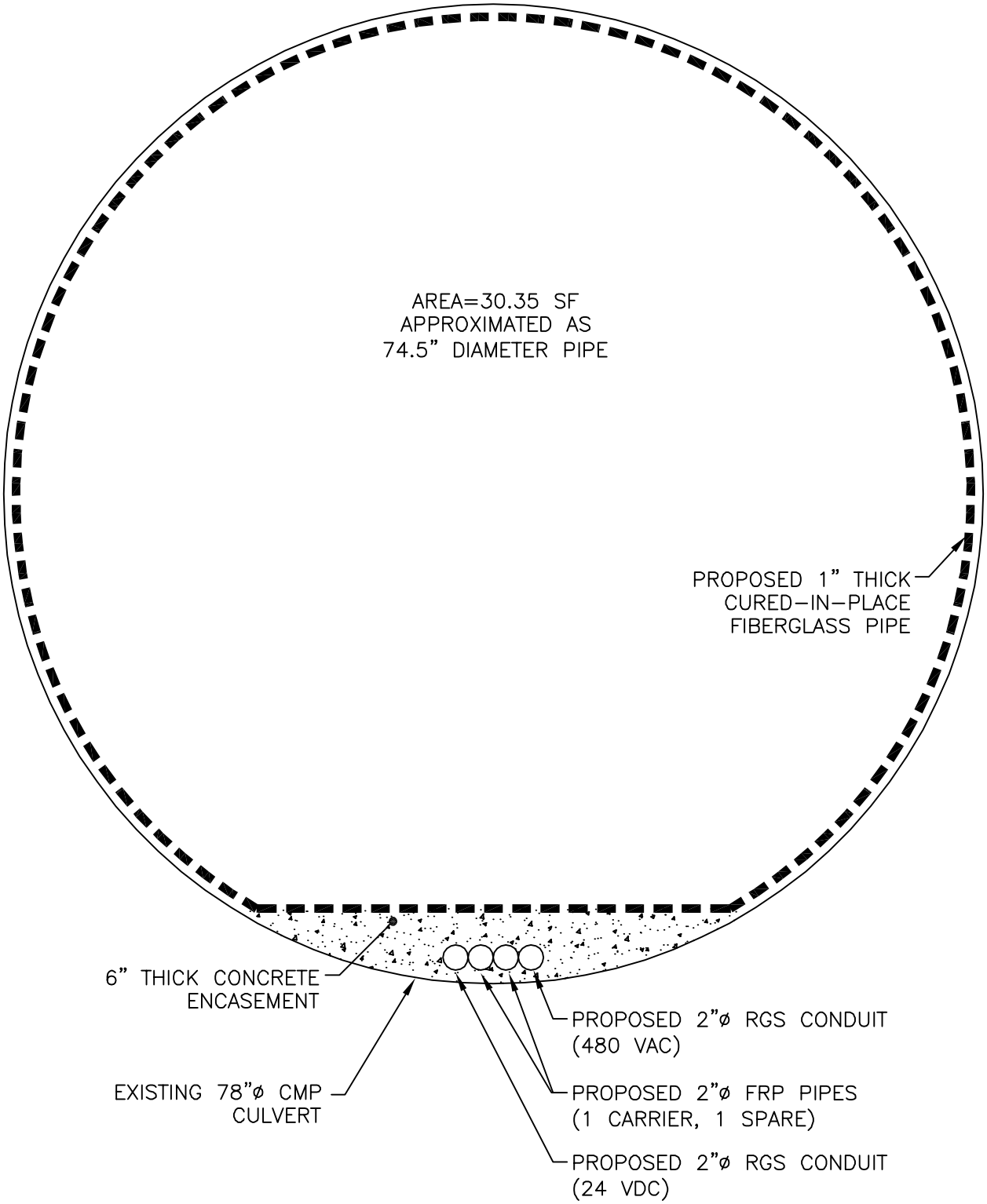
Hf (fric loss)=	**0.43**	FT
	0.19	PSI

Proposed Conditions

Hf = (10.44)(L)((GPM^1.85)/((C^1.85)(D"^4.8655))) 0.0252

L	257.0	FT			
MGD	121.56		**GPM =**	**84,416.7**	
C	120.0		**CFS =**	**188.09**	
D	74.5	IN			
D	6.21	FT			
			A =	**30.26**	**SF**
	2,683.1	10.44 X L	**Q =**	**AV**	
			V =	**6.22**	**FPS**

Hf (fric loss)=	**0.39**	FT
	0.17	PSI



SECTION

SCALE: 1"=1'

O'BRIEN & GERE

2007 © O'Brien & Gere Engineers, Inc.

PROPOSED CULVERT CROSS SECTION

FILE NO.	1163.46096
DATE	SEPTEMBER 2010
DWG NO.	FIGURE 1

Restoration Plan

FINAL DESIGN REPORT

Upper Harbor Brook IRM
Appendix L – Restoration Plan

Honeywell

March 2012

O'BRIEN & GERE

TABLE OF CONTENTS

List of Tables ii
List of Sheets (Bound Separately) ii
1. Introduction 1
1.1 Site Definition 1
1.1.1 Wastebed B/Harbor Brook Site 1
1.1.2 Upper Harbor Brook Area 1
1.2 Project Background 1
1.3 Restoration and Stabilization Goals 2
2. Existing Conditions 4
2.1 Landscape Context 4
2.2 Natural Features 4
2.3 Anthropogenic Features 5
2.4 Remedial Activites 6
3. Stabilization Approach for Adjacent Areas 8
3.1 Target Communtiy – Successional Old Field 8
3.1.1 Ecological Considerations 8
3.1.2 Site Preparation and Plant Installation 8
4. Restoration Approach for Wastebed D/E Adjacent Areas 10
4.1 Target Community – Floodplain Forest 10
4.1.1 Ecological Considerations 10
4.1.2 Site Preparation and Plant Installation 10
5. Wetland Restoration Approach 11
5.1 Target Communities 11
5.1.1 Ecological Considerations 12
5.1.2 Site Preparation Plant and Installation 12
6. Upper Harbor Brook and Ditch Restoration 14
6.1 Brook and Ditch Bank Target Community – Successional Shrubland 14
6.1.1 Ecological and Engineering Considerations 14
6.1.2 Site Preparation and Plant Installation 14
6.2 In-Stream Habitat 14
7. Restoration Operations Maintenance and Monitoring (OM&M) Plan Outline 16
References 17

LIST OF TABLES

L-1 Successional Old Field Seed Mix
L-2 Seed Mix to Accompany Floodplain Forest and Successional Shrubland Plantings
L-3 Floodplain Forest Plant Mix
L-4 Wet Meadow Plant Mix—Freshwater Species
L-5 Wet Meadow Seed Mix
L-6 Wet Meadow Plant Mix—Salt Tolerant Species
L-7 Shrub Swamp Plant Mix
L-8 Red Maple-Hardwood Swamp Plant Mix
L-9 Successional Shrubland Plant Mix

LIST OF SHEETS (BOUND SEPARATELY)

G-39 Sediment and Vegetation Removal Plan
G-40 Vegetation Restoration Plan

1. INTRODUCTION

This Restoration Plan presents the aquatic, upland and wetland restoration design and methods that will be used to restore areas of Upper Harbor Brook impacted by the construction of the Wastebed B/Harbor Brook Interim Remedial Measure (IRM). The Final Design Report was prepared pursuant to Consent Order #D-7-008-01-09 between the New York State Department of Environmental Conservation (NYSDEC) and Honeywell International, Inc. (Honeywell) dated December 15, 2003 (NYSDEC 2003). The Final Design Report was also prepared in accordance with Section 3.7.1 of the *Wastebed B/Harbor Brook IRM Final Work Plan* (O'Brien & Gere 2004) that was approved by the NYSDEC on August 25, 2004, and the *Engineering Evaluation/Cost Analysis* (EE/CA) (O'Brien & Gere 2010). The EE/CA was determined to be acceptable for the NYSDEC to move forward with the *Proposed Response Action Document* (PRAD, NYSDEC 2010).

This Restoration Plan was prepared in response to NYSDEC comments on the 95% Design Report submittal (NYSDEC 2011a) and finalized following a second round of comments (NYSDEC 2011b).

1.1 SITE DEFINITION

1.1.1 Wastebed B/Harbor Brook Site

The Wastebed B/Harbor Brook Site is located on the border of the City of Syracuse and the Town of Geddes, and is proximate to Onondaga Lake's southwest shoreline. Harbor Brook lies along the eastern border of the Wastebed B/Harbor Brook Site. The Wastebed B/Harbor Brook Site initially consisted of four areas:

1. Harbor Brook
2. Lakeshore Area (including Wastebed B, the East Flume, Dredge Spoils Areas (DSA) #1 and #2, wetlands along the lakeshore, and the Route I-690 Drainage Ditch)
3. Penn-Can Property
4. Railroad Area

The SYW-12 Area (north of Onondaga Creek) was added to the Wastebed B/Harbor Brook Site during the supplemental remedial investigation. Additional areas of study (AOS #1 and AOS #2) east of Harbor Brook were subsequently added at the request of the NYSDEC.

1.1.2 Upper Harbor Brook Area

This Restoration Plan addresses only the Upper Harbor Brook portion of the site which includes:

- areas associated with Upper Harbor Brook from the Floatable Control Facility to the downstream extent of Open Water area #1
- areas associated with the I-690 Drainage Ditch and a wetland delineated in the southwestern portion of the Lakeshore Area (WL6)
- areas associated with the Penn-Can Drainage Ditch and wetlands delineated in the southern portion of the Penn-Can Property (WPC1 to WPC3)
- areas associated with the Railroad Drainage Ditches #1 and #2 and wetlands delineated on the central and southern portions of the Railroad Area (WRR1 to WRR5)
- areas associated with the Wastebed D/E Drainage Ditch.

1.2 PROJECT BACKGROUND

The Record of Decision (ROD) for the Onondaga Lake Bottom site (NYSDEC and USEPA 2005) notes that "the control of contamination migrating from…upland sub-sites to Onondaga Lake is an integral part of the overall remediation of Onondaga Lake." The ROD also acknowledges the need to coordinate the timing of the remedial work related to the lake bottom with the work that is performed as part of the remedies at the upland sites.

These key elements of the ROD reflect that Onondaga Lake is part of a watershed that includes creeks, rivers, wetlands, and floodplains that discharge to the lake. Achieving the goals of the ROD and the community's vision of a restored Onondaga Lake requires addressing these components of the watershed.

Wastebed B consists primarily of inorganic wastes resulting from the production of soda ash using the Solvay process. In addition, the Penn-Can portion of the site was formerly used for the production and storage of asphalt products consisting mainly of asphalt, coal tar, caustic soda and muriatic acid. Available information suggests that these products were disposed of at this site and/or leaked into the soil. This deposition may provide sources or potential sources of pollution to Onondaga Lake and Harbor Brook.

The Upper Harbor Brook IRM consists of a shallow ground water collection and conveyance system; sediment removal and restoration of wetlands, ditches and select reaches of Harbor Brook; and membrane liner installation in select areas. These measures are described in detail in the Final Design Report and are discussed in sufficient detail in Section 2.4 in this Restoration Plan.

Because the final site remedy has not been designed, this restoration plan draws a distinction between two different areas impacted by the IRM project:

1. Areas directly associated with the IRM which include wetlands, ditches, and Harbor Brook reaches.
2. Adjacent Areas impacted by clearing, grubbing, temporary road construction or other site activities that disturb existing vegetation or destabilize soils. These areas (herein called "Adjacent Areas") will likely be impacted by activities associated with installing a final site remedy to be installed subsequent to the IRM. Therefore, these Adjacent Areas will be temporarily stabilized as part of the IRM and will receive final restoration as part of the final site remedy. Stabilization efforts will include planting of native species and communities providing ecological benefits to the site in the time period between the completion of the IRM and the implementation of the final site remedy. There is one exception to this stabilization approach. Namely on Wastebed D/E, Adjacent Areas impacted by site work will be targeted for restoration because subsequent impacts to installed vegetation are not anticipated. Site work following IRM installation on Wastebed D/E will be considered restoration and, as such, will have different vegetation goals than stabilization (goals detailed in the next subsection).

1.3 RESTORATION AND STABILIZATION GOALS

Two general types of activities are proposed to occur after the installation of the shallow ground water collection and conveyance system is installed and the sediment is removed from Harbor Brook, site ditches and wetlands:

1. Restoration
2. Stabilization

Site wetlands, ditches, and Harbor Brook banks, and areas impacted by the clearing and grubbing of Wastebed D/E will be targeted for restoration. The general goal of restoration is to recreate the following community types where appropriate:

- Floodplain forest
- Wet meadow (freshwater and salt tolerant variants)
- Shrub swamp
- Red maple-hardwood swamp
- Successional shrubland

To the extent practicable, Edinger *et al*. (2002) was used to guide target community design. In restoration areas, the goal is 85% relative cover of native species attained after installation of restoration measures. In addition, wetland restoration areas will be re-delineated after restoration measures as a part of site operations, maintenance, and monitoring (OM&M) to evaluate that no net loss of wetland function and value has occurred

due to IRM or restoration measures. However, Honeywell will not be responsible for mitigating losses of wetland or other habitat due to the actions/inactions of property owners, *e.g.* filling of wetlands and ditches as described in Section 2.2.

Adjacent Areas identified for stabilization will be seeded with native species that are consistent with successional old field habitat. A goal of 80% vegetative cover will be specified in accordance with the NYSDEC State Pollutant Discharge Elimination System (SPDES) general permit for storm water discharges from construction activities (GP-0-10-001).

This Restoration Plan presents:

- the proposed methods for initiating vegetation development towards meeting these goals, and
- an outline of proposed OM&M measures.

A forthcoming submittal will present an OM&M plan for the site.

2. EXISTING CONDITIONS

2.1 LANDSCAPE CONTEXT

The site is located in an urban context presenting multiple barriers (*e.g.*, I-690, Hiawatha Blvd., railroads) for plant and animal dispersal to or from the site. Therefore, opportunities to improve the upland habitat connectivity between Upper and Lower Harbor Brook will be presented, though the efficacy of these efforts is substantially limited by I-690. In general, the current natural value of the site is limited (O'Brien & Gere 2011b), largely as a result of past and current land uses.

Due to the urban, relatively isolated location of the site, and observations suggesting that white-tailed deer (*Odocoileus virginianus*) densities are relatively low, deer browse is not anticipated to significantly impact survivorship of woody species on-site.

Penn-Can Property

The Penn-Can Property is presently used by Spano Container Corporation for the storage of equipment. The area is approximately 1,600 feet (ft) wide (east to west) and 450 ft deep (north to south) and consists of buildings, above ground storage tanks, and a gravel parking lot, with limited vegetation around the periphery of the area. A shallow drainage swale (Penn-Can Drainage Ditch) runs along the southern and eastern perimeter of the property.

Railroad Area

The Railroad Area is presently owned and actively used by CSX Corporation Inc., a rail-based transportation service, and is situated to the south of the Penn-Can Property. The area is primarily vacant land with multiple rail tracks and sparse vegetation. Drainage ditches flowing east towards Harbor Brook are located on the central and southern portions of the property. The Railroad Area is bound on all sides by rail tracks. The area is approximately 1,400 ft wide (east to west) and 400 ft deep (north to south).

Wastebed D/E

AOS #2 is situated east of Harbor Brook and south of I-690 between Harbor Brook and the western dike of Wastebeds D/E. AOS #2 consists of the western end of Wastebeds D/E and the northeastern side of the Wastebed D/E Drainage Ditch. Currently, the eastern end of Wastebeds D/E is occupied by multiple car dealerships; however, the portion near Harbor Brook is generally undeveloped and vegetated with a mix of herbaceous and woody species. The area is approximately 1,900 ft wide (east to west) and 650 ft deep (north to south).

2.2 NATURAL FEATURES

Upper Harbor Brook

Harbor Brook originates southeast of Syracuse, New York, in the Town of Onondaga and flows through the western side of Syracuse passing Wastebeds D/E. It discharges to the southwest corner of Onondaga Lake adjacent to the eastern end of Wastebed B. Harbor Brook drains a watershed of approximately 13.2 square miles (Blasland & Bouck 1989). According to USGS data, the 10 year and 20 year average flow rate is approximately 11.5 cubic feet per second. Harbor Brook is most consistent with the description of confined river (Edinger *et al.* 2002), *i.e.*, an aquatic community of fast flowing water with moderate to gentle gradient. Although Harbor Brook is considered a natural water course, it has been channelized along much of its course through the developed areas of Syracuse and the site. Upper Harbor Brook is classified as a Class C stream by the NYSDEC.

Vegetative communities observed by O'Brien & Gere (2008) along the banks of Harbor Brook at the site and in a portion of AOS #2 were floodplain forest and successional shrubland (Edinger *et al.* 2002). Dominant species observed in the floodplain forest areas included Virginia creeper (*Parthenocissus quinquefolia*), common buckthorn (*Rhamnus cathartica*), box elder (*Acer negundo*), and ground ivy (*Glechoma hederacea*). Wildlife observed in and along the banks of Harbor Brook, primarily adjacent to Onondaga Lake, included mallard (*Anas platyrhynchos*), great blue heron (*Ardea herodias*), green heron (*Butorides striatus*), common carp (*Cyprinus carpio*), and muskrat (*Ondatra zibethicus*) (O'Brien & Gere 2011b).

Much of Upper Harbor Brook is culverted as it runs through the site, except for daylighted reaches referred to as Open Water (OW) areas 1 through 5 having approximate lengths of 94, 29, 240, 91, and 221 feet respectively.

Delineated Freshwater Wetlands

As described in O'Brien & Gere (2003), nine wetlands are located within the project site (**Sheet G-3**). One wetland is associated with the I-690 Drainage Ditch (WL6), three are associated with the Penn-Can Drainage Ditch (WPC1 to WPC3), two are associated with Railroad Drainage Ditch #1 (WRR1 and WRR2), and three are associated with Railroad Drainage Ditch #2 (WRR3, WRR4, and WRR5). Wildlife observed in the vicinity of delineated wetland areas included mallard, green heron, red-winged blackbird (*Agelaius phoeniceus*), belted kingfisher (*Megaceryle alcyon*), ring-billed gull (*Larus delawarensis*), white-tailed deer, and eastern cottontail (*Sylvilagus floridanus*) (O'Brien & Gere 2011b).

Wetland WL6

Wetland WL6 is located at the eastern end of the I-690 Drainage Ditch, and is approximately 0.35 acres in size (O'Brien & Gere and Parsons 2010). Abrupt rises in topography (*i.e.,* the embankment of Route 690 and the berm of Wastebed B) define the southern and northern borders of the wetland, respectively. WL6 is vegetated primarily with common reed (*Phragmites australis*) and purple loosestrife (*Lythrum salicaria*). Wetland hydrology was indicated via the presence of inundation and saturated soils within 12 inches of the ground surface. This area receives runoff from the I-690 embankment and discharges from the I-690 Drainage Ditch. Portions of this wetland are periodically disturbed by the New York State Department of Transportation (NYSDOT) as part of their routine roadside ditch maintenance activities that entail the clearing of excess sediment and vegetation in the ditch to improve and direct surface water flow away from the highway.

Penn-Can Property Wetlands WPC1 to WPC3

These wetlands are adjacent to the Penn-Can Drainage Ditch running along the southeastern boundary of the Penn-Can Property. It appears that the wetlands are actively being filled by adjacent commercial operations. The three Penn Can wetland areas totaled approximately 0.89 acres prior to the ongoing addition of construction debris and fill. Site observations made by O'Brien & Gere during a March 2010 site reconnaissance revealed that portions of WPC1, WPC2, WPC3, and the Penn-Can Drainage Ditch have been filled such that the total wetland acreage has been reduced to approximately 0.447 acres and Figure 11 of the Final Design Report does not reflect the current extent of the Penn Can wetlands. In general, wetland hydrology was indicated via the presence of saturation within 12 inches of the ground surface. These wetlands are primarily vegetated by common reed, spotted Joe-pye weed (*Eupatoriadelphus maculatus*), eastern cottonwood (*Populus deltoides*), and purple loosestrife (O'Brien & Gere 2003). The substrate consisted of saturated fill and Solvay waste.

Railroad Area Wetlands WRR1 to WRR5

Railroad Area wetlands WRR 1 to WRR5 are approximately 0.046, 0.21, 1.21, 0.19, and 0.04 acres in size, respectively. These wetlands likely formed as a result of sedimentation buildup in culverts causing water to back up against the railroad embankments. Vegetation primarily consists of common reed, willow species (*Salix* spp.), purple loosestrife, box elder, and eastern cottonwood. Wetland hydrology was indicated by soil saturation within 12 inches of the ground surface (O'Brien & Gere 2003).

Uplands

Successional northern hardwoods, floodplain forest and successional shrublands exist on-site interspersed with herbaceous, disturbed areas and are described in Appendix F of the Final Design Report. In general, uplands are low quality, dominated by non-native or invasive species such as buckthorn and tatarian honeysuckle (*Lonicera tatarica*). The abundance of low quality habitat is likely the result of this site's urban context, history of on-site and adjacent industrial use, and poor soils composed of fill and Solvay waste.

2.3 ANTHROPOGENIC FEATURES

Site soils

Boring logs for the site (O'Brien & Gere 2007) indicate that the soils on site are generally poor for plant growth, *i.e.*, embankment materials and low chroma, compacted soils ranging from sand to silt. In general, Solvay waste

layers are present at a depth of 2 to 5 feet; however, visual observations suggest that waste has mixed with surface soils, likely impacting its fertility.

I-690 Drainage Ditch

The I-690 Drainage Ditch is situated to the north and parallel to the westbound lane of I-690 on the southeastern portion of the Lakeshore Area. The ditch is maintained as a drainage feature by the NYSDOT (O'Brien & Gere 2001). The ditch flows west to east, and discharges to Harbor Brook at OW#1. Near the midpoint, an outfall from the storm drainage system beneath I-690 discharges to the ditch. The substrate of the Drainage Ditch primarily consists of weathered Solvay waste. This ditch is likely to be heavily impacted by road salt application to I-690. A reed grass/purple loosestrife marsh community (RG/PL) was observed in portions of the ditch (O'Brien & Gere 2008).

Penn-Can Drainage Ditch

The Penn-Can Drainage Ditch is situated to the south of I-690 and consists of a shallow drainage swale that runs along the southern and eastern perimeter of the property. The I-690 bridge replacement construction that occurred in 2009 altered the route of the ditch, and the substrate was replaced with railroad ballast material up to the bridge abutment. The lower portion of the ditch intermittently flows east along the railroad access path and discharges into Upper Harbor Brook at OW#2. A mixture of RG/PL with a stand of dogwood species (*Cornus* spp.) and RG/PL with successional northern hardwoods communities were observed in areas associated with the Penn-Can Drainage Ditch. Dominant species include gray dogwood (*Cornus racemosa*), common reed, common buckthorn, and eastern cottonwood (O'Brien & Gere 2008).

Railroad Drainage Ditches #1 and #2

There are two Drainage Ditches designated as Railroad Drainage Ditch #1 and #2 located on the central and southern portions of the Railroad Area, respectively and south of the Penn-Can Drainage Ditch. The ditches intermittently flow east and discharge into Upper Harbor Brook at OW#3 and OW#4, respectively. A successional shrubland community was observed in areas of Railroad Drainage Ditch #1. Dominant species observed included willow species (*Salix* spp.), clasping-leaved dogbane (*Apocynum cannabinum*), common reed, and purple loosestrife. A mixture of RG/PL and successional northern hardwoods communities were observed within areas of Railroad Drainage Ditch #2. Dominant species observed included common reed, Canada goldenrod (*Solidago canadensis*), ground ivy, summer grape (*Vitis aestivalis*), and box elder (O'Brien & Gere 2008).

Wastebed D/E Drainage Ditch

The Wastebed D/E Drainage Ditch appears to have been designed as a storm water drainage feature for I-690 and is maintained by the NYSDOT. The drainage ditch parallels the eastbound lane of I-690 adjacent to Wastebeds D/E. The ditch intermittently flows east to west for approximately 1,950 feet from Hiawatha Boulevard to Upper Harbor Brook where it discharges into OW #3. The substrate of the drainage ditch primarily consists of weathered Solvay waste. Successional shrubland currently exists along the banks of the Wastebed D/E Drainage Ditch (O'Brien & Gere 2008). Dominant species observed included Virginia creeper, Canada goldenrod, dogwood species, common buckthorn, field sowthistle (*Sonchus arvensis*), and tatarian honeysuckle .

2.4 REMEDIAL ACTIVITES

The Upper Harbor Brook IRM consists of a shallow ground water collection and conveyance system; sediment removal and restoration of wetlands, ditches and select reaches of Harbor Brook; and membrane liner installation in select areas. In order to construct this project, clearing and grubbing, and temporary road installation will occur. The approximate spatial extents of the IRM impacts to the site are shown on **Sheet G-39** and each impact is described in the following sub-sections.

Sediment Removal and Replacement

Wetlands – Sediments in wetlands will be removed to a depth of 2 feet. Following sediment removal, two soil layers will be installed: a 20% clay layer compacted to one foot depth overtopped by one foot layer (not compacted) comprised of silt loam with moderate pH (4.5 to 6.5) and organic matter concentration (minimum of

4%). The clay layer will be compacted to a maximum hydraulic conductivity of 1 x 10^{-7} cm/sec in order create an aquitard. Since the wetlands on site are dominated by invasive species, this soil replacement (as well as soil replacement in select ditches) represents a significant ecological enhancement to the site by removing a soil bank with abundant rhizomes and seeds of invasive species.

Ditches and Harbor Brook – Soils and sediments in ditches and select Harbor Brook reaches will be removed to various depths, ranging from 2 to 8 feet, and replaced with embankment material/select fill (type J or K river stone) to approximately the shoulder of the bank where 6 inches of silt loam and embankment material will be placed (**Sheets G-35 to G-38**). In the I-690 ditch, OW #1 through OW #4, and a portion of the Wastebed D/E ditch, a liner will be placed prior to soil installation. In areas where ditches intersect with wetlands, soils specified for wetlands will be used in lieu of river stone.

Groundwater Collection

Groundwater collection trenches will intersect wetlands WL6 and WRR1 (**Sheet G-3**). While these trenches may result in reduced groundwater discharge to these wetlands, long term wetland functions and values are not considered to be at risk due to placement of a low permeability clay layer following sediment/soil removal and specification of wetland species with relatively low moisture sensitivity. Further, site observations suggest that these wetlands are largely driven by surface water runoff from adjacent berms and water backed up from clogged culverts, likely limiting the importance of groundwater discharge to wetland hydrology.

Clearing and Grubbing/Temporary Road Installation

Approximately 2.86 acres of the site will be impacted by clearing and grubbing of adjacent areas or temporary road installation. Besides vegetation removal, these activities will result in soil compaction, and rutting. A variety of site preparation measures (outlined in Section 3.1.2) will be used to stabilize soil surfaces and increase the likelihood of successful vegetation establishment.

During clearing and grubbing, removal of woody vegetation will be avoided and existing roads used to the extent practicable. Though NYSDEC comments dated January 25, 2011 suggest leaving woody species roots in place to the extent practicable, it is proposed that the roots be raked and tilled to remove invasive species (*e.g.,* buckthorn) root stock from site soils. Large trees (greater than 8 inches diameter breast height [DBH]), if removed, will be stockpiled for later use as habitat features in restored wetlands.

3. STABILIZATION APPROACH FOR ADJACENT AREAS

3.1 TARGET COMMUNTIY – SUCCESSIONAL OLD FIELD

A successional old field community will be installed as the stabilization approach in areas impacted by clearing, grubbing and/or temporary road construction (except on Wastebed D/E; see Section 4). Approximately 2.86 acres of the site are anticipated to be stabilized using this successional old field design (**Sheet G-40**).

3.1.1 Ecological Considerations

Plant selection – Successional old field species (**Table L-1**) were selected based on anticipated ability to tolerate the low quality topsoil, embankment material, and Solvay waste present on-site. Because increased functional diversity in plant communities generally leads to increased ecological function (Hooper and Vitousek 1998), the mix includes species with a variety of life history characteristics such as annuals, short lived perennials, long-lived perennials, herbaceous species and woody species. For example, approximately forty five percent of the mix (by weight) comprises fast-establishing species (*e.g., Elymus canadensis, Avena sativa*) which will provide short term soil stabilization and preemption of non-native and invasive species while longer-lived species develop. Though areas impacted by clearing and grubbing are considered to be in an upland setting, plants may be subject to temporarily elevated water tables due to the proximity of the site to Onondaga Lake and Harbor Brook. Therefore species were selected in light of the potential for periodic stresses due to oxygen deficiency in soil.

Schedule – Seeding for stabilization or restoration will be performed during two seasonal windows: mid-April to early June or from late October through November. Seeding during July or August risks poor stand establishment due to moisture limitation, while seeding during September or early October risks poor stand establishment due to limited plant growth prior to season-ending frosts. Seeding in late October/November is a viable option for permanent seeding because soil and air temperatures are typically reduced relative to times earlier in the fall. Hence seeds remain dormant through the winter and germinate when conditions allow the following spring. If site soils require seeding at times outside of the preferred seasonal windows, they will be temporarily seeded and mulched using 100 pounds per acre of oats (*Avena sativa*) and 2 tons per acre of straw.

Landscape context –This community type will be restored on both sides of the I-690 overpass which will likely result in habitat connectivity improvements between Upper and Lower Harbor Brook in comparison to current site conditions.

3.1.2 Site Preparation and Plant Installation

Following clearing and grubbing, the general stabilization approach will consist of (in this order) removing coarse soil debris, tilling, seeding, fertilizing, tracking, and mulching. Details are provided below.

Coarse debris removal will be performed using a Harley rake or equivalent to facilitate use of agricultural equipment for restoration work, assist in seedbed preparation, and increase worker safety (reduced tripping hazards). Tilling to a depth of 4 to 6 inches will be performed using a Bobcat tiller or equivalent to break up clods of soil, prepare the seedbed, and smooth ruts. Prior to tilling, the abundance of non-target species will be qualitatively assessed. If the assessment suggests that substantial germination of non-target species will occur after tilling (*e.g*., buckthorn emergence from the seed bank), a two to three week waiting period will occur after tilling. The waiting period will allow for non-target species to germinate. These species will then be eradicated by using NYSDEC approved herbicides at manufacturer-specified rates. This approach will allow for elimination of non-target species prior to introduction of target species, and increase the chances of vegetation stand establishment with the minimum proportion of non-target species.

Seed and fertilizer (10% nitrogen, 2% phosphoric acid, and 10% potash [10-2-10], pelletized) will be applied by broadcasting at 60 and 450 pounds per acre, respectively. Fertilizer that includes phosphorus is needed as the site soils are impacted by Solvay waste which is highly phosphorus deficient (Hewlett 1954, Michalenko 1991, Eallonardo 2010). Tracking will be performed using the tracks of a bulldozer (or equivalent) running

perpendicular to the slope gradient to increase seed/soil contact, improving germination and stand establishment. Following seed tracking, straw mulch (or equivalent) will be applied 1 to 1.5 inches thick.

Watering of herbaceous species installed for stabilization or restoration will occur if 0.25 inches of precipitation is not received in any seven-day window from June through August in the year of seed (or plant) installation. In wetlands, watering will not be performed if soils remain moist and plants are showing no signs of moisture stress.

4. RESTORATION APPROACH FOR WASTEBED D/E ADJACENT AREAS

4.1 TARGET COMMUNITY – FLOODPLAIN FOREST

Approximately 1.24 acres of Wastebed D/E currently inhabited by woody species will be targeted for floodplain forest restoration (**Sheet G-40**).

4.1.1 Ecological Considerations

In general, the considerations for this section are similar to those presented in Section 3.

Plant selection –Floodplain tree species (*e.g*., eastern cottonwood, American elm [*Ulmus americana*], green ash [*Fraxinus pennsylvanica*], red maple [*Acer rubrum*], and hackberry [*Celtis occidentalis*]) are tolerant of wide-ranging soil fertility and moisture conditions (Hardin *et al*. 2001) suggesting that they will be ideal for establishment and growth in the poor soils present on site. This approach is further supported by the current abundance of another floodplain species, box elder, across the site (Appendix F, Section 2 in the Final Design Report). To simulate the successional process leading to floodplain forest, the plant mix (**Table L- 3**) includes shrub and tree species with varied growth rate, form, and mature height. A companion seed mix comprising quick establishing species will be applied after tree installation to assist in soil stabilization and preemption of non-target species.

Between the seed and plant mixes (**Tables L-2** and **L-3**, respectively) 25 species will be introduced. The species encompass a range of functional groups facilitating improved short and long term performance of the restored community. The seed mix will be applied at a rate of 40 pounds per acre. Plants shall be 12-inch diameter pots (unless otherwise specified in **Table L-3**), planted on 4- or 8-foot centers for shrubs and trees, respectively. Planting potted stock will occur from mid-April to early June or from September through December.

4.1.2 Site Preparation and Plant Installation

Site preparation measures similar to those described in Section 3.1.2 will be used in floodplain forest restoration, with the following exceptions:

- Soil tracking will occur before tree installation and seed broadcasting. Ideally, tracking occurs after seed broadcasting (Dickerson *et al*. 1997); however, the microtopography provided by the track marks will still facilitate germination by collecting moisture and fine soil. This modified order is proposed for the floodplain forest restoration because tree planting was desired to occur prior to seed broadcast to avoid haphazardly disturbing the soil once it has been seeded.
- Approximately 100 grams of slow-release 10-2-10 fertilizer will be placed in each planting hole to facilitate establishment of woody potted stock.
- Watering of woody species will occur if one inch of rain is not received during any seven-day window from June through August in the year of plant installation.

5. WETLAND RESTORATION APPROACH

5.1 TARGET COMMUNITIES

Following sediment removal and, where relevant, groundwater collection trench and membrane liner installation, the following wetland types will be targeted for restoration:

Wet meadow

This target community is similar to shallow emergent marsh (as described in Edinger *et al.* 2002) with the exception that flooding depths are not expected to exceed 2 feet (O'Brien and Gere 2003 and 2007). Wetland conditions are expected to be primarily driven by saturated soils within 12 inches of the soil surface. The species complement will focus on those that are relatively intolerant of prolonged, deep flooding in comparison to some (*e.g., Typha* spp.) included in the Edinger *et al.* (2002) description of shallow emergent marsh. Approximately 0.98 acres of wetland will be restored to wet meadow. Primary vascular plant species targeted for specific areas were selected based on conditions therein.

Freshwater conditions

Railroad Wetland WRR1, WRR2 and part of WRR3 (totaling 0.63 acres) that is relatively low in elevation will be targeted (**Sheet G-21, G-40**). The wetland plant mix (**Table L-4**) will comprise 22 species encompassing a range of functional groups. The accompanying seed mix (**Table L-5**) will be applied at a rate of 30 pounds per acre and will consist of ten species. Species that germinate and establish easily were selected for the seed mix while species that are relatively difficult to establish from seed were selected for the plant mix. This combined approach takes advantage of the strengths of the particular target species, with seeded species providing short term cover and invasive species pre-emption and planted species providing quick establishment of robust wetland perennials offering habitat structure. The wet meadow seed mix includes species that are relatively salt tolerant and will also be used to complement the plantings in the salt tolerant wet meadow (described below). Primary vascular plant species targeted in freshwater wet meadow restoration are bluejoint (*Calamagrostis canadensis*), fox sedge (*Carex vulpinoidea*), soft rush (*Juncus effusus*), Joe-pye-weed and bonset (*E. perfoliatum*).

Saline conditions

Wet meadow restoration is also targeted in Wetland WL6 (0.35 acres). However the target species mix is modified to account for loading of saline runoff from the I-690 ditch. While many of the species specified for planting are also found in inland salt marshes, this restoration target is not called "inland salt marsh" because the long term intent will not be to maintain inland salt marsh vegetation as described in Eallonardo (2010), but to simply maintain a productive wetland community comprising native species. It is anticipated that installing salt tolerant plants will be an appropriate approach to meeting this objective; however, natural vegetation dynamics over time may lead to a different native species composition than what was planted.

In combination with the wet meadow seed mix (**Table L-5**); eight herbaceous, salt-tolerant species will be installed as 2-inch plugs (**Table L-6**). The primary target species is prairie cord grass (*Spartina pectinata*). This species is present in inland salt marshes and has performed well under a variety of conditions on the wastebeds (Eallonardo 2010). As with the other mixes described in this Restoration Plan, the species list has been biased towards relatively robust, aggressive native species in an attempt to compete as effectively as possible with invasives.

Shrub swamp

Approximately 0.64 acres of wetland (WPC1, WPC2, WPC3 and WRR4) will be restored to a shrub swamp community. This wetland type is expected to have shorter flooding durations than those targeted for wet meadow based on the current presence of buckthorn in these wetlands. As the wetland site work will match existing grades and these wetlands are not associated with groundwater collection, a substantial deviation from current hydrologic conditions is not expected. Flooding may be increased relative to existing conditions due to the installation of the clay substrate layer. If this increase occurs, relatively flood tolerant species (*e.g.,* button bush [*Cephalanthus occidentalis*]) included in the target mixes (**Tables L-5** and **L-7**) will be favored over time.

The plant mix (**Table L-7**) for the shrub swamp restoration consists of 10 species that are common to shrub swamps in Central New York and are tolerant of wide ranging hydrologic and soil conditions. They differ in mature height, form, and growth rate, facilitating development of complex habitat structure.

Red maple-hardwood swamp

Approximately 0.88 acres of wetland WRR3 (*i.e.,* the southern portion) will be restored to red maple-hardwood swamp. This area is relatively elevated and vegetated with box elder and eastern cottonwood, suggesting that the hydrology is appropriate for the woody species. To simulate the successional process leading from shrub swamp to red maple-hardwood swamp, the plant mix (**Table L-8**) includes 16 shrub and tree species, assuming that differences among species in mature height, growth rate, and shade tolerance facilitate the development of red maple-hardwood swamp structure over time. The wet meadow seed mix (**Table L-5**) will be broadcast after planting in order to vegetate soils between the woody plants.

5.1.1 Ecological Considerations

Hydrology – In each of the wetlands on-site, existing grades will be matched and a compacted clay layer will be installed (Section 2.4) such that the wetlands are hydrologically maintained or enhanced by precipitation and surface water runoff.

Wetlands WL6 and WRR1 may be affected by proposed groundwater collection trenches. While the trenches may reduce groundwater discharge to these wetlands, significant impacts to wetland functions and values are not anticipated. Site observations suggest that these wetlands are largely driven by surface water (*e.g.*, runoff from adjacent berms and water backed up from clogged culverts). In addition, a low permeability clay layer will be placed following sediment removal and facultative (likely to occur in wetlands or elsewhere) or other wetland species with relatively low moisture sensitivity (*e.g.*, salt tolerant species) will be specified.

Soils – Following sediment removal, two soil layers will be installed: a 20% clay layer compacted to one foot depth overtopped by one foot layer (not compacted) comprised of silt loam with moderate pH (4.5 to 6.5) and organic matter concentration (minimum of 4%). The clay layer will be compacted to a maximum hydraulic conductivity of 1×10^{-7} cm/sec in order create an aquitard. Fertilizer or other soil amendments will not be used in the wetlands as native wetland species are typically at a competitive advantage under relatively low fertility conditions.

Invasive species – Where anticipated wetland hydrology permits (*i.e.*, where periodic flooding is not too deep to kill saplings), swamps will be targeted to use shade as a mechanism to reduce the long term likelihood of common reed and purple loosestrife dominance. Following final grading, the wetlands will be allowed to sit for two to three weeks, allowing for non-target species to germinate. These plants will then be killed using an approved herbicide (herbicide is proposed instead of tilling because the soil mixing could bring viable seeds to the soil surface). Following herbicide application, target species will be introduced by planting and seeding.

Planting strategy – Similar planting/seeding strategies that are proposed for the floodplain forest restoration are also proposed for the wetland restoration. That is, fast germinating species are selected for the seed mix to develop short term cover while relatively difficult to establish or habitat specific species are included in the plant mixes. The same seed mix is proposed across these target communities because the range of species included is expected to provide adaptability to a range of hydroperiods such that species of varied flooding tolerance/requirements will sort out over time given the ultimate hydrology of each wetland. Specific plant mixes are proposed for subsets of the nine wetlands on site and are described in prior subsections.

5.1.2 Site Preparation Plant and Installation

Following soil placement and non-target species removal, areas targeted for shrub or red maple-hardwood swamp will be planted with 6 to 12 inch diameter potted stock (*i.e.,* the diameter of the pot; unless otherwise noted in **Tables L-7** and **L-8**) on 4 foot and 8 foot centers for each respective community type. Areas targeted for wet meadow will be planted with 2-inch (diameter) plugs on 2 foot centers. Following planting, seed will be applied (30 pounds per acre) by broadcasting and straw mulch (or equivalent) will be applied 1 to 1.5 inches thick.

Within each target community a "sculpted" (Dickerson *et al*. 1997) planting approach will be taken. Namely, plants will be installed with respect to each species' optimal moisture requirements. For example, in the salt tolerant wet meadow restoration, hardstem bulrush (*Schoenoplectus acutus*) will be planted at relatively low elevations while switchgrass (*Panicum virgatum*) will be planted at relatively high elevations.

6. UPPER HARBOR BROOK AND DITCH RESTORATION

6.1 BROOK AND DITCH BANK TARGET COMMUNITY – SUCCESSIONAL SHRUBLAND

A successional shrubland is a shrub-dominated plant community typically occurring after land clearing. The target species will tolerate the soils used as part of the IRM efforts and provide restoration in-kind of disturbed habitats. Approximately 1.05 acres of the site will be restored to successional shrubland (**Sheet G-40**).

6.1.1 Ecological and Engineering Considerations

Interaction with IRM facilities –Successional shrubland is proposed for the 5-foot wide (average) bank shoulders adjacent to Upper Harbor Brook and ditches shown on **Sheets G-35** to **G-38** (total length approximately 9,200 feet) due to the following:

- Adjacent Areas, described in Section 3, will not be managed until the final remedy is installed; therefore, a shrubby community will be less easily invaded by non-target species.
- Shrubs will provide some shading of Upper Harbor Brook and ditch waters while not reaching such sizes that liner integrity would be threatened by tip-ups or root growth.
- Shrub structure will complement the herbaceous structure of Adjacent Areas.
- Presence of larger woody vegetation on the Harbor Brook banks (*i.e.*, base flow elevation to bank shoulder) may negatively impact the IRM by entraining debris and increasing bank stresses during flood events.

Soil quality –Due to the placement of topsoil, stresses associated with the poor site soils are expected to be relieved. Shrubs (**Table L-9**) will be planted in a soil comprising 6 inches of topsoil and embankment material of various depths (**Sheets G-35** to **G-38**).

6.1.2 Site Preparation and Plant Installation

The same soil specification and installation approach as specified for wetland restoration will also be used in the successional shrubland restoration. Following soil placement and non-target species removal, the soil will be tracked. Plants (6 to 12-inch potted stock; unless otherwise specified in **Table L-9**) will be installed on 4 foot centers and the companion seed mix (**Table L-2**) broadcast as a complement at 40 pounds per acre. Straw mulch (or equivalent) will be applied 1 to 1.5 inches thick. Planting will occur from mid-April to early June or from September through December. Approximately 100 grams of slow-release 10-2-10 fertilizer will be placed in each planting hole to facilitate establishment of woody potted stock. Watering of woody species will occur if one inch of rain is not received during any seven-day window and with otherwise similar criteria as described in Section 3.1.2.

In areas where ditch or stream banks exceed a 1V:2H slope (1 foot vertical to 2 foot horizontal ratio), planting will not take place but seed will be broadcast. As noted in the Contract Drawings (**Sheet G-37**), these areas will be covered by biodegradable erosion control blanket instead of straw after seeding.

6.2 IN-STREAM HABITAT

In-stream structure will be added at OW#3, and OW#4 to provide habitat for fish and other biota potentially inhabiting Upper Harbor Brook. Structure was not added at OW#1 and OW#2 due to their relatively small size and, with regard to OW#5, due to inappropriate base material (limestone blocks).

Channel stability features such as cross vanes, log vanes, and rock weirs are generally applied in an effort to reduce or redirect stream velocity and erosive force. These features provide aquatic habitat as a secondary benefit. Because in-stream habitat is a primary concern in OW areas, in-flow boulders have been specified to provide aquatic structure without significantly impacting flow dynamics. The holding spots associated with localized flow patterns created by in-stream boulders will provide feeding and resting opportunities for fish. Boulders will be placed in a staggered pattern at a an approximate spacing of 10 ft and a minimum distance of 20 ft from existing stream structures (*e.g.,* culverts, ditch discharge points) and 5 ft from Harbor Brook banks. Boulders will be placed such that approximately two thirds of the vertical height of the boulder is below the finished creek bed to minimize the potential for movement. A biologist will be present during boulder placement

to identify preferred boulder locations based on bed conditions, flow velocity, and erosion potential. Boulders will range in size from 0.5 to 1 cubic yard, and 1 to 2 tons.

Biotechnical features such as root wads and log revetments have not been specified because of the potential for these features to collect debris that can alter flow and result in significant scour and erosion. Such impacts could interfere with the integrity of the stream bed and banks, and the performance of culverts and the IRM.

7. RESTORATION OPERATIONS MAINTENANCE AND MONITORING (OM&M) PLAN OUTLINE

Below are the components of the Upper Harbor Brook IRM restoration OM&M plan. Details of these components will evolve as the OM&M plan develops. The OM&M plan will be presented as part of the construction work plan.

1. Site Work
    a. Restoration
    b. Stabilization
2. Restoration Monitoring
    a. Stage 1 (short term)
        i. Year 0 performance metrics
    b. Stage 2 (long term)
        i. Years 0 through 4 [5 total years]—ecosystem structure and function metrics
            1. Hydrology
            2. Vegetation
            3. Wildlife
            4. Media sampling and analysis
            5. Wetland boundary delineation
3. Annual Reports
4. Maintenance and Adaptive Management Program
    a. Water maintenance (e.g., bypass pumping and irrigation in year of planting)
    b. Invasive species control
    c. Adaptive strategies

REFERENCES

Blasland & Bouck. 1989. *Hydrogeologic Assessment of the Allied Waste Beds in the Syracuse Area, Solvay, New York*. Blasland, Bouck & Lee, Syracuse, New York.

Dickerson, J., Burgdorf, D., Bush, T., and Miller, D. 1997. *Vegetating with Native Grasses in Northeastern North America*. USDA Natural Resource Conservation Service, Washington, D.C.

Eallonardo Jr., A. S. 2010. *Inland salt marsh ecology and the restoration of rare plant communities on a Solvay waste site: a functional approach.* Dissertation, State University of New York College of Environmental Science and Forestry, Syracuse, NY.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero (editors). 2002. *Draft Ecological Communities of New York State*. Second Edition. New York Natural Heritage Program. New York State Department of Environmental Conservation. Albany, New York.

Hardin, J.W., Leopold, D.J., and White, F.M. 2001. *Harlow and Harrar's Textbook of Dendrology*. McGraw Hill, Boston, MA.

Hooper, D.U., Vitousek, P.M. 1998. *Effects of plant composition and diversity on nutrient cycling*. Ecol. Monogr. 68:121-149.

Hewlett, J. D. 1956. *The development of vegetation on the Solvay waste beds.* State University of New York College of Forestry, Syracuse, NY.

Michalenko, E.M. 1991. *Pedogenesis and invertebrate microcommunity succession in immature soils originating from chlor-alkali wastes.* State University of New York College of Environmental Science and Forestry, Syracuse, NY.

New York State Department of Environmental Conservation (NYSDEC). 2011a. *Re*: *Upper Harbor Brook 95% Design Report.* NYSDEC. Albany, New York.

New York State Department of Environmental Conservation (NYSDEC). 2011b. *Re: Upper Harbor Brook Restoration Plan.* NYSDEC. Albany, New York.

NYSDEC. 2010. *Proposed Response Action Document, Interim Remedial Measure, Wastebed B/Harbor Brook Site, Subsite of the Onondaga Lake Site, Onondaga County, New York.* NYSDEC, Albany, New York.

NYSDEC. 2003. Consent Order Case No. #D-7-008-01-09 (Harbor Brook Investigation).

NYSDEC and USEPA. 2005. *Onondaga Lake Record of Decision*. NYSDEC, Albany, NY. USEPA, Washington, DC. July 1, 2005.

O'Brien & Gere. 2011a. *95% Design Report. Upper Harbor Brook Interim Remedial Measure. Wastebed B/Harbor Brook Site. Geddes and Syracuse, New York.* Prepared for Honeywell, Morristown, NJ. .

O'Brien & Gere. 2011b. *Baseline Ecological Risk Assessment. Wastebed B/Harbor Brook Site. Geddes and Syracuse, New York*. Prepared for Honeywell, Morristown, NJ. August.

O'Brien & Gere. 2010. *Engineering Evaluation/Cost Analysis. Harbor Brook Interim Remedial Measure. Wastebed B/Harbor Brook Site. Geddes and Syracuse, New York*. Prepared for Honeywell, Morristown, NJ.

O'Brien & Gere. 2008. *Upper Harbor Brook PDI - Vegetation Survey Memorandum. Wastebed B/Harbor Brook Site. Geddes and Syracuse, New York*. Prepared for Honeywell, Morristown, NJ.

O'Brien & Gere. 2007. *Revised Report. Remedial Investigation. Wastebed B/Harbor Brook Site. Geddes and Syracuse, New York.* Prepared for Honeywell, Morristown, NJ.

O'Brien & Gere. 2004. *Interim Remedial Measure. Wastebed B/Harbor Brook. Final Work Plan. Geddes and Syracuse, New York*. Prepared for Honeywell, Morristown, NJ.

O'Brien & Gere. 2003. *Jurisdictional Wetland Delineation Report. Harbor Brook Site. Geddes, New York*. Prepared for Honeywell, Morristown, NJ.

O'Brien & Gere. 2001. *Harbor Brook Preliminary Site Assessment Data Summary, Geddes, New York*. Prepared for Honeywell, Morristown, NJ.

O'Brien & Gere and Parsons. 2010. *Wetland/Floodplain Assessment for Onondaga Lake*. Prepared for Honeywell, Morristown, NJ. March 2010.

O'Brien & Gere and Parsons. 2004. *Final Work Plan, Interim Remedial Measure, Wastebed B/Harbor Brook. Geddes and Syracuse, New York.* Prepared for Honeywell, Morristown, NJ.

Table L-1
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Successional Old Field Seed Mix

Concentration in mix (%)	Common Name	Latin Name
20	oats	*Avena sativa*
15	Canada wild rye	*Elymus canadensis*
15	switchgrass	*Panicum virgatum*
10	Indiangrass	*Sorghastrum nutans*
10	Virginia wild rye	*Elymus virginicus*
8	purpletop	*Tridens flavus*
5	autumn bentgrass	*Agrostis perennans*
3	partridge pea	*Chamaecrista fasciculata*
3	wild senna	*Senna hebecarpa*
1	black-eyed Susan	*Rudbeckia hirta*
1	tall white beard tongue	*Penstemon digitalis*
1	grass-leaved goldenrod	*Euthamia graminifolia*
1	wild bergamot	*Monarda fistulosa*
1	flat-topped white aster	*Aster umbellatus*
1	Maryland senna	*Senna marilandica*
1	Ohio spiderwort	*Tradescantia ohiensis*
1	zigzag aster	*Aster prenanthoides*
1	New England aster	*Aster novae-angliae*
1	early goldenrod	*Solidago juncea*
1	lance-leaved coreopsis	*Coreopsis lanceolata*

Note: This seed mix will be applied at a rate of 60 pounds per acre.

Table L-2
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Seed Mix to Accompany Floodplain Forest and Successional Shrubland Plantings

Concentration in mix (%)	Common Name	Latin Name
30	oats	*Avena sativa*
10	Canada wild rye	*Elymus canadensis*
10	switchgrass	*Panicum virgatum*
10	Indiangrass	*Sorghastrum nutans*
10	Virginia wild rye	*Elymus virginicus*
10	purpletop	*Tridens flavus*
10	autumn bentgrass	*Agrostis perennans*
5	partridge pea	*Chamaecrista fasciculata*
5	wild senna	*Senna hebecarpa*

Note: This seed mix will be applied at a rate of 40 pounds per acre.

Table L-3
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Floodplain Forest Plant Mix

Number needed	Common Name	Latin Name	Percentage of area
254	silver maple	*Acer saccharinum*	30
169	speckled alder	*Alnus incana*	5
169	silky dogwood	*Cornus amomum**	5
169	redosier dogwood	*Cornus sericea**	5
169	pussy willow	*Salix discolor**	5
169	elderberry	*Sambucus canadensis**	5
169	spicebush	*Lindera benzoin*	5
169	river birch	*Betula nigra*	5
102	nannyberry	*Viburnum lentago**	3
85	red maple	*Acer rubrum*	10
68	bladdernut	*Staphylea trifolia*	2
68	buttonbush	*Cephalanthus occidentalis**	2
43	shellbark hickory	*Carya laciniosa*	5
43	Virginia creeper	*Parthenocissus quinquefolia**	5
43	hackberry	*Celtis occidentalis*	5
43	eastern cottonwood	*Populus deltoides*	5
17	bitternut hickory	*Carya cordiformis*	2
9	American sycamore	*Platanus occidentalis*	1

Notes: Unless listed with an asterisk (*), plants will be 6 to 12-inch diameter pot size and planted on 4-foot centers (shrubs) or 8-foot centers (trees and vines). Percent of area adds up to greater than 100% (*i.e.,* 105%) because the vine species is considered a separate vegetation layer.

*Where possible, 24-inch live cuttings will be used in lieu of potted stock. Cuttings will be installed on 4-foot centers as they will have similar stem diameter and 1st year canopy size as potted stock.

Table L-4
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Wet Meadow Plant Mix—Freshwater Species

Number needed	Common Name	Latin Name	Percentage of area
682	bluejoint grass	*Calamagrostis canadensis*	10
682	soft rush	*Juncus effusus*	10
546	fox sedge	*Carex vulpinoidea*	8
546	Joe-pye-weed	*Eupatorium maculatum*	8
546	boneset	*Eupatorium perfoliatum*	8
546	green bulrush	*Scirpus atrovirens*	8
546	woolgrass	*Scirpus cyperinus*	8
341	swamp milkweed	*Asclepias incarnata*	5
341	New England aster	*Aster novae-angliae*	5
341	rattlesnake mannagrass	*Glyceria canadensis*	5
341	marsh mallow	*Hibiscus moscheutos*	5
341	blue vervain	*Verbena hastata*	5
205	rice cutgrass	*Leersia oryzoides*	3
137	cosmos sedge	*Carex comosa*	2
137	sensitive fern	*Onoclea sensibilis*	2
137	royal fern	*Osmunda regalis*	2
69	lesser bur-reed	*Sparganium americanum*	1
69	giant bur-reed	*Sparganium eurycarpum*	1
69	turtlehead	*Chelone glabra*	1
69	bladder sedge	*Carex intumescens*	1
69	shallow sedge	*Carex lurida*	1
69	awl sedge	*Carex stipata*	1

Note: Individual 2-inch diameter plugs will be planted on 2-foot centers.

Table L-5
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Wet Meadow Seed Mix

Concentration in mix (%)	Common Name	Latin Name
32	Virginia wild rye	*Elymus virginicus*
30	oats	*Avena sativa*
15	fowl bluegrass	*Poa palustris*
5	wild senna	*Senna hebecarpa*
4	beggar ticks	*Bidens frondosa*
4	tall meadow-rue	*Thalictrum pubescens*
4	Pennsylvania smartweed	*Polygonum pensylvanicum*
3	Culver's root	*Veronicastrum virginicum*
3	seedbox	*Ludwigia alternifolia*

Note: This seed mix will be applied at a rate of 30 pounds per acre.

Table L-6
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Wet Meadow Plant Mix—Salt Tolerant Species

Number needed	Common Name	Latin Name	Percentage of area
1525	prairie cordgrass	*Spartina pectinata*	40
953	seaside goldenrod	*Solidago sempervirens*	25
382	saltmeadow rush	*Juncus gerardii*	10
191	New York aster	*Aster novi-belgii*	5
191	switchgrass	*Panicum virgatum*	5
191	boneset	*Eupatorium perfoliatum*	5
191	marsh mallow	*Hibiscus moscheutos*	5
191	hardstem bulrush	*Scirpus acutus*	5

Note: Individual 2-inch diameter plugs will be planted on 2-foot centers.

Table L-7
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Shrub Swamp Plant Mix

Number needed	Common Name	Latin Name	Percentage of area
349	redosier dogwood	*Cornus sericea**	20
349	speckled alder	*Alnus incana*	20
175	meadow sweet	*Spiraea alba*	10
175	elderberry	*Sambucus canadensis**	10
175	buttonbush	*Cephalanthus occidentalis**	10
175	silky dogwood	*Cornus amomum**	10
88	spicebush	*Lindera benzoin**	5
88	ironwood	*Carpinus carolinianus*	5
88	bladdernut	*Staphylea trifolia*	5
88	nannyberry	*Viburnum lentago**	5

Notes: Unless listed with an asterisk (*), plants will be 6 to 12-inch diameter pot size and planted on 4-foot centers.

*Where possible, 24-inch live cuttings will be used in lieu of potted stock. Cuttings will be installed on 4-foot centers as they will have similar stem diameter and 1st year canopy size as potted stock.

Table L-8
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Red Maple-Hardwood Swamp Plant Mix

Number needed	Common Name	Latin Name	Percentage of area
150	red maple	*Acer rubrum*	25
120	silver maple	*Acer saccharinum*	20
120	speckled alder	*Alnus rugosa*	5
120	redosier dogwood	*Cornus sericea**	5
120	silky dogwood	*Cornus amomum**	5
60	yellow birch	*Betula alleghaniensis*	10
30	Virginia creeper	*Parthenocissus quinquefolia**	5
30	eastern cottonwood	*Populus deltoides*	5
30	American sycamore	*Platanus occidentalis*	5
30	hackberry	*Cetlis occidentalis*	5
30	bitternut hickory	*Carya cordiformis*	5
30	swamp white oak	*Quercus bicolor*	5
24	ironwood	*Carpinus caroliniana*	1
24	spicebush	*Lindera benzoin*	1
24	elderberry	*Sambucus canadensis**	1
24	nannyberry	*Viburnum lentago**	1
6	white pine	*Pinus strobus*	1

Notes: Unless listed with an asterisk (*), plants will be 6 to 12-inch diameter pot size and planted on 4-foot centers (shrubs) or 8-foot centers (trees and vines). Percent of area adds up to greater than 100% (*i.e.,* 105%) because the vine species is considered a separate vegetation layer.

*Where possible, 24-inch live cuttings will be used in lieu of potted stock. Cuttings will be installed on 4-foot centers as they will have similar stem diameter and 1st year canopy size as potted stock.

Table L-9
Honeywell Upper Harbor Brook
Wastebed B/Harbor Brook Site IRM - 95% Design
Successional Shrubland Plant Mix

Number needed	Common Name	Latin Name	Percentage of area
699	gray dogwood	*Cornus racemosa**	25
699	speckled alder	*Alnus incana*	25
420	black chokeberry	*Aronia melanocarpa*	15
280	elderberry	*Sambucus canadensis**	10
280	choke cherry	*Prunus virginiana*	10
140	nannyberry	*Viburnum lentago**	5
140	eastern ninebark	*Physocarpus opulifolius*	5
140	buffalo berry	*Shepherdia canadensis*	5

Notes: Unless listed with an asterisk (*), plants will be 6 to 12-inch diameter pot size and planted on 4-foot centers.

*Where possible, 24-inch live cuttings will be used in lieu of potted stock. Cuttings will be installed on 4-foot centers as they will have similar stem diameter and 1st year canopy size as potted stock.