Habitat Monitoring and Management Plan

Lower Muskegon River

Muskegon, Michigan

GEI Consultants

Consulting Engineers and Scientists

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Introduction

The Muskegon Lake Area of Concern (AOC) was established under the Environmental Protection Agency (EPA) in 1987 due to ecological problems, including large-scale impacts on critical wetlands and degradation of water quality. Since the designation, a collection of ongoing remediation and restoration efforts have been undertaken to achieve delisting from the EPA's AOC program. A key constituent in these efforts is the West Michigan Shoreline Regional Development Commission (WMSRDC), a regional planning and development agency responsible for the oversight of the Lower Muskegon River Fish and Wildlife Habitat Restoration Project. The purpose of this project was to reconnect the Muskegon River to its historic floodplain and construct various wetland habitats and native vegetation to benefit fish, wildlife, and the public.

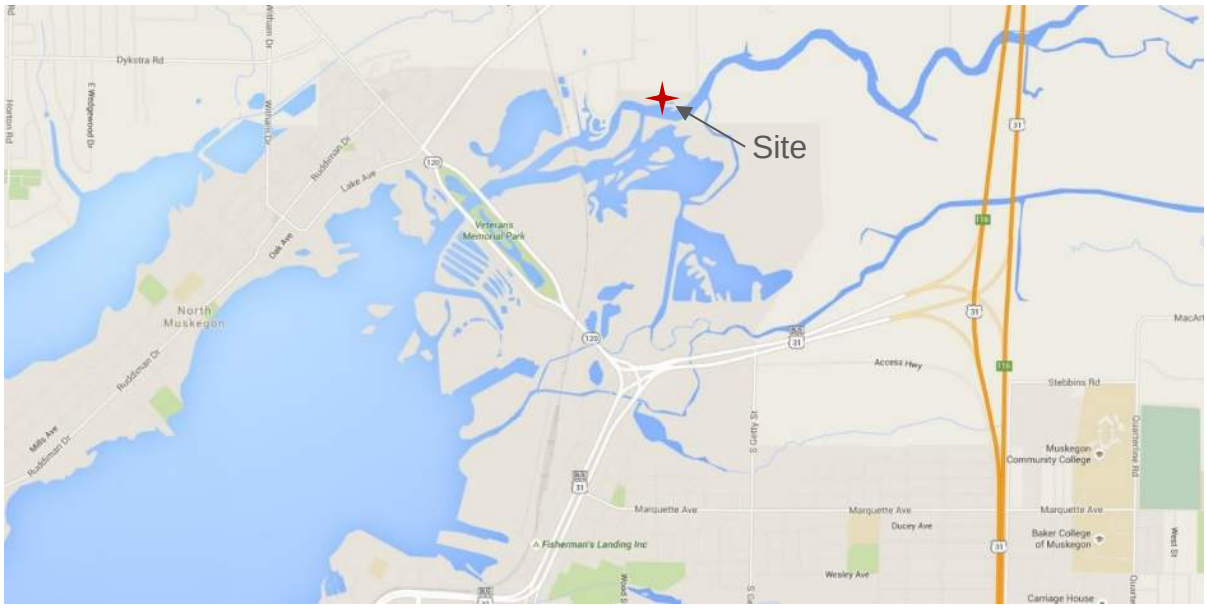


Figure 1. Project Location Map

A cumulative effort between Muskegon County, the West Michigan Shoreline Regional Development Commission (WMSRDC), Muskegon Lake Watershed Partnership (MLWP), Great Lakes Commission (GLC), National Oceanic and Atmospheric Administration (NOAA), GEI Consultants of Michigan, P.C. (GEI), Jackson-Merkey Contractors, Inc. (JMC), and the Annis Water Resource Institute (AWRI) of Grand Valley State University (GVSU) took place for this habitat restoration project. Funding was sourced from the Great Lakes Restoration Initiative. This management plan aims to maintain the improved ecological conditions of the restored property, offering guidance for both short- and long-term management in the face of disturbances. Site assessment and appropriate management actions that follow the ecological restoration process (Figure 2) are given with the long-term vision of creating a self-sustaining site with minimal intervention necessary.

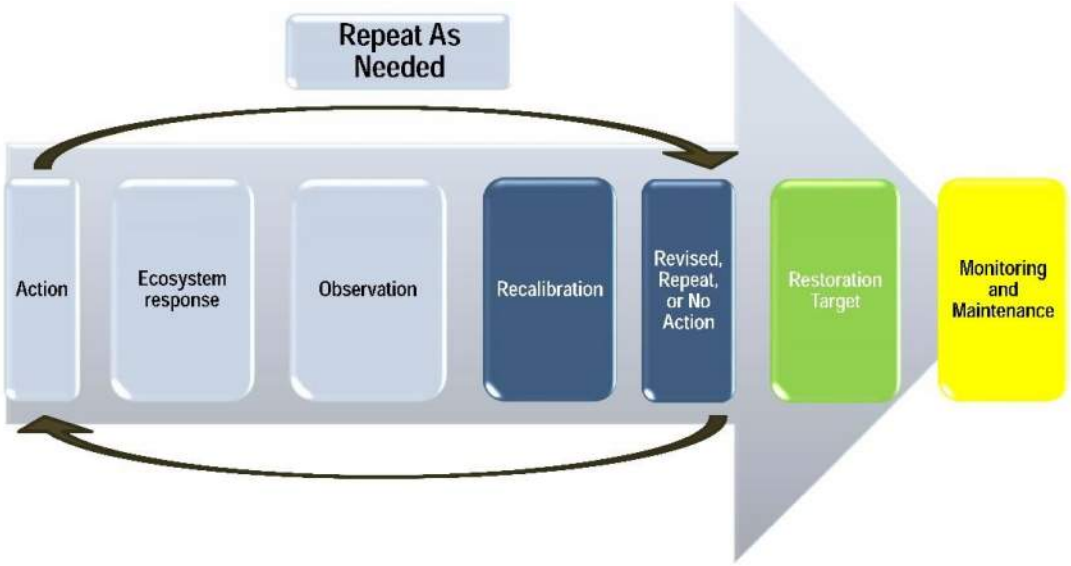


Figure 2. The Ecological Restoration Process

1. Project Design and Construction

1.1 Design Intent and Function

Located south of M-120 and adjacent to the Muskegon River, the 57.7-acre Lower Muskegon River restoration site was a formerly hydrologically disconnected celery farm. Due to it being a former agricultural site, a thick layer of phosphorus-rich muck was present across the ponded area. Prior to its agricultural designation and separation from the Muskegon River via dike, the site consisted of a historical floodplain.

Figure 3. Pre-Restoration Conditions

This project's overarching goals were twofold- restoring wetlands and reconnecting the structurally isolated pond to the Muskegon River. The design intent of the restoration project was to create multiple habitats, taking note to mimic surrounding historical conditions. These habitat types include shallow submergent marsh (4 acres), deep submergent marsh (3.4 acres), emergent marsh (9.1 acres), southern wet meadow (7.5 acres), southern shrub-carr (12.1 acres), floodplain forest (7.4 acres), and shallow open water (5.5 acres) for a total of 49 acres of created wetlands. Cooperatively, the project was designed to reduce the high phosphorus concentrations in the sediment and minimize the threat of excessive nutrient loading to

Muskegon Lake. A key component in reconnecting the site to the Muskegon River was to model hydrology to reduce sedimentation into the new flow-through channel. In conjunction with the hydrologic connection, the project was designed to enhance pond functionality and native wildlife habitat by removing unconsolidated sediment, planting native vegetation, installing varying topographical features, and installing large woody material for fish and amphibian nesting, reptile hibernacula, and osprey nesting structures. Full construction plans are listed in Appendix A.

1.1.1 *Site Hydrology*

Following hydrologic reconnection, water levels in the wetland now fluctuate with Lake Michigan and Muskegon River water levels. The restored site now experiences more regular, natural fluctuation. Water levels at the site will generally track those of Lake Michigan, which has both short- and long-term fluctuations (low of 576.46 feet and high of 582 feet). Additionally, periodic flood events along the Muskegon River will cause short-term water level fluctuations within site. The site was designed to be part of a fluid and dynamic coastal ecosystem, so one specific water depth is not anticipated, but a range of an approximate 581 feet during low water levels and 583 feet during high water levels can be expected. Wetlands were reconnected to the Muskegon River along a bend in the river channel where the flow velocity is sufficient to prevent sedimentation and future hydrologic disconnection.

1.1.2 *Site Soils and Water Quality*

High nutrient levels are one of the most common and significant causes of agricultural pollution, degrading soil and water quality. As a former agricultural site, excessively high phosphorus levels were present, evident through algal blooms. Certain hotspots throughout the ponded area showed phosphorus levels of 1,800 mg/kg, whereas levels higher than 600 mg/kg are detrimental to water quality. Grading plans were developed to remove high phosphorus soils, primarily consisting of the upper one to two feet of the soil column. 101,850 cubic yards of muck was excavated, revealing a sandy substrate. The mineral composition of sand does not bind with phosphorus the way muck does. Improving water quality was one of the broad project goals- achieved by removing nutrient-rich sediment and designing site hydrology to carry sediment through and prevent deposition from disconnecting the site from the river again. This ultimately minimizes water quality impacts on Muskegon River, Muskegon Lake, and Lake Michigan.

Photo 1. Sand and Gravel Bottom Post-Excavation

1.1.3 *Pre-Restoration Site Vegetation*

A pre-restoration vegetation survey was conducted at the project site in September of 2019. The plant community present prior to construction activity consisted of primarily native vegetation (approximately 70%). However, several non-native and invasive plant species were present. A list of plant species observed at the site in 2019 is shown below.

Scientific Name	Common Name	Native Status
Agrostis gigantea	Redtop	Non-native
Apios americana	American groundnut	Native
Arctium minus	Common burdock	Non-native
Asclepias syriaca	Common milkweed	Native
Bolboschoenus fluviatilis; scirpus f.	River bulrush	Native
Calystegia sepium	Hedge bindweed	Native
Circaea canadensis; c. lutetiana	Eastern enchanter's nightshade	Native
Cirsium vulgare	Bull thistle	Non-native
Cornus amomum	Silky dogwood	Native
Daucus carota	Queen Anne's lace	Non-native
Echinocystis lobata	Wild cucumber	Native
Eutrochium maculatum; eupatorium m.	Spotted joe-pye weed	Native
Impatiens capensis	Jewelweed	Native
Lemna minor	Common duckweed	Native
Lythrum salicaria	Purple loosestrife	Non-native
Persicaria amphibia; polygonum a.	Water smartweed	Native
Persicaria pensylvanica; polygonum p.	Pennsylvania smartweed	Native
Phalaris arundinacea	Reed canary grass	Native
Phragmites australis var. australis	Common reed	Non-native
Phytolacca americana	American pokeweed	Native
Populus deltoides	Eastern cottonwood	Native
Rhus typhina	Staghorn sumac	Native
Rubus allegheniensis	Common blackberry	Native
Rubus strigosus	American raspberry	Native
Rumex crispus	Curly dock	Non-native
Salix exigua	Sandbar willow	Native
Sambucus canadensis	American elder	Native
Saponaria officinalis	Soapwort	Non-native
Solanum dulcamara	Bittersweet	Non-native
Solidago altissima	Tall goldenrod	Native
Spartina pectinata	Prairie cordgrass	Native
Symphyotrichum lanceolatum; aster l.	Panicled aster	Native
Symphyotricum praealtum; aster p.	Willowleaf aster	Native
Typha x glauca	Cattail hybrid	Non-native
Urtica dioica	Stinging nettle	Native
Verbascum Thapsus	Common mullein	Non-native
Verbena hastata	Blue vervain	Native

1.2 Site Construction

Construction began by dewatering the site in April 2020, with all water discharged into the Muskegon River. The dewatering operation began with surface water pumping, and underground tile-fed pumps were installed once water levels were low enough. Additionally, a berm dewatering system was installed using well points to capture river water while enhancing berm stability. However, in July 2020, the berm was breached before the berm dewatering system was fully operational, thus extending the overall construction timeline.

Major earthwork began in October 2020 and was completed in December 2020. Following earthwork, the habitat structures were installed, and the site was seeded and planted with native vegetation in Spring 2021. Water levels were held at an elevation of 580-581 throughout the 2021 growing season to aid in establishing the native vegetation because above-average Lake Michigan water levels would show plant growth. The berms were removed, and the final reconnection was made in the Fall of 2021.

1.2.1 *Timeline*

Design and construction was completed from May of 2016 to September of 2022. Significant milestones and events are as follows:

May/June 2016:	Initial site investigations (topographic survey, soils surveys, wetland delineation, etc.)
September 2016 – October 2018:	Project design and permitting (hydrologic modeling, permit negotiations, etc.)
November 2018 – March 2019:	Contractor procurement
June 2020 – December 2020:	Dewatering
October 2020 – December 2020:	Major earth excavation
December 2020 – January 2020:	Installation of habitat structures
January 2021:	Complete site recontouring and habitat structure installation
April 2021 – September 2021:	Pumping to hold water at 581 feet for plant establishment
May 2021 – June 2021:	Native seeding and planting
October 2021 – November 2021:	Berm removal to complete hydrologic connection
May 2022 – September 2022:	Site management and supplemental plantings

Photo 2. Site Dewatering, Looking East

Photo 3. Berm Failure, Looking East, Occurred on July 23, 2020

Photo 4. Construction During Dewatered Conditions, Looking East

Photo 5. Habitat Structure Installation

Photo 6. Native Plantings Outside and Within Protective Fencing

Photo 7. Berm Removal

1.2.2 *Planted Vegetation*

The restoration site was seeded and planted with a variety of native wetland and upland species to assist with the establishment of the desired plant communities that correspond with habitats and locations within the site. Plantings occurred in two segments, the first following the final grading in May throughout June of 2021. A total of 143 pounds of seed, 34,714 plugs, 6,455 shrubs, and 533 trees were planted. Protective fencing was installed around areas of establishing plants to reduce wildlife depredation. Established plants are more resilient to wildlife activity and assist in establishing a seed bank. A secondary supplementary planting consisting of 6,791 plugs occurred in barren areas from May through September of 2022. Planting plans are provided in Appendix A, and the installed seed and plant species are given below.

Photo 8. Establishing Wetland Plants and Corresponding Animal Exclusion Fencing

2021 Planted List

Emergent Marsh Seed Mix- 9.1 acres

Scientific Name	Common Name	PLS Oz Per Acre
Acorus calamus	Sweet flag	4
Asclepias incarnata	Swamp milkweed	4
Avena sativa	Seed oats	512
Bidens cernua	Nodding bur-marigold	2
Calamagrostis canadensis	Bluejoint grass	2
Carex vulpinoidea	Brown fox sedge	4
Decodon verticillatus	Swamp loosestrife	0.25
Eleocharis acicularis	Needle spike rush	0.5
Eleocharis palustris	Great spike rush	1
Glyceria striata	Fowl manna grass	1
Hibiscus moscheutos	Swamp rose mallow	4
Iris virginica shrevei	Blue flag iris	6
Juncus canadensis	Canadian rush	1
Juncus effusus	Common rush	3
Juncus torreyi	Torrey's rush	0.25
Leersia oryzoides	Rice cut grass	2
Lolium multiflorum	Annual rye	160
Mimulus ringens	Monkey flower	1
Peltandra virginica	Arrow arum	6
Pontederia cordata	Pickerel weed	4
Rumex orbiculatus	Great water dock	1
Sagittaria latifolia	Common arrowhead	2
Saururus cernuus	Lizard's tail	0.5
Schoenoplectus pungens	Three-square	3
Scirpus acutus	Hard-stemmed bulrush	2
Scirpus atrovirens	Dark green rush	2
Scirpus cyperinus	Wool grass	1
Scirpus fluviatilis	River bulrush	2
Scirpus validus creber	Great bulrush	4
Sparganium eurycarpum	Common bur reed	2
Zizania aquatica	Wild rice	32
	Total PLS Ounces	**769.5**
	Total PLS Pounds	**48.09**

Floodplain Forest Seed Mix- 7.4 acres

Scientific Name	Common Name	PLS Oz Per Acre
Angelica atropurpurea	Great angelica	2
Asclepias incarnata	Swamp milkweed	1
Aster novae-angliae	New England aster	2
Avena sativa	Seed oats	512
Bidens cernua	Nodding bur marigold	2
Bidens frondosa	Common beggars tick	2
Bromus pubescens	Woodland brome	3
Calamagrostis canadensis	Blue joint grass	4
Carex crinita	Fringed sedge	2
Carex grayi	Common bur sedge	2
Carex lupulina	Common hop sedge	2
Carex muskingumensis	Swamp oval sedge	2
Carex vulpinoidea	Brown fox sedge	3
Cinna arundinacea	Common wood reed	2
Coreopsis tripteris	Tall coreopsis	1
Elymus riparius	Riverbank wild rye	12
Elymus virginicus	Virginia wild rye	32
Eupatorium maculatum	Spotted joe-pye weed	1
Glyceria striata	Fowl manna grass	2
Iris virginica shrevei	Blue flag iris	4
Leersia oryzoides	Rice cut grass	3
Lobelia cardinalis	Cardinal flower	0.5
Lobelia siphilitica	Great blue lobelia	1
Lolium multiflorum	Annual rye	160
Rudbeckia laciniata	Wild golden glow	3
Saururus cernuus	Lizard's tail	0.5
Thalictrum dasycarpum	Purple meadow rue	1
	Total PLS Ounces	**762**
	Total PLS Pounds	**47.63**

Southern Wet Meadow/Southern Shrub-Carr Seed Mix- 19.6 acres

Scientific Name	Common Name	PLS Oz Per Acre
Acorus calamus	Sweet flag	2
Angelica atropurpurea	Great angelica	2
Asclepias incarnata	Swamp milkweed	4
Aster novae-angliae	New England aster	1
Avena sativa	Seed oats	512
Bidens cernua	Nodding bur marigold	2
Bromus ciliatus	Fringed brome	2
Calamagrostis canadensis	Blue joint grass	2
Carex comosa	Bristly sedge	2
Carex crinita	Fringed sedge	2
Carex hystericina	Porcupine sedge	2
Carex lupulina	Common hop sedge	2
Carex muskingumensis	Swamp oval sedge	2
Carex stricta	Common tussock sedge	0.5
Carex vulpinoidea	Brown fox sedge	2
Coreopsis tripteris	Tall coreopsis	1
Elymus virginicus	Virginia wild rye	16
Eupatorium maculatum	Spotted joe-pye weed	2
Eupatorium perfoliatum	Common boneset	2
Glyceria striata	Fowl manna grass	2
Hibiscus moscheutos	Swamp rose mallow	2
Iris virginica shrevei	Blue flag iris	5
Juncus effusus	Common rush	2
Leersia oryzoides	Rice cut grass	2
Liatris spicata	Marsh blazing star	1
Lobelia cardinalis	Cardinal flower	0.5
Lobelia siphilitica	Great blue lobelia	1
Lolium multiflorum	Annual rye	160
Mimulus ringens	Monkey flower	2
Monarda fistulosa	Wild bergamot	2
Pycnanthemum virginianum	Common mountain mint	1
Rosa palustris	Swamp rose	1
Sagittaria latifolia	Common arrowhead	1
Scirpus atrovirens	Dark green rush	1
Scirpus cyperinus	Wool grass	1
Solidago ohioensis	Ohio goldenrod	1

Continued- Southern Wet Meadow/Southern Shrub-Carr Seed Mix- 19.6 acres

Scientific Name	Common Name	PLS Oz Per Acre
Spartina pectinata	Prairie cord grass	6
Thalictrum dasycarpum	Purple meadow rue	0.5
Verbena hastata	Blue vervain	2
Zizia aurea	Golden Alexanders	2
	Total PLS Ounces	**756.5**
	Total PLS Pounds	**47.28**

2021 Planting List- Live Plant Materials

Scientific Name	Common Name	Wetland Indicator Status	Deep Submergent Marsh (3.4 ac)	Shallow Submergent Marsh (4.0 ac)	Emergent Marsh (9.1 ac)	Southern Shrub Carr (12.1 ac)	Southern Wet Meadow (7.5 ac)	Floodplain Forest (7.4 ac)
Asclepia incarnata	Swamp milkweed	OBL			125		100	
Eupatorium maculatum	Joe-Pye weed	OBL					100	
Iris virginica shrevei	Blue flag iris	OBL			125		100	
Liatris spicata	Marsh blazing star	FAC					100	
Lobelia cardinalis	Cardinal flower	OBL					100	
Lobelia siphilitica	Blue lobelia	FACW					100	
Mimulus ringens	Monkeyflower	OBL					100	
Nuphar advena	Spatterdock	OBL		500				
Nymphaea tuberosa	White water lily	OBL		500				
Peltandra virginica	Arrow arum	OBL			100			
Pontederia cordata	Pickerelweed	OBL		250	100			
Sagittaria latifolia	Arrowhead	OBL			100			
Saururus cernuus	Lizard's tail	OBL			50			
Solidago patula	Swamp goldenrod	OBL					100	
Vallisneria americana	Wild celery	OBL	1,000	300				
Calamagrostis canadensis	Blue joint grass	OBL					75	
Carex comosa	Bristly sedge	OBL					100	
Carex lacustris	Lake sedge	OBL			100			
Carex muskingumensis	Sand bracted sedge	OBL					150	
Carex vulpinoidea	Brown fox sedge	OBL						
Juncus effusus	Soft rush	OBL			50			
Schoenoplectus acutus	Hardstem bulrush	OBL			300			
Schoenoplectus pungens	Common threesquare	OBL			300			
Schoenoplectus tabernaemontani	Softstem bulrush	OBL			300			
Scirpus cyperinus	Wool Grass	OBL					100	
Sparganium eurycarpum	Common burreeed	OBL			100			
	Per-acre total		1,000	1,550	1,750		1,225	
	Total quantity		3,400	6,200	15,926		9,188	
Shrubs								
Cephalanthus occidentalis	Buttonbush	OBL				50		
Cornus amomum	Silky dogwood	FACW				50		75
Cornus sericea	Red-osier dogwood	FACW				50		75
Rosa palustris	Swamp rose	OBL				50		
Sambucus canadensis	Elderberry	FACW				50		75
Spiraea alba	Meadowsweet	FACW				50		
Viburnum opulus v. americanum	American highbush cranberry	FACW				50		75
	Per-acre total					350		300
	Total quantity					4235		2220
Trees (24-36" bare-root)								
Acer rubrum	Red maple	FAC						10
Nyssa sylvatica	Black gum	FACW						10
Platanus occidentalis	Sycamore	FACW						10
Quercus bicolor	Swamp white oak	FACW						10
Quercus palustris	Pin oak	FACW						10
Salix nigra	Black willow	OBL						10
	Per-acre total							60
	Total quantity							444
Trees (2" caliper)								
Acer rubrum	Red maple	FAC						2
Acer saccharinum	Silver maple	FACW						2
Celtis occidentalis	Hackberry	FAC						2
Platanus occidentalis	Sycamore	FACW						2
Quercus bicolor	Swamp white oak	FACW						2
Quercus palustris	Pin oak	FACW						2
	Per-acre total							12
	Total quantity							89

2022 Planting List- Live Plant Materials

Scientific Name	Common Name	Stock	Quantity
Peltandra virginica	Arrow arum	Plug	828
Sagittaria latifolia	Common arrowhead	Bare root	100
Saururus cernuus	Lizard's tail	Plug	114
Acorus americanus	Sweet flag	Plug	266
Carex lacustris	Lake sedge	Plug	114
Schoenoplectus tabernaemontani	Softstem bulrush	Plug	910
Schoenoplectus acutus	Hardstem bulrush	Plug	304
Schoenoplectus pungens	Three-square	Plug	3173
Sparganium eurycarpum	Common bur-reed	Plug	184
Decodon verticillatus	Swamp loosestrife	Plug	152
Iris virginica	Southern blue flag	Plug	532
Cephalanthus occidentalis	Buttonbush	Plug	114
		Total	6791

Photo 9. Swamp Rose Mallow (*Hibiscus moscheutos*)

2. Site Assessment Methods and Tools

To provide for the short- and long-term health of the Lower Muskegon River restoration project, the site should be systematically assessed for factors that may potentially degrade ecological, aesthetic, or functional conditions of the site. This may include, but not necessarily be limited to, inspections for:

- Soil erosion
- Installed vegetation degradation
- Excessive wildlife depredation
- Invasive vegetation establishment
- Wildlife habitat structures damage

A checklist that may be used for these inspections has been included in Appendix B, and management techniques are provided in Section 3 of this report.

2.1 Soil Erosion Inspection

Soil erosion occurs when water, wind, or ice displaces soil. Soil erosion may occur at the site as a result of the freeze-thaw cycle, wave action, rainfall, or public use. When erosion occurs, the site may become unstable. This instability may cause the site to degrade by limiting the establishment of native vegetation, jeopardizing the integrity of adjacent roads or structures, or reducing water quality through sedimentation. The two most common forms of erosion expected at the site are *toe erosion* and *gully erosion*. Toe erosion occurs when waves or ice destabilize the soil on a shoreline. Gully erosion occurs when runoff from rain events washes over the surface and cuts gullies into the soil.

The site should be inspected for soil erosion each spring after the spring thaw has occurred, after significant rainfall events for the first three years following planting, and at minimum three times per growing season in the long term. During each inspection, the inspector should note the apparent cause and severity of the erosion and whether it is causing or may cause significant negative impacts on the site.

2.2 Vegetation Inspections

Vegetation is a strong indicator of the overall ecological health of wetland systems. Therefore, the vegetation should be inspected at least once yearly using a meander survey. When conducting a meander survey, the observer walks the vegetated areas of the site and documents the vegetation present. Specifically, the observer(s) should look for:

1) Native wetland vegetation, specifically plant species that were installed. Photographs of key indicator species planted at this site are included in Appendix C. Installed vegetation faces significant pressure from wildlife- particularly excessive grazing by the Canada goose (*Branta canadensis*), as seen in Photo 10.

Vegetation loss, feces, and tracks indicate an infestation of Canada geese. While Canada geese will eat a broad array of vegetation, it appears they avoid swamp rose mallow (*Hibiscus moscheutos*), as seen in Photo 11. Excessive plant depredation can lead to a lack of ground cover, thus increasing the risk of soil erosion, as discussed in Section 2.1. Preventative and reactive measures are provided in Section 3.3.1.

2) Invasive plant species that may spread throughout the site and outcompete the desirable native species. Photographs of primary invasive species that are expected to occur at the site are included in Appendix D, and control measures for these species are described in Section 3.3.2 below.

Photo 10. Vegetated Wildlife Exclosure Plot Surrounded by Bare Soil

Photo 11. Swamp Rose Mallow Response to Canada Goose Grazing

2.3 Wildlife Habitat Structures Inspections

Wildlife habitat structures include large woody material for fish and amphibian nesting, reptile hibernacula, and osprey nesting structures. Inverted root wads, root wads, free-standing snags, log structures, and brush and log piles were installed for fish and amphibian nesting. The reptile hibernacula consist of an underground-ground-level refuge composed of gravel, rubble, stumps, and large branches. Hibernacula should be inspected for blockage around openings that inhibit or restrict use. The osprey nesting structures are elevated platforms made to mimic the high naturally occurring platforms that ospreys nest on. Placement of the habitat structures throughout the site can be seen in the full construction plans in Appendix A. Habitat structures should be inspected for structural integrity and any accumulation of debris. Damage to structures could occur from inclement weather, general wear from use by wildlife, etc.

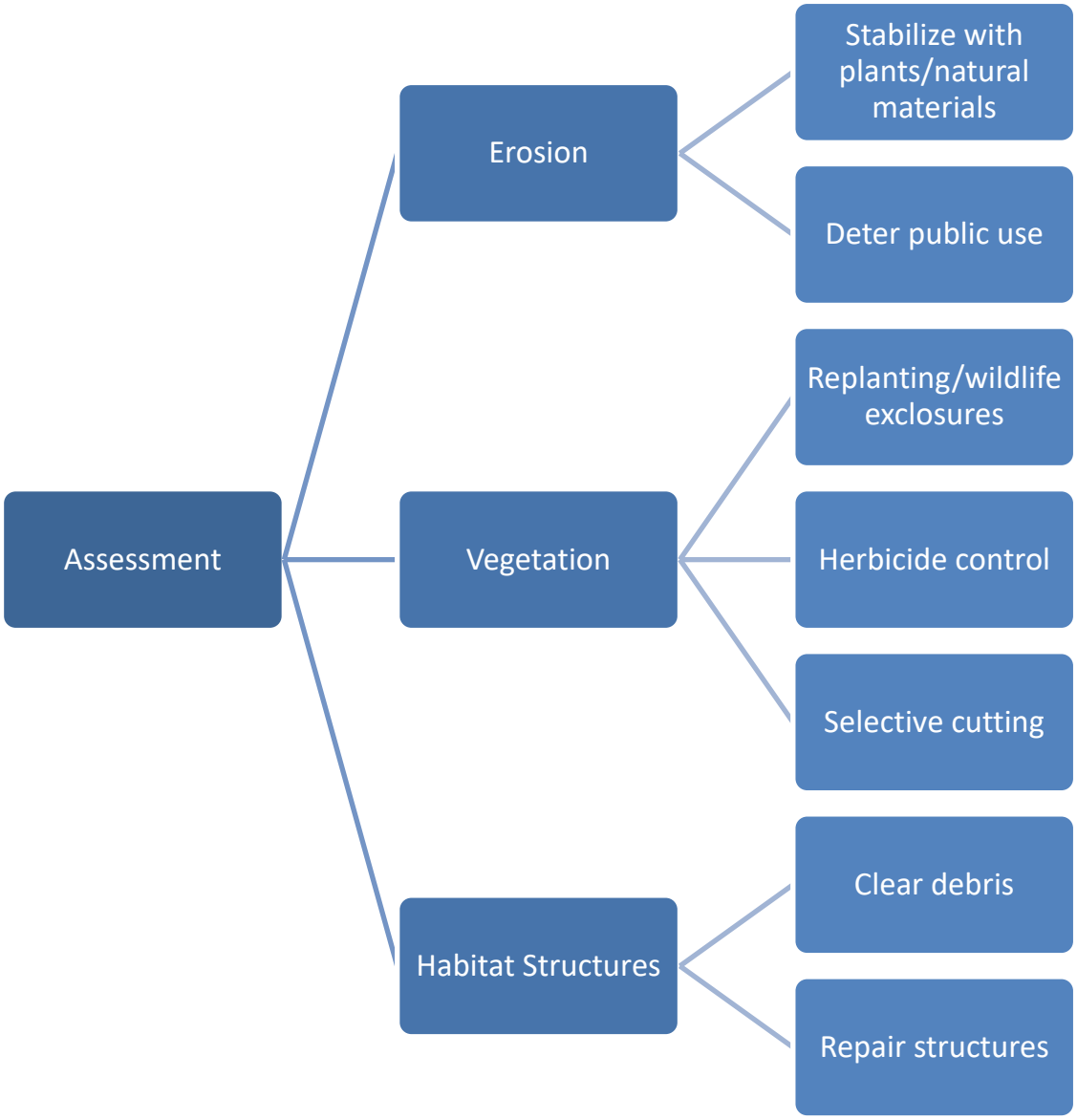
Furthermore, the wildlife habitat structures should be inspected for wildlife use. Signs of use include sightings, feathers, feces, accumulating nesting material, etc. Special care should be taken to not disturb or encroach on wildlife, particularly during nesting seasons. The inspector should note any signs of structural damage, degradation, and use.

Photo 13. Osprey Nesting Structure

3. Site Management

3.1 Overview

Appropriate site management should be undertaken after an assessment indicating excessive degradation has occurred and the site is unable to or unlikely to self-repair and may cause long-term harm to the site's health. Corrective measures should be determined depending on severity. Minor fixes may be able to be performed by volunteers or County and City staff, whereas more complex may require professional design and implementation. It is highly recommended that the WMSRDC or GEI be contacted with site-specific questions. It is also important to note that permitting may be required depending on the problem and severity.



3.2 Erosion

As previously discussed, if erosion is noted at the site, the cause and type of erosion should be determined. The severity of the erosion will dictate the exact means and measures taken. Simple erosion may require minor fixes that can be implemented by volunteers or County and City staff. More severe erosion, however, may require professional design and construction. Contact the WMSRDC or GEI with site-specific questions related to soil erosion. It is also important to note that erosion controls may require permits from Michigan Department of Environment, Great Lakes, and Energy (EGLE) or Muskegon County (Soil Erosion and Sedimentation Control Program (SESC)).

Minor soil erosion may only require stabilization with vegetation or natural materials such as rocks or woody materials. Using vegetation for erosion control on restoration sites is a standard method. Root systems of plants will both secure the soil in place and de-compact soils to increase infiltration. Natural materials such as rocks and woody materials like logs and branches provide both ground cover and can deter foot traffic.

Although the Lower Muskegon River restoration site is accessed through private property, it is still accessible and experiences occasional use from the public via access from the Muskegon River. Although recreational activities are unlikely to degrade the site and cause erosion, preventative measures should be taken to minimize damage if warranted. Preventative measures include signage to educate and discourage foot traffic or other trampling or degradation from kayaks or boats.

3.3 Vegetation

The project was designed to simplify long-term maintenance measures. There are five types of plant zones within the restored wetland:

1. Submergent Marsh
2. Emergent Marsh
3. Wet Meadow
4. Scrub Shrub
5. Floodplain Forest

In addition to routine maintenance, areas planted with native seed and plant materials may be damaged by flooding, erosion, wildlife predation, invasive species competition, or other factors. Irrigation, replanting, and invasive species control measures may be necessary to address these issues.

Photo 14. Overlook of Wet Meadow Habitat.

3.3.1 *Replanting and Wildlife Exclosures*

If areas of bare soil or sparse vegetation are present, replanting or supplemental planting may be necessary. Native species equivalent to those installed in the original plantings should be used for replanting purposes. Seed and plant materials should be obtained from a native plant nursery located within the same (or an adjacent) Environmental Protection Agency Level III Ecoregion in order to maintain consistency in genotypes. The following list includes several native plant nurseries for consideration:

1. Muskegon Conservation District
   4735 Holton Rd.
   Twin Lake, MI 49457
   Phone: 231-828-5097
   Website: http://muskegoncd.org

2. Michigan Wildflower Farm
   11770 Cutler Rd.
   Portland, MI 48875-9452
   Phone: 517-647-6010
   Email: wildflowers@voyager.net
   Website: http://www.michiganwildflowerfarm.com

3. Wildtype Native Plant Nursery
   900 N Every Rd.
   Mason, MI 48854
   Phone: 517-244-1140
   Email: wildtype@msu.edu
   Website: http://www.wildtypeplants.com

4. Native Connections
   17080 Hoshel Rd.
   Three Rivers, MI 49093
   Phone: 269-273-1367
   Email: info@nativeconnections.net
   Website: http://www.nativeconnections.net

Seeding should occur in spring (April – May) or fall (October – November). After preparing the soil by very shallow tilling or surface scarification only, lightly rake the seed into the soil no deeper than ¼ inch. Ground disturbance during soil preparation should be minimized, and newly seeded areas should be cultipacked to promote seed-soil contact after seed installation.

Trees and shrubs should be planted in spring, and herbaceous plants may be installed from May through July. Contact the WMSRDC or the Muskegon Lake Watershed Partnership (MLWP) for volunteer assistance under the Shoreline Stewards program or to discuss specific replanting measures.

Muskegon Lake Watershed Partnership - Shoreline Stewards
c/o Fallon Chabala, West Michigan Shoreline Regional Development Commission
316 Morris Avenue, Suite 340
Muskegon, MI 49440
(231) 722-7878 x 130
fchabala@wmsrdc.org

Wildlife exclosures may be necessary and should be considered with replanting efforts to protect vegetation susceptible to predation. Stakes placed around the vegetated area and strung with fishing line and bird deterrent reflective tape can be an effective and low-cost preventative or reactive measure to deter grazing. An example is provided in Photo 15. Depending on the degree of damage or presence of heavily grazing wildlife, such as the Canada goose, more extensive protection like wildlife exclusion fencing, as seen in Photo 16 may be necessary. Wildlife exclosures should be monitored for effectiveness after installation.

Photo 15. Wildlife Exclosure Using Fishing Line and Reflective Tape

Photo 16. Wildlife Exclusion Fencing

3.3.2 *Control of Undesirable Vegetation*

Several non-native, invasive plant species were present on the site prior to restoration, including, but not limited to, cattails (*Typha* spp.), reed canary grass (*Phalaris arundinacea*), purple loosestrife (*Lythrum salicaria*), and common reed (*Phragmites australis*). It is important to note that there is also a population of the native variety of common reed on site, not to be mistaken with the aggressive-acting invasive *Phragmites* haplotype. Appendix D contains sample photographs of these and other commonly encountered invasive plants in the project area. There is a high probability that these plants will continue to infiltrate the site's vegetative community from the existing seed bank or mature populations in the vicinity if not controlled. The prevalence of these invasive species will impede the establishment and long-term survival of the native planted species; therefore, control of invasive plant populations is recommended.

Below, several specific techniques are described for vegetation management. After the techniques are described, site-specific recommendations are provided in Section 3.3.2.4.

3.3.2.1 Selective Herbicide Application

Large populations of invasive plants and species that are difficult to remove by hand may be more efficiently controlled using herbicides. A glyphosate formulation approved for use in wetlands (such as Rodeo or AquaNeat) may be selectively applied to the foliage of target plants. Mix the chemical in a 2% active ingredient solution with water to treat common reed, purple loosestrife, cattails, and reed canary grass. Include a wetland-safe surfactant such as Cygnet Plus in the solution at a rate of 0.6 ounces per gallon. Treatments to reed canary grass should occur in spring after emergence, and common reed and purple loosestrife treatments should occur when the majority of plants are blooming (July – September).

Certified pesticide applicators should perform herbicide treatments. Always follow chemical manufacturer label instructions for herbicide application. Please note that the use of herbicides over standing water may require an Aquatic Nuisance Control (ANC) permit from EGLE.

Plant	Herbicide	Timing
Purple loosestrife	2% glyphosate or 2% triclopyr	July-September (when flowering)
Cattails	2% glyphosate	July-September
Common reed	2% glyphosate	August-October
Reed canary grass	2% glyphosate	May-September

3.3.2.2 Selective Cutting

Certain annual and biennial invasive plants, such as Canada thistle (*Cirsium arvense*), may be effectively reduced through selective cutting. This technique may be preferable to hand pulling when larger populations are present. A mechanical weed trimmer may be used to cut the plants close to the ground just prior to flowering (May/June). Cutting may need to be repeated once or twice during this timeframe. Spring cutting should be paired with a fall herbicide treatment to ensure root death.

3.3.2.3 Cut-Stump Treatments to Woody Vegetation

Invasive trees and shrubs, including willow species, glossy buckthorn, and black locust, may be controlled by cutting the stems within two to four inches of the ground (using a handsaw, pruners, or chainsaw) followed by application of herbicide to the cut surface. A glyphosate formulation approved for use in wetlands (such as Rodeo or AquaNeat) may be selectively applied in a solution of 75% active ingredient with water or undiluted. Include a wetland-safe surfactant such as Cygnet Plus in the solution at a rate of 0.6 ounces per gallon of solution. Treatments may occur throughout the year except during spring sap flow (mid-March through May).

Certified pesticide applicators should perform herbicide treatments. Always follow chemical manufacturer label instructions for herbicide application. Please note that the use of herbicides over standing water may require an Aquatic Nuisance Control permit from EGLE.

3.3.2.4 Site-Specific Recommendations

Each technique described above may be implemented when and where appropriate at the site. The primary steps needed to manage the vegetation within the wetland and adjacent area are as follows:

Whole Site Management:

1. Apply 1-4 herbicide applications of a wetland-approved 2% triclopyr solution (either Renovate or Garlon 3A) between May and September. Herbicide may be sprayed with backpack sprayers or tank sprayers, depending on density and accessibility in these areas. These herbicides are broadleaf-specific and will not damage grass or sedge species, so they can be sprayed over the planting zone if needed. It is important to note that off-target damage to broadleaf or forb species in adjacent planting zones will occur if the herbicide is not selectively applied to the sedge planting zones only.
2. Apply a 2% glyphosate solution (Rodeo or AquaNeat) selectively to the foliage of undesired target invasive grass plants (reed canary grass, phragmites, cattail).
3. Special care should be taken to be selective and limit drift around habitat structures.
4. Replant as needed. Species may be the same as those installed initially or may be different equivalent native species provided the plants meet the site's overall aesthetic and ecological goals.

Photo 17. Restored Ponded Area, Looking North

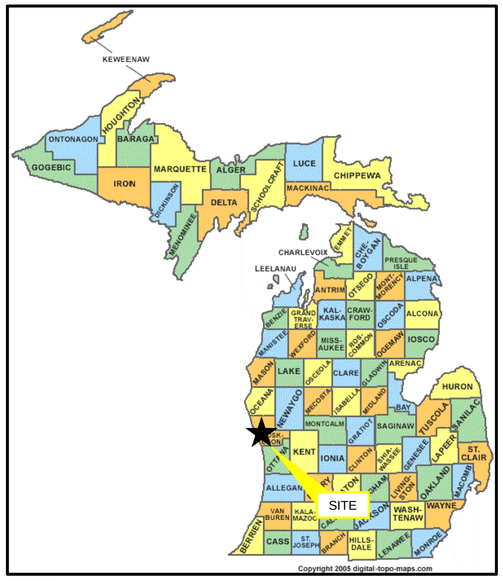
3.4 Habitat Structures

Wildlife habitat structures may be prone to debris accumulation, which may act as a deterrent to wildlife and be unsightly, or may undergo structural damage, as discussed in Section 2.3. The appropriate measures will depend on the type of habitat structure and level and type of degradation. It is vital to maintain the quality of the habitat structures to promote use by wildlife. Minor structural issues may be able to be completed by volunteers or County or City staff, whereas severe structural damage may require consultation and construction. It is recommended that the WMSRDC or GEI be contacted with any questions regarding habitat structure functionality or maintenance/repairs. Many of the habitat structures are only accessible by boat or kayak. Take appropriate safety precautions when using water transportation and do not perform tasks that are outside of the skill or comfort level.

Appendix A Project Design Plans

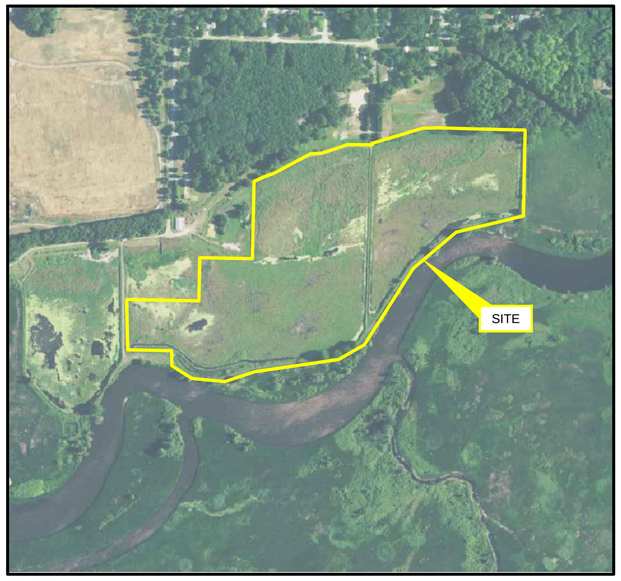
LOWER MUSKEGON RIVER

HYDROLOGIC RECONNECTION
FISH & WILDLIFE HABITAT RESTORATION PROJECT
CONSTRUCTION DRAWINGS



SOURCE:
GOOGLE ™ IMAGES

STATE MAP
(NOT TO SCALE)



SOURCE:
GOOGLE ™ EARTH

SITE LOCATION MAP
(NOT TO SCALE)

SHEET INDEX

SHEET NO.	DRAWING NO.	TITLE
1	G-01	COVER SHEET
2	A-01	OFF-SITE SOIL DISPOSAL LOCATION
3	C-01	EXISTING CONDITIONS
4	C-02	SOIL BORING DATA
5	C-03	PROPOSED ACCESS PLAN
6	C-04	DEMOLITION, SEQUENCING AND DEWATERING PLAN
7	C-05	PROPOSED GRADING PLAN
8	C-06	VISUAL DISPLAY OF PROPOSED EXCAVATION AND FILL
9	C-07	PROPOSED CROSS SECTIONS (1 OF 5)
10	C-08	PROPOSED CROSS SECTIONS (2 OF 5)
11	C-09	PROPOSED CROSS SECTIONS (3 OF 5)
12	C-10	PROPOSED CROSS SECTIONS (4 OF 5)
13	C-11	PROPOSED CROSS SECTIONS (5 OF 5)
14	C-12	SB-106 SOIL REMOVAL DIAGRAM
15	L-01	SOIL EROSION AND SEDIMENT CONTROL PLAN
16	L-02	LANDSCAPING PLAN
17	L-03	WILDLIFE HABITAT STRUCTURES
18	D-01	DETAILS (1 OF 3)
19	D-02	DETAILS (2 OF 3)
20	D-03	DETAILS (3 OF 3)

PREPARED FOR:

WEST MICHIGAN SHORELINE REGIONAL
DEVELOPMENT COMMISSION
316 MORRIS AVE, SUITE 340
MUSKEGON, MI 49940
(231)722-7878

MUSKEGON COUNTY
990 TERRACE ST #105
MUSKEGON, MI 49442

GREAT LAKES COMMISSION
2805 S INDUSTRIAL HWY # 100
ANN ARBOR, MI 48104
(734)971-9135

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION
4840 S. STATE RD
ANN ARBOR, MI 48108

PREPARED BY:

GEI CONSULTANTS OF MICHIGAN P.C.
5225 EDGEWATER DRIVE
ALLENDALE, MI 49401
(616)384-2710

FOR CONSTRUCTION

12/06/2018
GEI PROJECT NO. 1602940

NO.	DATE	ISSUE/REVISION	APP
1	11/16/2018	JPA DRAWINGS	SD
0	6/1/2018	JPA DRAWINGS	SD

STATE OF MICHIGAN
SCOTT B. DIERKS
ENGINEER
No. 44371
LICENSED PROFESSIONAL ENGINEER

DWG. NO.
G-01

SHEET NO.
1 OF 20

\\geiconsulta B:\Working\WMSRDC\1602940 Lower Muskegon River\00_CAD\Design\Production\PLTS_COVER-G-01.dwg - 12/6/2018

PROPOSED SOIL DISPOSAL LOCATION

NOTES:

1. SOIL SHALL BE PLACED AND SPREAD TO A UNIFORM THICKNESS.
2. EXACT LOCATION AND SOIL DEPTH WITHIN THE DESIGNATED DISPOSAL AREA WILL BE DETERMINED BY THE LANDOWNER AND THE ENGINEER.
3. SOIL SHALL CONTAIN A MINIMUM OF 5% ORGANIC MATTER BY WEIGHT.
4. SEEDING TO BE COMPLETED BY OTHERS.

N

0 150' 300'

SCALE: 1" = 150'

For Construction

GEI Consultants
5225 EDGEWATER DRIVE
ALLENDALE, MI 49401
(616)384-2710

WMSRDC
WEST MICHIGAN SHORELINE
REGIONAL DEVELOPMENT COMMISSION

LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
2	12/6/2018	CONSTRUCTION DRAWINGS	SD
1	11/16/2018	JPA DRAWINGS	SD
0	6/1/2018	JPA DRAWINGS	SD

STATE OF MICHIGAN
SCOTT B. DIERKS
ENGINEER
No. 44371
LICENSED PROFESSIONAL ENGINEER

Designed:	B. Majka
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

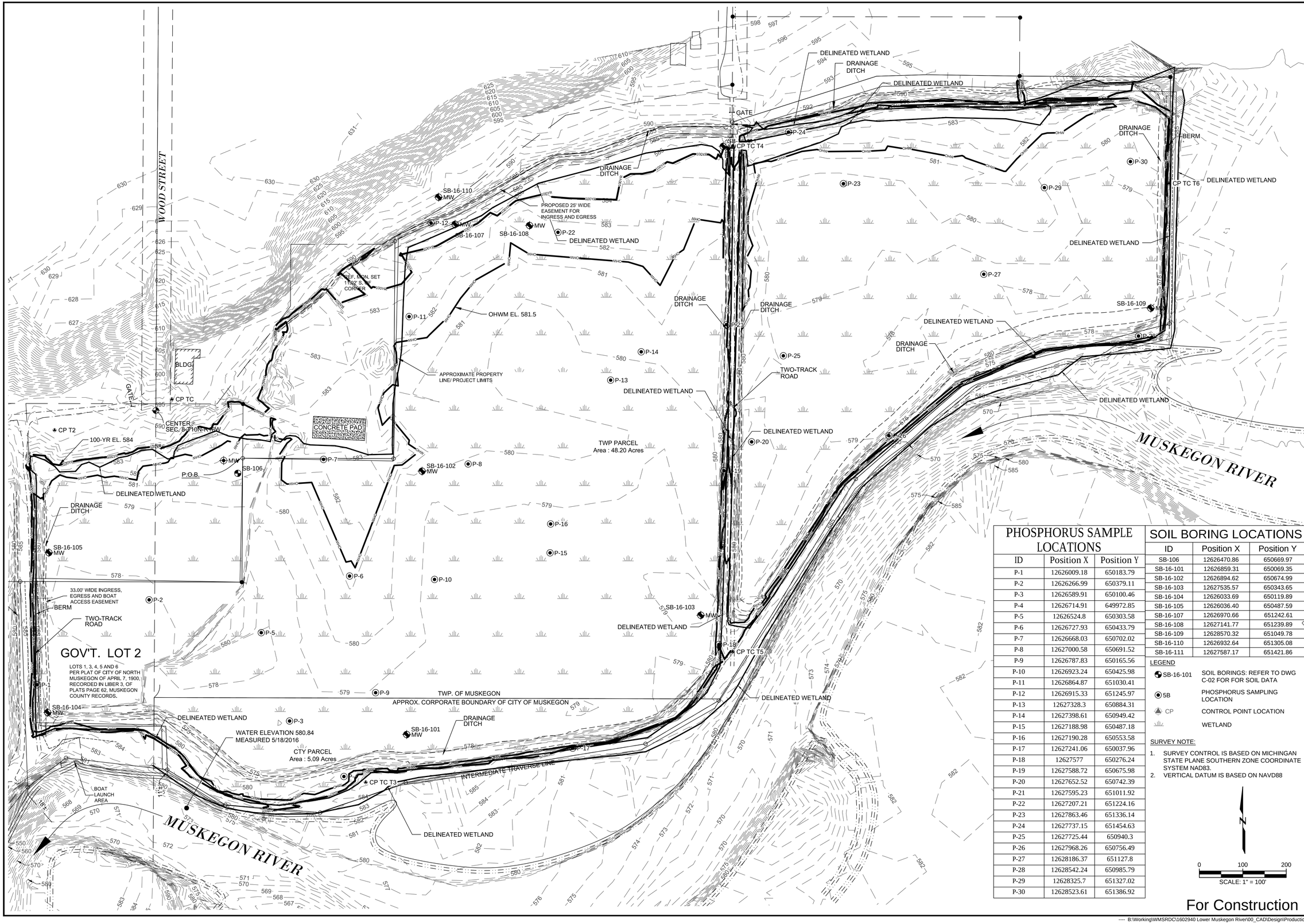
ALTERNATE A1: PROPOSED OFF SITE SOIL DISPOSAL LOCATION

GEI Project 1602940

DWG. NO.
A-01

SHEET NO.
2 OF 20

---- B:\Working\WMSRDC\1602940 Lower Muskegon River\00_CAD\Design\Production\PLTS_Off_Site_Soil_Disposal_Location.dwg - 12/6/2018



PHOSPHORUS SAMPLE LOCATIONS		
ID	Position X	Position Y
P-1	12626009.18	650183.79
P-2	12626266.99	650379.11
P-3	12626589.91	650100.46
P-4	12626714.91	649972.85
P-5	12626524.8	650303.58
P-6	12626727.93	650433.79
P-7	12626668.03	650702.02
P-8	12627000.58	650691.52
P-9	12626787.83	650165.56
P-10	12626923.24	650425.98
P-11	12626864.87	651030.41
P-12	12626915.33	651245.97
P-13	12627328.3	650884.31
P-14	12627398.61	650949.42
P-15	12627188.98	650487.18
P-16	12627190.28	650553.58
P-17	12627241.06	650037.96
P-18	12627577	650276.24
P-19	12627588.72	650675.98
P-20	12627652.52	650742.39
P-21	12627595.23	651011.92
P-22	12627207.21	651224.16
P-23	12627863.46	651336.14
P-24	12627737.15	651454.63
P-25	12627725.44	650940.3
P-26	12627968.26	650756.49
P-27	12628186.37	651127.8
P-28	12628542.24	650985.79
P-29	12628325.7	651327.02
P-30	12628523.61	651386.92

SOIL BORING LOCATIONS		
ID	Position X	Position Y
SB-106	12626470.86	650669.97
SB-16-101	12626859.31	650069.35
SB-16-102	12626894.62	650674.99
SB-16-103	12627535.57	650343.65
SB-16-104	12626033.69	650119.89
SB-16-105	12626036.40	650487.59
SB-16-107	12626970.66	651242.61
SB-16-108	12627141.77	651239.89
SB-16-109	12628570.32	651049.78
SB-16-110	12626932.64	651305.08
SB-16-111	12627587.17	651421.86

LEGEND

- SB-16-101 — SOIL BORINGS: REFER TO DWG C-02 FOR FOR SOIL DATA
- 5B — PHOSPHORUS SAMPLING LOCATION
- CP — CONTROL POINT LOCATION
- WETLAND

SURVEY NOTE:

1. SURVEY CONTROL IS BASED ON MICHINGAN STATE PLANE SOUTHERN ZONE COORDINATE SYSTEM NAD83.
2. VERTICAL DATUM IS BASED ON NAVD88

N

0 100 200

SCALE: 1" = 100'

For Construction

GEI Consultants
5225 EDGEWATER DRIVE
ALLENDALE, MI 49401
(616)384-2710

WMSRDC
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

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NO.	DATE	ISSUE/REVISION	APP
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STATE OF MICHIGAN
SCOTT B. DIERKS
ENGINEER
No. 44371
PROFESSIONAL ENGINEER

Designed:	B. Majka
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

EXISTING CONDITIONS

GEI Project 1602940

DWG. NO.
C-01

SHEET NO.
3 OF 20

SOIL CORE ID	DEPTH (INCHES)	COLOR	TEXTURE	COMMENTS	SAMPLE ID
P-1	0-18"	BLACK	ORGANIC/TOPSOIL/ROOTS	1.2' STANDING WATER, SAMPLED BELOW BOTTOM OF WATER	1a 0-0.5'
	18"-48"	TAN	FINE-MEDIUM SAND	EOB4	1b 1'
					1c 2'
					1d 3'
P-2	0-8.4"	BLACK	TOPSOIL W/ ORGANICS	2' STANDING WATER	2a 0-0.5'
	8.4-36"	BLACK	PEAT	EOB @ 3'	2b 1'
					2c 2'
					2d 3'
P-3	0-20.4"	BLACK	SILTY ORGANIC TOPSOIL		3a 0-0.5'
	20.4-36"	N/A	FINE SAND		3b 1'
					3c 2'
					3d 3'
P-4	0-20.4"	BROWN	TOPSOIL W/ MEDIUM SAND	ON DIKE	4a 0-0.5'
	20.4-12"	TAN BROWN	SILTY SAND AND GRAVEL	EOB @ 3'	4b 1'
	12-36"	BROWN	SILTY MEDIUM SAND		4c 2'
					4d 3'
P-5	0-18"	BLACK	TOPSOIL/ORGANIC	2' STANDING WATER	5a 0-0.5'
	18-36"	TAN	FINE-MEDIUM SAND	EOB @ 3'	5b 1'
					5c 2'
					5d 3'
P-6	0-24"	BLACK	SILTY TOPSOIL/ORGANICS	EOB @ 3'	6a 0-0.5'
	24-30"	BLACK	PEAT		6b 1'
	30-36"	TAN	FINE-MEDIUM SAND W/ PLANT FRAGS		6c 2'
					6d 3'
P-7	0-6"	BLACK	ORGANIC SOIL W/ ROOTS	3' STANDING WATER	7a 0-0.5'
	6-12"	BROWN	FINE-MEDIUM SAND W/ ORG.	EOB @ 3'	7b 1'
	12-30"	TAN-BROWN	MEDIUM-COARSE SAND		7c 2'
	30-36"	TAN	COARSE SAND W/ WOOD FRAGS		7d 3'
P-8	0-36"	TAN BLACK	FINE -MEDIUM SAND	NO STANDING WATER	8a 0-0.5'
				WATER 2' DOWN	8b 1'
				EOB @ 3'	8c 2'
					8d 3'
P-9	0-18"	BLACK	SILTY TOPSOIL/ORGANICS	2' STANDING WATER	9a 0-0.5'
	18-30"	N/A	SILTY FINE SAND	EOB @ 3'	9b 1'
	30-36"	BROWN	SILTY PEAT		9c 2'
					9d 3'
P-10	0-24"	N/A	SILTY TOPSOIL + ORGANICS	2' STANDING WATER	10a 0-0.5'
	24-36"	N/A	SILTY FINE SAND	EOB @ 3'	10b 1'
					10c 2'
					10d 3'
P-11	0-8.4"	BLACK	TOPSOIL + ORGANICS	EOB @ 3'	11a 0-0.5'
	8.4-36"	TAN	MEDIUM-COARSE SAND	WET @ 1'	11b 1'
					11c 2'
					11d 3'
P-12	0-8.4"	BLACK	TOPSOIL W/ MEDIUM SAND	EOB @ 3'	12a 0-0.5'
	8.4-24"	BLACK	PEAT		12b 1'
	24-30"	TAN	MEDIUM-COARSE SAND		12c 2'
	30-36"	TAN	MEDIUM SAND		12d 3'
P-17	0-12"	TAN-BROWN	SILTY SAND W/ GRAVEL	EOB @ 3'	17a 0-0.5'
	12-36"	TAN-BROWN	SILTY FINE-MEDIUM SAND	ON BERM	17b 1'
					17c 2'
					17d 3'
P-18	0-6"	BROWN	TOPSOIL/ORGANICS	WEST SIDE OF BERM	18a 0-0.5'
	6-12"	BROWN	SILTY FINE SAND, GRAVEL, GLASS FRAGS	EOB @ 3'	18b 1'
	12-24"	BROWN			18c 2'
	24-36"	TAN-BROWN			18d 3'
P-19	0-30"	BROWN	SILT W/ ORGANICS	EOB @ 3'	19a 0-0.5'
	30-36"	TAN	FINE SAND	JUST OFF WEST SIDE BERM	19b 1'
					19c 2'
					19d 3'
P-20	0-30"	BROWN	SILT W/ ORGANICS	PHOTO @ 2'	20a 0-0.5'
	30-36"	TAN	FINE SAND	EOB @ 3'	20b 1'
				1.5' ON STANDING WATER	20c 2'
					20d 3'

SOIL CORE ID	DEPTH (INCHES)	COLOR	TEXTURE	COMMENTS	SAMPLE ID
P-21	0-6"	BLACK	TOPSOIL/ORGANIC ROOT MASS	WEST SIDE OF DIKE @ STAFF GAGE	21a 0-0.5'
	6-36"	BROWN-BLACK	MEDIUM COARSE SAND W/ ORGS, WOOD FRAGS	WET AT 2'	21b 1'
				EOB @ 3'	21c 2'
					21d 3'
P-23	0-6"	N/A	TOPSOIL/ORGANIC W/ MEDIUM COARSE SAND	EOB @ 3'	23a 0-0.5'
	6-30"	TAN	MEDIUM COARSE SAND	SAT @ 0.5'	23b 1'
	30-36"	TAN-BROWN	MEDIUM COARSE SAND W/ ORGANIC AND SHELL FRAGS		23c 2'
					23d 3'
P-24	0-12"	BLACK	ORGANIC TOPSOIL		24a 0-0.5'
	12-24"	TAN-BROWN	FINE SAND	MOIST TO WET, SAT @ 2'	24b 1'
	24-36"	TAN	SILT W/ FINE SAND	EOB @ 3'	24c 2'
					24d 3'
P-25	0-6"	BLACK	ORGANIC/ROOT	EOB @ 3'	17a 0-0.5'
	6-12"	GRAY-BLACK	SILT	2' STANDING WATER	17b 1'
	12-24"	BLACK	MEDIUM-COARSE SAND + PEAT		17c 2'
	24-36"	TAN	FINE SAND		17d 3'
P-26	0-24"	BROWN	SILT W/ FINE SAND, ORGANIC	EOB @ 3'	26a 0-0.5'
	24-36"	TAN-BROWN	FINE-MEDIUM SAND	INSIDE EDGE OF DIKE	26b 1'
				0.5' STANDING WATER	26c 2'
					26d 3'
P-27	0-12"	BLACK	TOPSOIL/ORGANIC ROOT MAT W/ MEDIUM COARSE SAND	EOB @ 3'	27a 0-0.5'
	12-36"	TAN	MEDIUM-COARSE SAND	1.25' STANDING WATER	27b 1'
					27c 2'
					27d 3'
P-28	0-30"	BROWN	SILTY ORGANICS	EOB @ 3'	28a 0-0.5'
	30-36"	TAN-BROWN	FINE SAND	MOVED TO INSIDE EDGE OF BERM DUE TO ACCESS	28b 1'
				1.5' STANDING WATER	28c 2'
					28d 3'
P-29	0-12"	BLACK	TOPSOIL/ORGANIC ROOT MASS	EOB @ 3'	29a 0-0.5'
	12-18"	BLACK	TOPSOIL/ORGANIC ROOT MASS W/ MEDIUM COARSE SAND	1.5' STANDING WATER	29b 1'
	18-36"	TAN	MEDIUM-COARSE SAND		29c 2'
					29d 3'
P-30	0-24"	BLACK	MUCKY TOPSOIL	EOB @ 3'	30a 0-0.5'
	24-36"	TAN	MEDIUM-COARSE SAND	1.5' STANDING WATER, SAMPLED BELOW WATER	30b 1'
					30c 2'
					30d 3'
SB-16-101	0-6"	BLACK-GRAY	SILTY TOPSOIL/ORGANIC	2' STANDING WATER	SB-16-101a 1'
	6-12"	BLACK-GRAY	SILTY TOPSOIL/ORGANIC	EOB @ 2'	SB-16-101b 2'
	12-18"	BLACK-GRAY	SILTY TOPSOIL/ORGANIC		
	18-24"	TAN	FINE-MEDIUM SAND		
SB-16-102	0-6"	BLACK	SILTY TOPSOIL/ORGANICS		SB-16-102a 1'
	6-12"	BLACK	FINE-MEDIUM SAND	EOB @ 2'	SB-16-102b 2'
	12-18"	TAN	FINE-MEDIUM SAND		
	18-24"	TAN	FINE-MEDIUM SAND		
SB-16-103	0-6"	GRAY-BLACK	SILT/ORGANICS	1' STANDING WATER	SB-16-103a 1'
	6-12"	GRAY-BLACK	SILT/ORGANICS	EOB @ 2.5'	SB-16-103b 2.5'
	12-18'	GRAY-BLACK	SILT/ORGANICS		
	18-24"	GRAY	FINE SAND		
	24-30"	GRAY	FINE SAND		
SB-16-104	0-6"	BROWN	FINE SAND W/ SILT/COAL/BRICK	NO WATER AT SURFACE	SB-16-104a 1'
	6-12"	BROWN	FINE SAND W/ SILT/COAL/BRICK	EOB @ 3'	SB-16-104b 3'
	12-18"	BROWN	FINE SAND W/ SILT/COAL/BRICK		
	18-24"	TAN-GRAY	MEDIUM SAND		
	24-30"	DARK GRAY	SILT	WET @ 2'	
	30-36"	DARK GRAY	SILT		
SB-16-105	0-6"	N/A	N/A	2' STANDING WATER	SB-16-105a 1.5'
	6-12"	DARK GRAY/BLACK	SILT W/ FINE SAND	EOB @ 3'	SB-16-10SB 3'
	12-18"	BLACK	PEAT		
	18-24"	BLACK	PEAT		
	24-30"	TAN	FINE SAND		
	30-36"	TAN	SAND		

SOIL CORE ID	DEPTH (INCHES)	COLOR	TEXTURE	COMMENTS	SAMPLE ID
SB-16-106	0-6"	BROWN-BLACK	TOPSOIL/ORGANIC	AT OIL WELL PIPE 100 YDS S OF BARN, WATER @ SURFACE	SB-16-106a 1'
	6-12"	BROWN-BLACK	TOPSOIL/ORGANIC	BOSMA SAYS PIPE MARKS AN OIL WELL	SB-16-106b 2'
	12-18"	BROWN-BLACK	TOPSOIL/ORGANIC	PETRO ODOR	SB-16-106c 2.5'
	18-24"	BROWN-BLACK	TOPSOIL/ORGANIC	PETRO ODOR	SB-16-106d 3'
	24-30"	BROWN-BLACK	SILTY W/ PEAT	STRONG ODOR	
	30-36"	BLACK	SILTY SAND	STRONG ODOR, OILY SHEEN	
	36-42"	TAN	FINE-MEDIUM SAND		
	42-48"	TAN	FINE-MEDIUM SAND	EOB @ 4'	
SB-16-107	0-6"	BLACK	TOPSOIL W/ MEDIUM SAND		SB-16-107a 1'
	6-12"	BLACK	TOPSOIL W/ MEDIUM SAND		SB-16-107b 3'
	12-18"	BLACK	TOPSOIL W/ MEDIUM SAND		
	18-24"	BLACK	TOPSOIL W/ PEAT		
	24-30"	N/A	TOPSOIL W/ PEAT	WOOD @ 2.2'	
	30-36"	TAN	MEDIUM SAND		
SB-16-108	0-6"	BLACK	TOPSOIL/ORGANIC W/ MEDIUM SAND	2' STANDING WATER	SB-16-108a 1.5'
	6-12"	BLACK	TOPSOIL/ORGANIC W/ MEDIUM SAND, WOOD/PEAT	EOB @ 2'	SB-16-108b 2'
	12-18"	BLACK	N/A		
	18-24"	BLACK	N/A	WOOD	
	24-30"	TAN	FINE-MEDIUM SAND		
SB-16-109	0-6"	BLACK-GRAY	SILTY ORGANIC	12" STANDING WATER	SB-16-109A 1'
	6-12"	BLACK-GRAY	SILTY ORGANIC		
	12"-18"	GRAY	GRAY SAND		
	18"-24"	GRAY	GRAY SAND		SB-16-109B 2'
SB-16-110	0-6"	BLACK-GRAY	SILT LOAM		SB-16-110A 1'
	6-12"	BLACK-GRAY	SILT LOAM		
	12-18"	TAN	COARSE SAND		
	18-24"	TAN	COARSE SAND		SB-16-110B 2'
SB-16-111	0-6"	BLACK-GRAY	SILT LOAM		SB-16-111A 1'
	6-12"	BLACK-GRAY	SILT LOAM		
	12-18"	TAN	FINE-MEDIUM SAND		
	18-24"	TAN	FINE-MEDIUM SAND		SB-16-111B 2'
SB-106-1E	0-60"	N/A	ORGANICS/PEAT	6' EAST OF STANDPIPE	SB-106-1E 4-5'
	36"	TAN-GRAY	FINE-MEDIUM SAND	ODOR AND SHEEN	SB-106-1E 7.5-8'
	60-120"	TAN	FINE-MEDIUM SAND	SOME ODOR AND SHEEN	
	72"	N/A	N/A	SHEEN STOPS	
	90"	TAN	MEDIUM-COARSE SAND, GRAVEL	EOB @ 10'	
SB-106-1N	0-60"	N/A	PEAT/ORGANICS	6' NORTH OF STANDPIPE	SB-106-1N 4-5'
	24"	TAN-GRAY	FINE SAND AND SILT		SB-106-1N 7.5-8'
	36"	TAN-GRAY	FINE SAND	SLIGHT ODOR	
	54"	TAN	FINE SAND	CLEAN, NO ODOR, SHEEN	
	60-120"	TAN	FINE-MEDIUM SAND		
	90"	TAN	MEDIUM-COARSE SAND, GRAVEL	EOB @ 10'	
SB-106-1S	0-60"	N/A	PEAT/ORGANICS	7.5' SOUTH OF STANDPIPE, SATURATED	SB-106-1S 4.5-5'
	24"	TAN-GRAY	FINE SAND, GRAVEL	ODOR AND STAINING (PETRO)	SB-106-1S 7.5-8'
	60-120"	TAN	FINE SAND	ODOR	
	90"	TAN	MEDIUM-COARSE SAND	NO ODOR OR SHEEN, EOB @ 10'	
SB-106-1W	0-60"	N/A	PEAT/ORGANICS	6' WEST OF STANDPIPE, SATURATED	SB-106-1W 4.5-5'
	30"	TAN-GRAY	FINE-MEDIUM SAND	SLIGHT SHEEN AND ODOR	SB-106-1W 7.5-8'
	60-120"	TAN	MEDIUM-FINE SAND	SLIGHT ODOR	
	90"	N/A	MEDIUM-COARSE SAND, GRAVEL	NO ODOR, EOB @ 10', 6FT NO ODOR REMAINING	

For Construction

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WMSRDC
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
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0	6/1/2018	JPA DRAWINGS	SD

STATE OF MICHIGAN
SCOTT B. DIERKS
ENGINEER
No. 44371
PROFESSIONAL ENGINEER

Designed:	B. Majka
Checked:	S. Dierks
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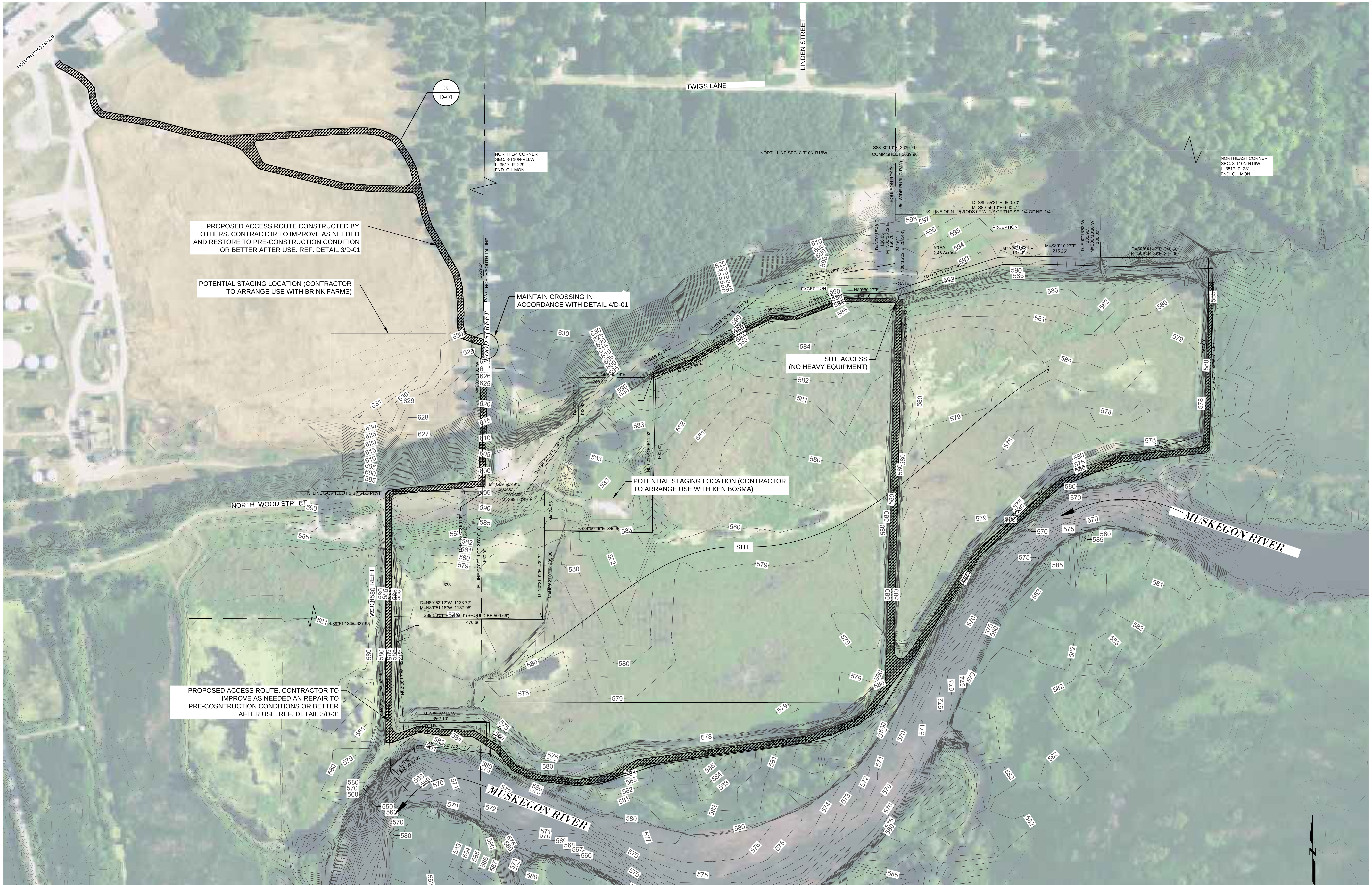
P.E. No.:	*44371*

SOIL BORING DATA

GEI Project 1602940

DWG. NO.
C-02

SHEET NO.
5 OF 20



PROPOSED ACCESS ROUTE

LEGEND

ACCESS ROAD

NOTES:

1. CONTRACTOR MAY CONSTRUCT ACCESS ROADS THROUGHOUT THE SITE AS NEEDED. ALL ACCESS ROADS SHALL BE REMOVED PRIOR TO HYDRAULIC RECONNECTION.
2. CONTRACTOR TO MAINTAIN ACCESS ROADS IN ADEQUATE CONDITION THROUGHOUT THE SITE AND THROUGH THE DURATION OF THE PROJECT.

0 150' 300'

SCALE: 1" = 150'

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PROPOSED ACCESS PLAN

GEI Project 1602940

DWG. NO.
C-03

SHEET NO.
5 OF 20

DEWATERING NOTES:

INSTALLATION

1. The CONTRACTOR shall be responsible for providing all materials, equipment, labor, and services necessary for management of surface and groundwater, including seepage and precipitation.
2. Install a dewatering system to lower and control ground and surface water in order to permit excavation and placement of backfill materials to be performed under dry conditions. Make the dewatering system adequate to pre-drain the water-bearing strata above and below the bottom of utilities and other excavations.
3. CONTRACTOR shall use a dewatering system that extracts groundwater through vacuum wells or other similar mechanism. All extracted water must come from locations outside the horizontal and vertical extents of earth excavation.
4. In addition, reduce hydrostatic pressure head in water-bearing strata below utilities and other excavations, to extent that water levels in the construction area are a minimum of 1 foot below prevailing excavation surface at all times.

WATER DISPOSAL

1. Dispose of water removed from the excavations in such a manner that will not endanger portions of work under construction or completed, and will not cause inconvenience to the OWNER, adjacent landowners, or to others working near the site.
2. All surface water pumped prior to the start of construction activities may be discharged into the Muskegon River.
3. Once construction activities have begun, maintenance pumping must come through the extraction of groundwater that is not directly impacted by earth excavation or construction activities. Clean groundwater may be pumped directly into the Muskegon River.
4. All maintenance dewatering must be disposed of in the manner described above until excavation, fill, and placement of structures is complete.
5. The CONTRACTOR shall be responsible for control of runoff in all work areas including, but not limited to, excavations, access roads, parking area, and staging areas. The CONTRACTOR shall provide, operate, and maintain all ditches, basins, sumps, culverts, site grading, and pumping facilities to divert, collect, and remove all water from the work areas.

OPERATION

1. Prior to any excavation below the ground water table, place system into operation to lower water table as required to facilitate construction.
2. The CONTRACTOR shall be responsible for providing all facilities required to divert, collect, control, and remove water from all construction work areas and excavations. Surface water shall drain away from active excavations.
3. Dewatering equipment shall be provided to remove and dispose of all surface and ground water entering excavations, trenches, or other parts of the work during construction. Each excavation shall be kept dry during subgrade preparation and continually thereafter until the excavation work is completed to the extent that no damage from hydrostatic pressure, flotation, or other cause will result. Water levels in the construction area shall be a minimum of 1 foot below the prevailing excavation surface.
4. In order to maintain embankment stability during pond dewatering a perimeter dike dewatering system shall be of sufficient size and capacity necessary to lower and maintain ground water table to an elevation at least 1 foot below lowest subgrade or bottom of pipe trench along the entire length of the perimeter dike and to allow material within the ponds to be excavated and/or placed in a reasonably dry condition. A dewatering system is not required along the center dike that separates the two ponds as long as the water levels in each pond is lowered at at the same rate and maintained at the same elevation. Materials to be removed shall be sufficiently dry to permit excavation to grades shown and to stabilize excavation slopes where sheeting is not required. Operate dewatering system continuously until backfill work has been completed. Drainage features shall have sufficient capacity to avoid flooding of work areas.
5. Prevent loss of fines, seepage, boils, quick conditions or softening of foundation strata.
6. Maintain stability of sides and bottom of excavation. Control of surface and subsurface water is part of dewatering requirements. Maintain adequate control so that the stability of excavated and constructed slopes are not adversely affected by saturated soil, including water entering prepared subbase and subgrades where underlying materials are not free draining or are subject to swelling or freeze-thaw action.
7. Drainage features shall be so arranged and altered as required to avoid degradation of the final excavated surface(s). The CONTRACTOR shall utilize all necessary erosion and sediment control measures as described herein to avoid construction related degradation of the natural water quality.

STANDBY EQUIPMENT

1. Provide complete standby equipment, installed and available for immediate operation, as may be required to adequately maintain de-watering on a continuous basis and in the event that all or any part of the system may become inadequate or fail.

CORRECTIVE ACTION

1. If dewatering requirements are not satisfied due to inadequacy or failure of the dewatering system, perform work necessary for reinstatement of damages to grading or work in place resulting from such inadequacy or failure by CONTRACTOR, at no additional cost to the OWNER.

DAMAGES

1. Immediately repair damages to any adjacent facilities or properties caused by dewatering operations at no additional cost to the OWNER.

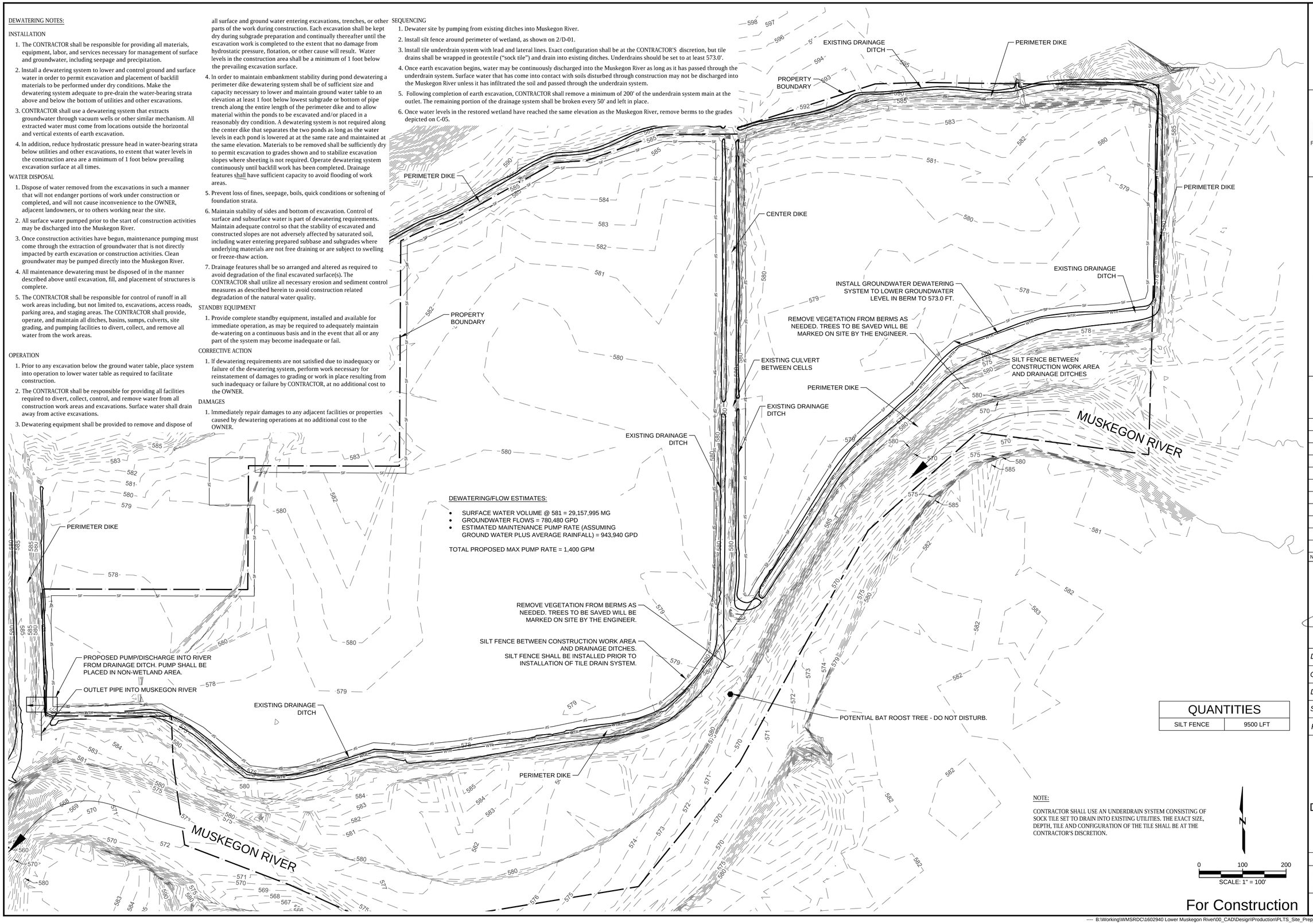
SEQUENCING

1. Dewater site by pumping from existing ditches into Muskegon River.
2. Install silt fence around perimeter of wetland, as shown on 2/D-01.
3. Install tile underdrain system with lead and lateral lines. Exact configuration shall be at the CONTRACTOR'S discretion, but tile drains shall be wrapped in geotextile ("sock tile") and drain into existing ditches. Underdrains should be set to at least 573.0'.
4. Once earth excavation begins, water may be continuously discharged into the Muskegon River as long as it has passed through the underdrain system. Surface water that has come into contact with soils disturbed through construction may not be discharged into the Muskegon River unless it has infiltrated the soil and passed through the underdrain system.
5. Following completion of earth excavation, CONTRACTOR shall remove a minimum of 200' of the underdrain system main at the outlet. The remaining portion of the drainage system shall be broken every 50' and left in place.
6. Once water levels in the restored wetland have reached the same elevation as the Muskegon River, remove berms to the grades depicted on C-05.

DEWATERING/FLOW ESTIMATES:

- SURFACE WATER VOLUME @ 581 = 29,157,995 MG
- GROUNDWATER FLOWS = 780,480 GPD
- ESTIMATED MAINTENANCE PUMP RATE (ASSUMING GROUND WATER PLUS AVERAGE RAINFALL) = 943,940 GPD

TOTAL PROPOSED MAX PUMP RATE = 1,400 GPM



QUANTITIES	
SILT FENCE	9500 LFT

NOTE:

CONTRACTOR SHALL USE AN UNDERDRAIN SYSTEM CONSISTING OF SOCK TILE SET TO DRAIN INTO EXISTING UTILITIES. THE EXACT SIZE, DEPTH, TILE AND CONFIGURATION OF THE TILE SHALL BE AT THE CONTRACTOR'S DISCRETION.

N

0 100 200

SCALE: 1" = 100'

For Construction

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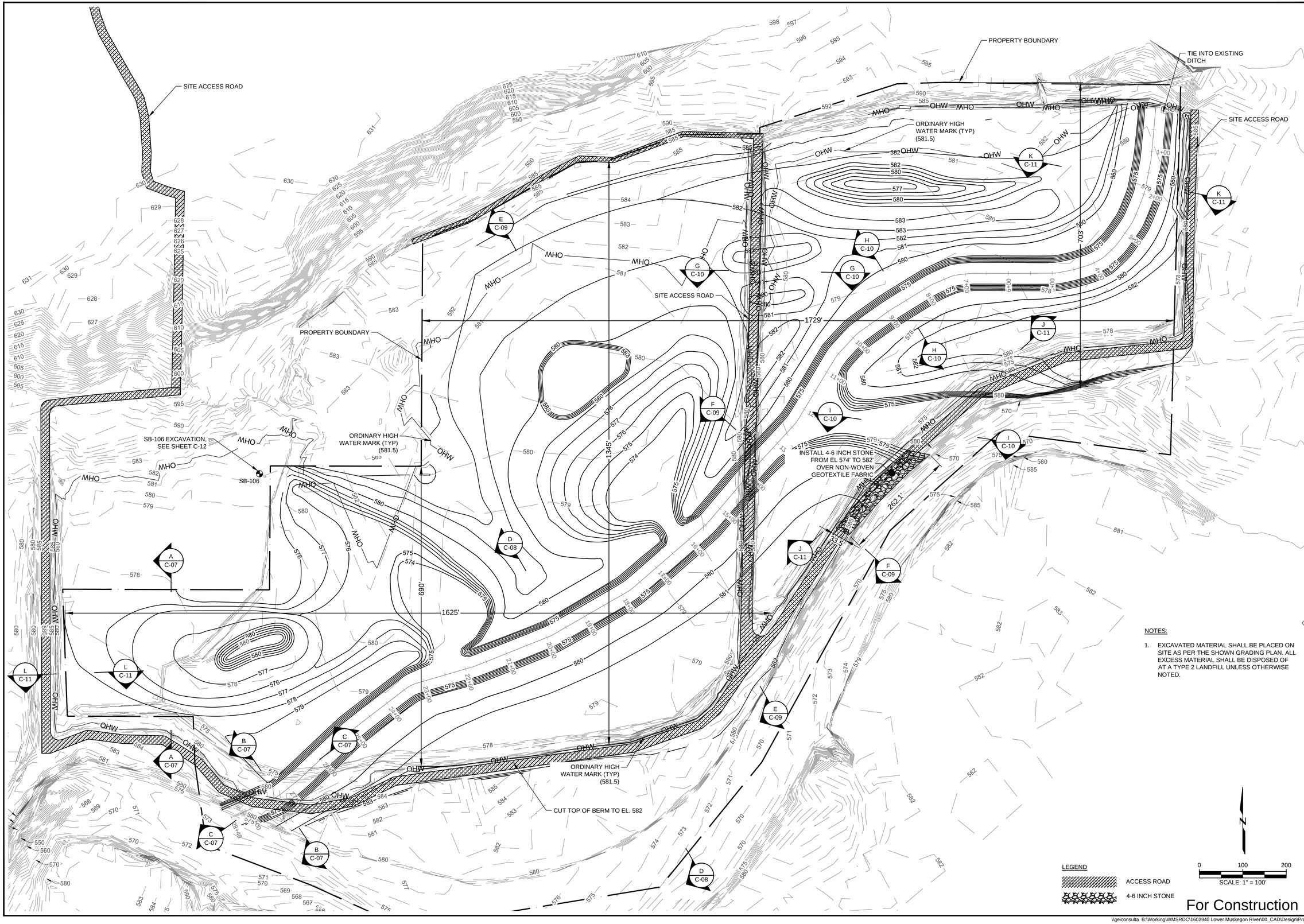
DEMOLITION, SEQUENCING AND DEWATERING PLAN

GEI Project 1602940

DWG. NO.
C-04

SHEET NO.
6 OF 20



NOTES:

1. EXCAVATED MATERIAL SHALL BE PLACED ON SITE AS PER THE SHOWN GRADING PLAN. ALL EXCESS MATERIAL SHALL BE DISPOSED OF AT A TYPE 2 LANDFILL UNLESS OTHERWISE NOTED.

LEGEND

ACCESS ROAD

4-6 INCH STONE

0 100 200

SCALE: 1" = 100'

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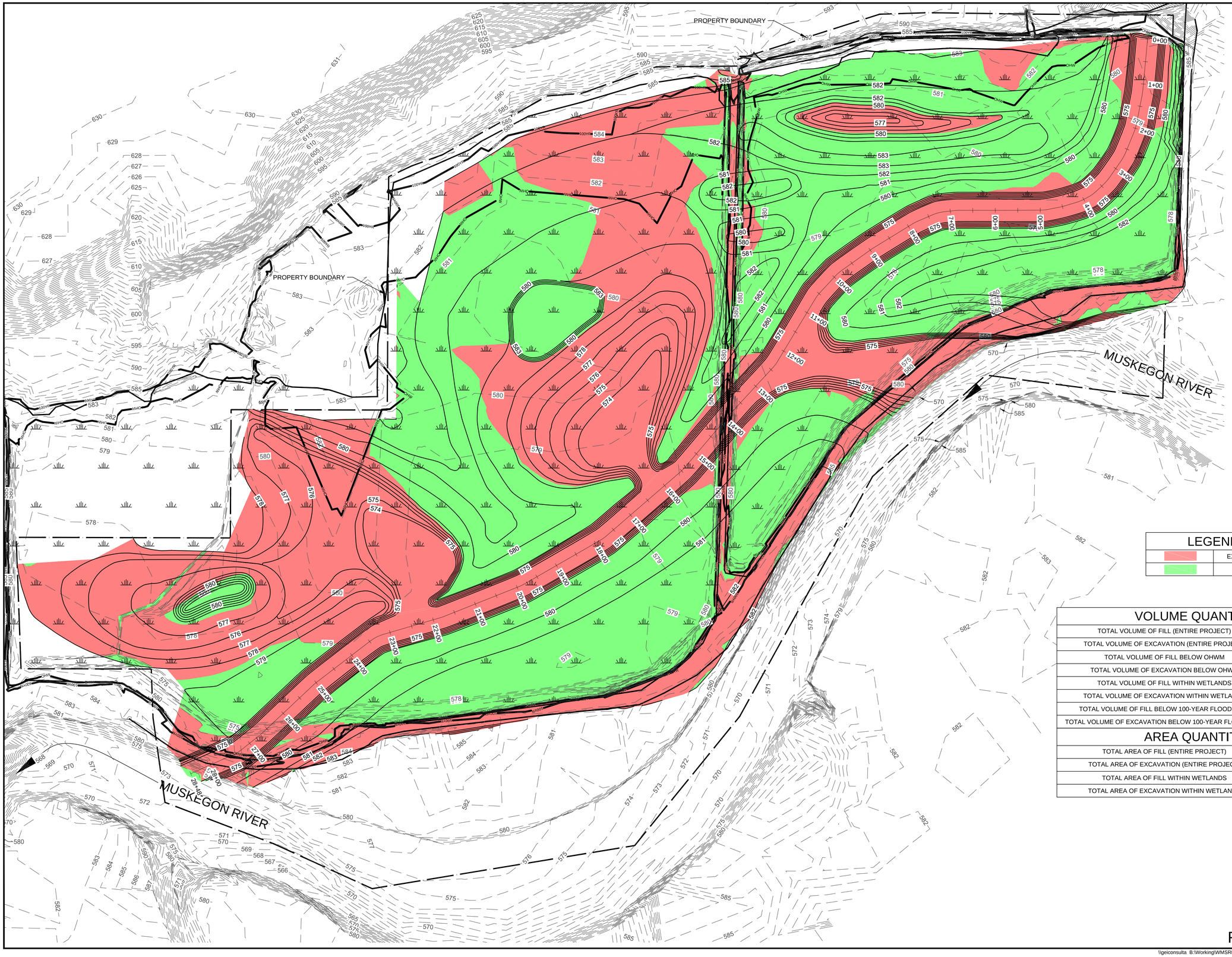
PROPOSED GRADING PLAN

GEI Project 1602940

DWG. NO.
C-05

SHEET NO.
7 OF 20



LEGEND

	EXCAVATION
	FILL

VOLUME QUANTITIES

TOTAL VOLUME OF FILL (ENTIRE PROJECT)	72,200 CYD
TOTAL VOLUME OF EXCAVATION (ENTIRE PROJECT)	101,850 CYD
TOTAL VOLUME OF FILL BELOW OHWM	61,450 CYD
TOTAL VOLUME OF EXCAVATION BELOW OHWM	86,850 CYD
TOTAL VOLUME OF FILL WITHIN WETLANDS	71,650 CYD
TOTAL VOLUME OF EXCAVATION WITHIN WETLANDS	86,600 CYD
TOTAL VOLUME OF FILL BELOW 100-YEAR FLOODPLAIN	72,200 CYD
TOTAL VOLUME OF EXCAVATION BELOW 100-YEAR FLOODPLAIN	95,000 CYD

AREA QUANTITIES

TOTAL AREA OF FILL (ENTIRE PROJECT)	24.8 ACRES
TOTAL AREA OF EXCAVATION (ENTIRE PROJECT)	24.3 ACRES
TOTAL AREA OF FILL WITHIN WETLANDS	24.7 ACRES
TOTAL AREA OF EXCAVATION WITHIN WETLANDS	20.9 ACRES

N

0 100 200

SCALE: 1" = 100'

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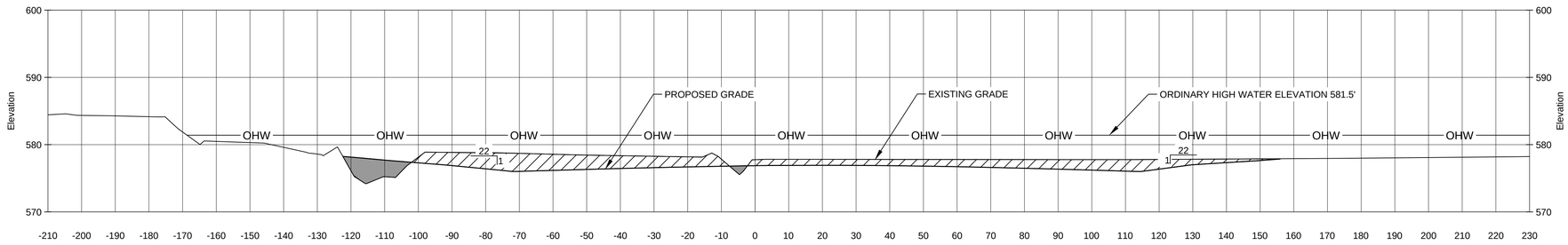
VISUAL DISPLAY OF PROPOSED EXCAVATION AND FILL

GEI Project 1602940

DWG. NO.
C-06

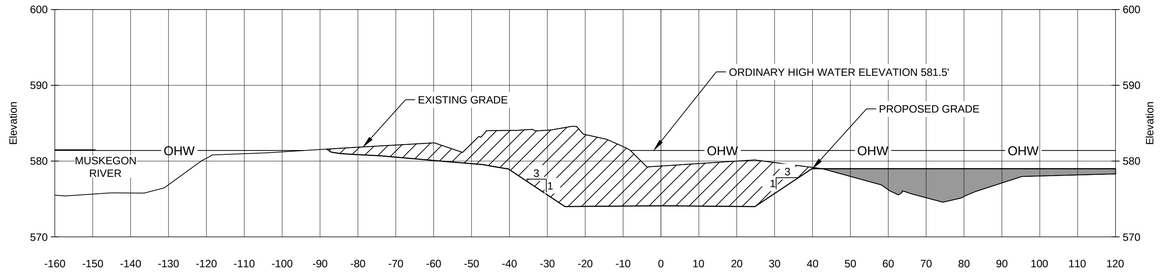
SHEET NO.
8 OF 20



A-A C-05 SECTION STA 28+20
FLOODPLAIN

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

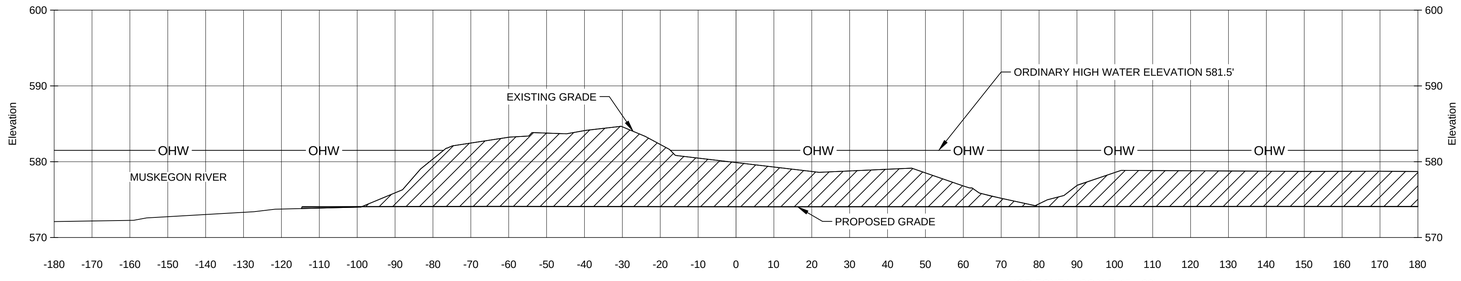
SECTION STA 28+20 EARTH EXCAVATION AREAS	
CUT	700 SFT
FILL	100 SFT



B-B C-05 SECTION STA 27+30
MAIN CHANNEL ENTRANCE

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

SECTION STA 27+30 EARTH EXCAVATION AREAS	
CUT	1215 SFT
FILL	305 SFT



C-C C-05 PROFILE STA 25+50 TO 29+00
MAIN CHANNEL BOTTOM

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

SECTION STA 25+50 TO 29+00 EARTH EXCAVATION AREAS	
CUT	2930 SFT
FILL	5 SFT

LEGEND	
	CUT
	FILL

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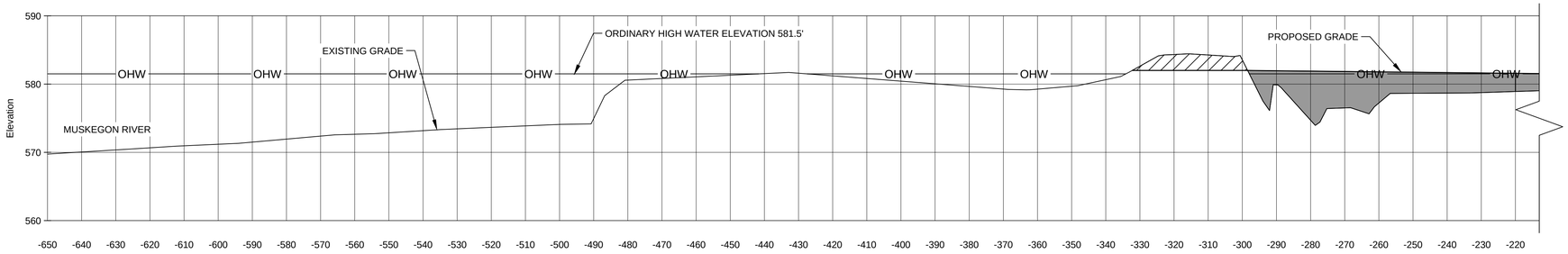
PROPOSED CROSS SECTIONS (1 OF 5)

GEI Project 1602940

DWG. NO.
C-07

SHEET NO.
9 OF 20

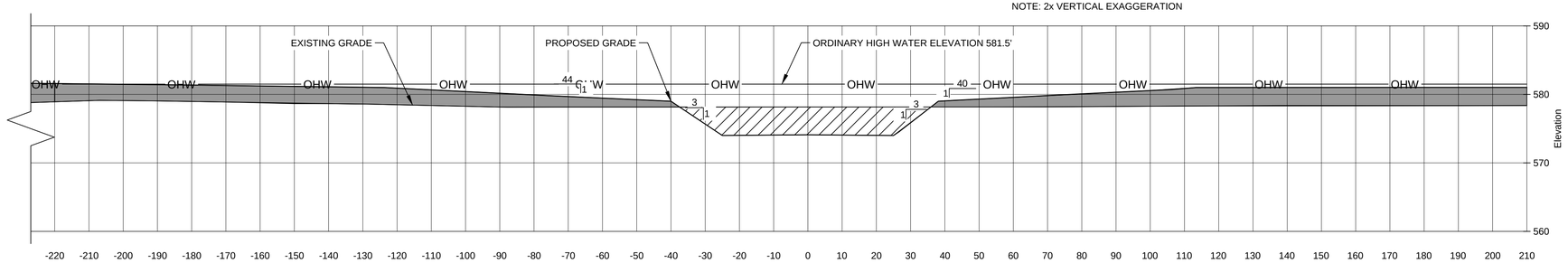


D-D
C-05

SECTION STA 19+50 650' to 220' LEFT OF CL
MAIN CHANNEL BOTTOM

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

SECTION STA 19+50 EARTH EXCAVATION AREAS	
CUT	640 SFT
FILL	2170 SFT



D-D
C-05

SECTION STA 19+50 220' LEFT OF CL TO 210' RIGHT OF CL
MAIN CHANNEL BOTTOM

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

LEGEND	
	CUT
	FILL

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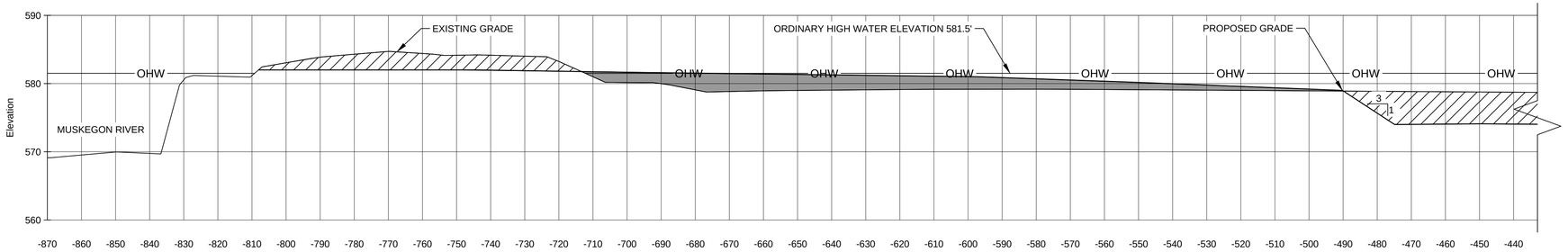
PROPOSED CROSS SECTIONS (2 OF 5)

GEI Project 1602940

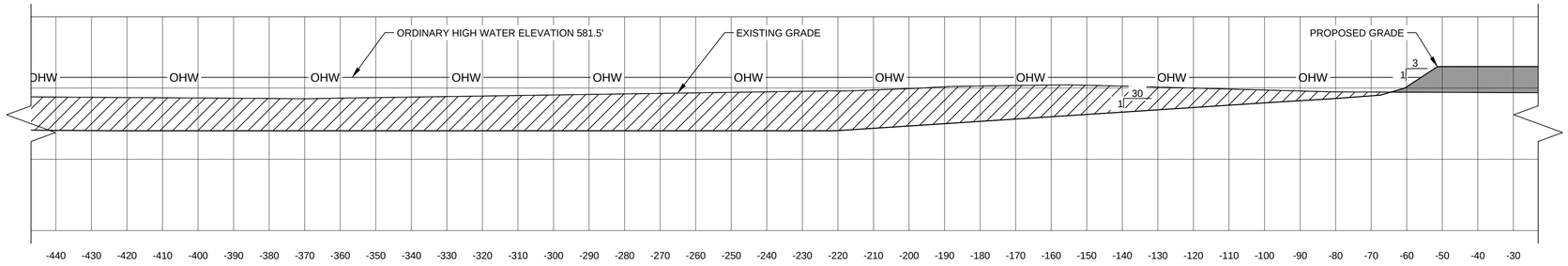
DWG. NO.
C-08

SHEET NO.
10 OF 20



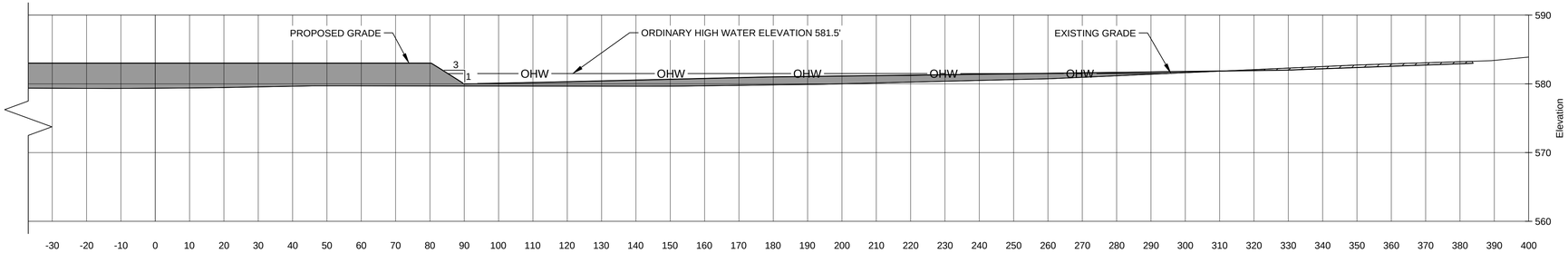
E-E
C-05
SECTION STA 16+20 870' TO 440' LEFT OF CL
FLOODPLAIN

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION



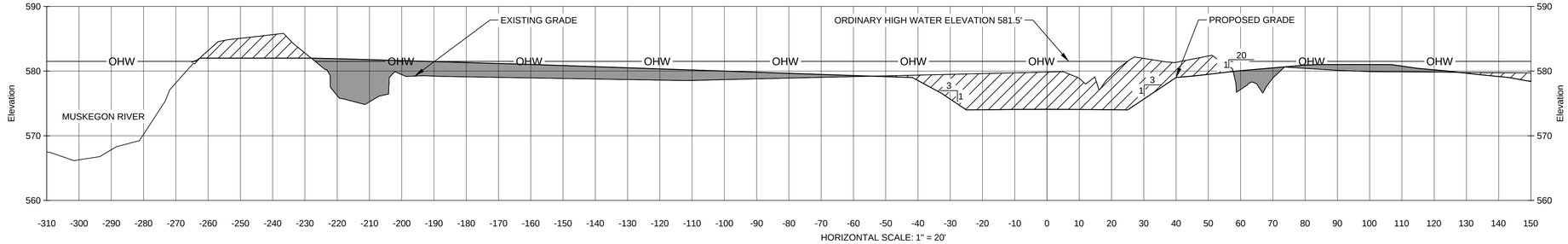
E-E
C-05
SECTION STA 16+20 440' TO 30' LEFT OF CL
FLOODPLAIN

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION



E-E
C-05
SECTION STA 16+20 30' LEFT OF CL TO 400' RIGHT OF CL
FLOODPLAIN

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION



F-F
C-05
SECTION 13+50
MAIN CHANNEL BOTTOM

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

SECTION STA 16+20
EARTH EXCAVATION AREAS

CUT	4000 SFT
FILL	2020 SFT

LEGEND

	CUT
	FILL

SECTION STA 13+50
EARTH EXCAVATION AREAS

CUT	1085 SFT
FILL	845 SFT

For Construction

GEI Consultants
5225 EDGEWATER DRIVE
ALLENDALE, MI 49401
(616)384-2710

WMSRDC
WEST MICHIGAN SHORELINE
REGIONAL DEVELOPMENT COMMISSION

LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

Attention:
0 1"
If this scale bar does not measure 1" then drawing is not original scale.

NO.	DATE	ISSUE/REVISION	APP
2	12/6/2018	CONSTRUCTION DRAWINGS	SD
1	11/16/2018	JPA DRAWINGS	SD
0	6/1/2018	JPA DRAWINGS	SD

STATE OF MICHIGAN
SCOTT B. DIERKS
ENGINEER
No. 44371
PROFESSIONAL ENGINEER
LICENSED

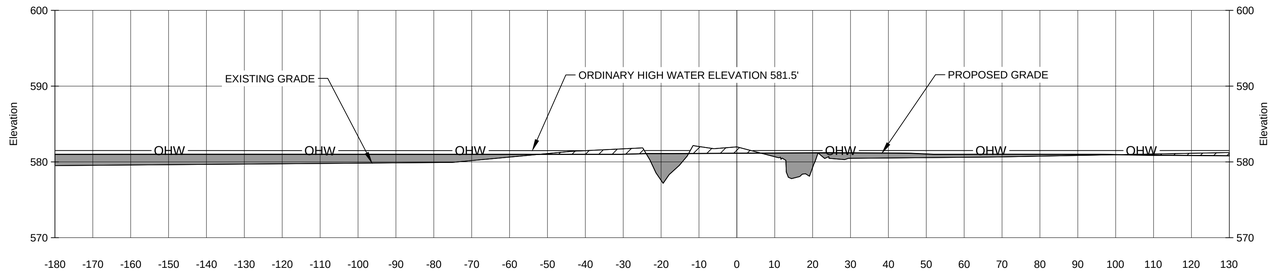
Designed:	B. Majka
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

PROPOSED CROSS SECTIONS (3 OF 5)

GEI Project 1602940

DWG. NO.
C-09

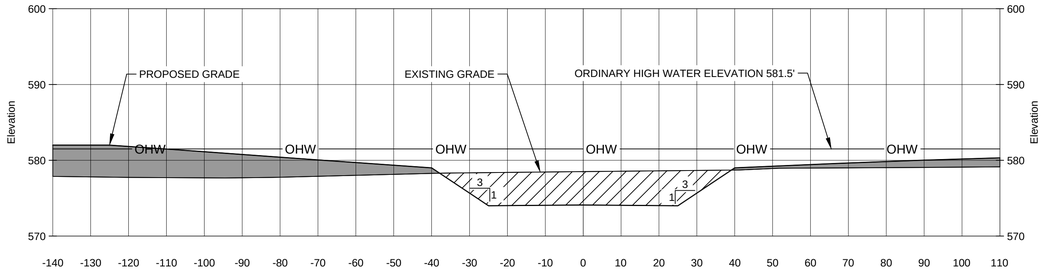
SHEET NO.
11 OF 20



G-G C-05 SECTION 12+70
FLOODPLAIN

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

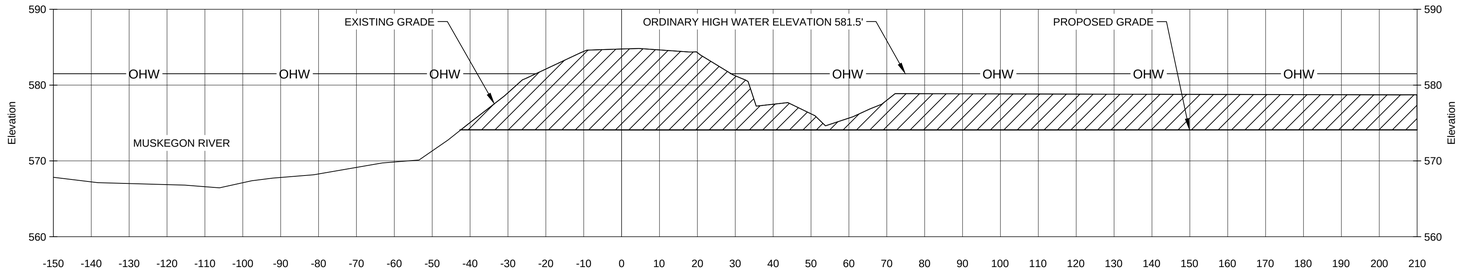
SECTION STA 12+70 EARTH EXCAVATION AREAS	
CUT	65 SFT
FILL	455 SFT



H-H C-05 SECTION 8+60
MAIN CHANNEL BOTTOM

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

SECTION STA 8+60 EARTH EXCAVATION AREAS	
CUT	570 SFT
FILL	680 SFT



I-I C-05 SECTION 12+00
MAIN CHANNEL ENTRANCE

HORIZONTAL SCALE: 1" = 20'
0 20 40
0 10 20
VERTICAL SCALE: 1" = 10'
NOTE: 2x VERTICAL EXAGGERATION

SECTION STA 12+00 EARTH EXCAVATION AREAS	
CUT	2730 SFT
FILL	0 SFT

LEGEND	
	CUT
	FILL

For Construction

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5225 EDGEWATER DRIVE
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REGIONAL DEVELOPMENT COMMISSION

LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

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STATE OF MICHIGAN
SCOTT B. DIERKS
ENGINEER
No. 44371
LICENSED PROFESSIONAL ENGINEER

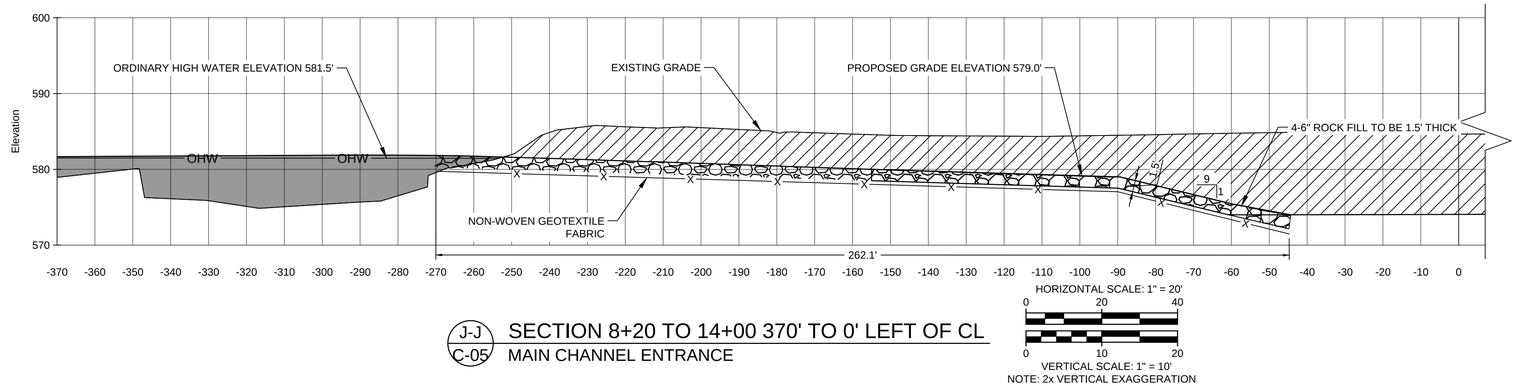
Designed:	B. Majka
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

PROPOSED CROSS SECTIONS (4 OF 5)

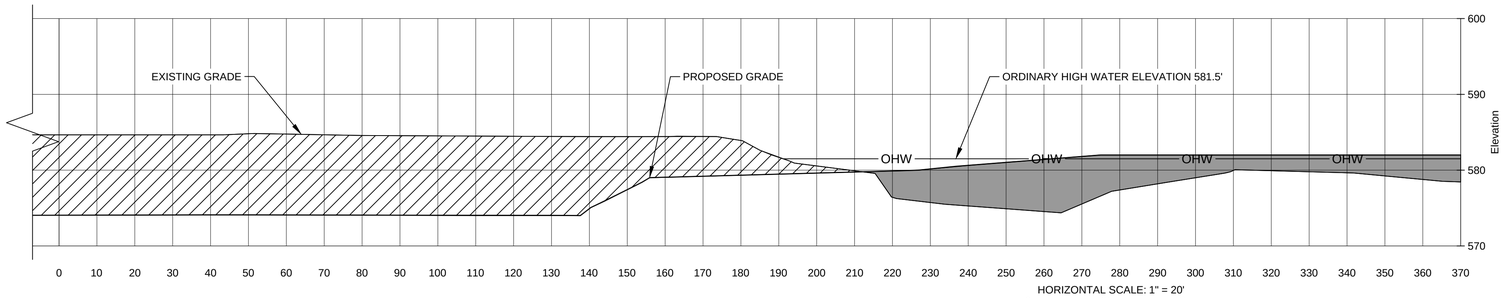
GEI Project 1602940

DWG. NO.
C-10

SHEET NO.
12 OF 20



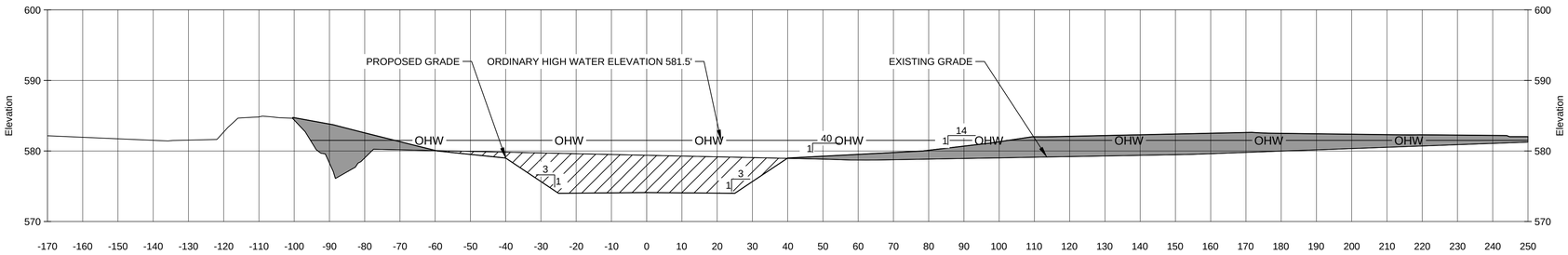
J-J / C-05 SECTION 8+20 TO 14+00 370' TO 0' LEFT OF CL
MAIN CHANNEL ENTRANCE



J-J / C-05 SECTION 8+20 TO 14+00 0' TO 370' RIGHT OF CL
MAIN CHANNEL ENTRANCE

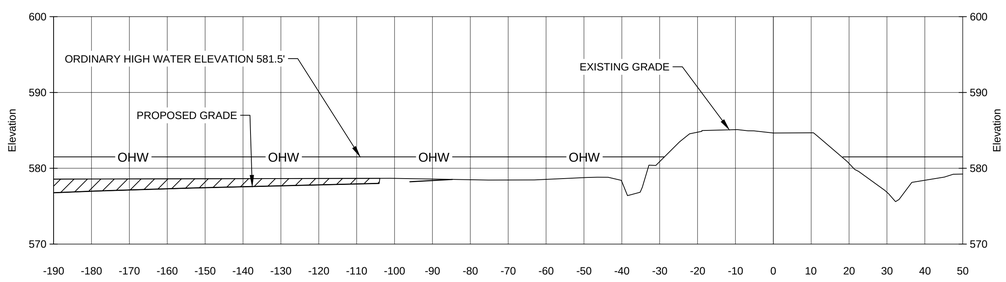
LEGEND	
	CUT
	FILL

SECTION STA 8+20 TO 14+00 EARTH EXCAVATION AREAS	
CUT	6715 SFT
FILL	2260 SFT



K-K / C-05 SECTION 1+70
FLOODPLAIN

SECTION STA 1+70 EARTH EXCAVATION AREAS	
CUT	725 SFT
FILL	1045 SFT



L-L / C-05 SECTION
ACCESS ROAD

SECTION EARTH EXCAVATION AREAS	
CUT	205 SFT
FILL	0 SFT

For Construction

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WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

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STATE OF MICHIGAN · SCOTT B. DIERKS · ENGINEER · No. 44371 · LICENSED PROFESSIONAL ENGINEER

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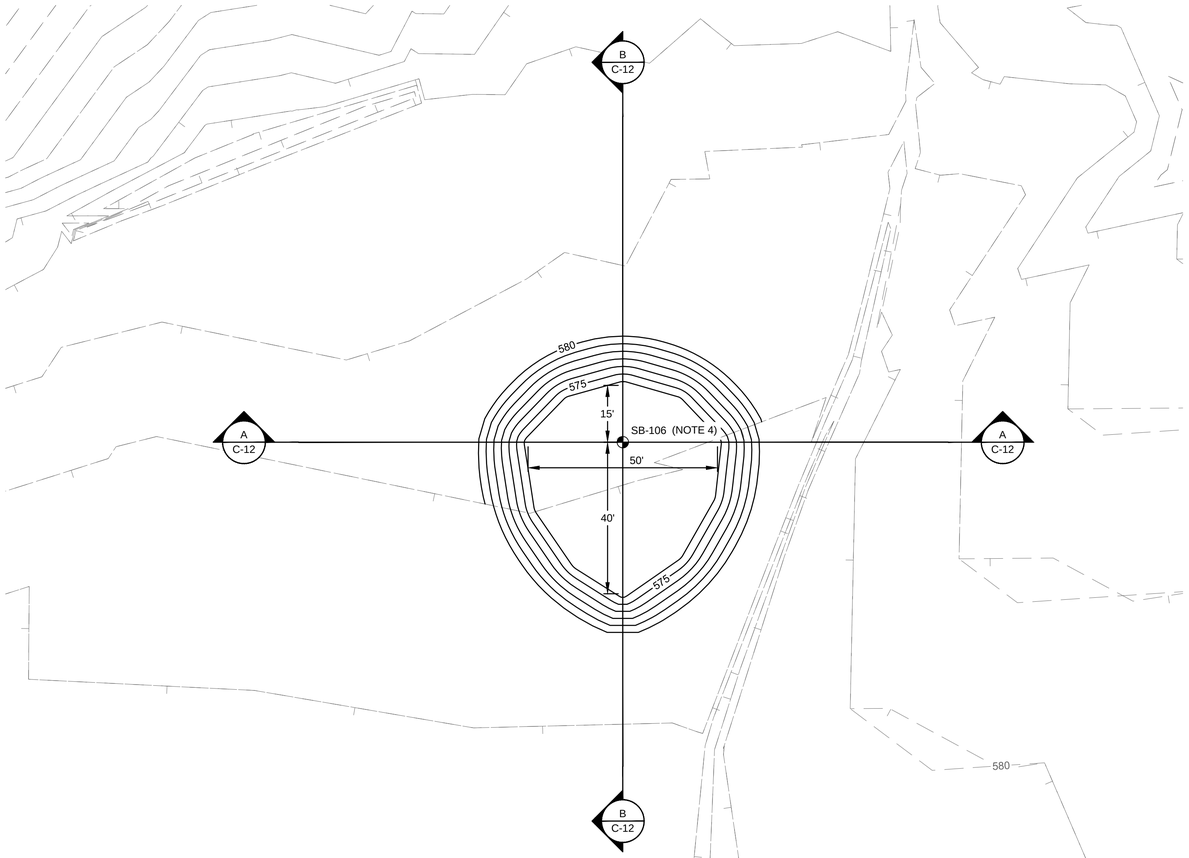
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

PROPOSED CROSS SECTIONS (5 OF 5)

GEI Project 1602940

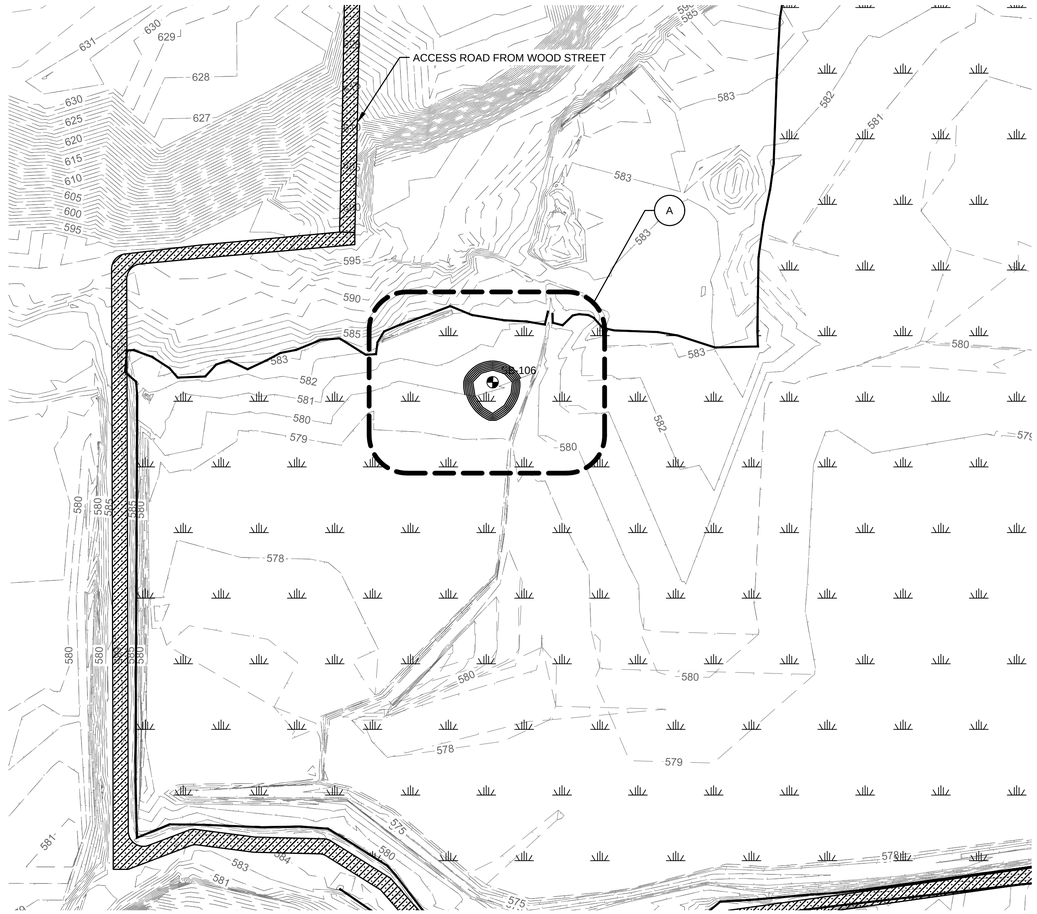
DWG. NO.
C-11

SHEET NO.
13 OF 20



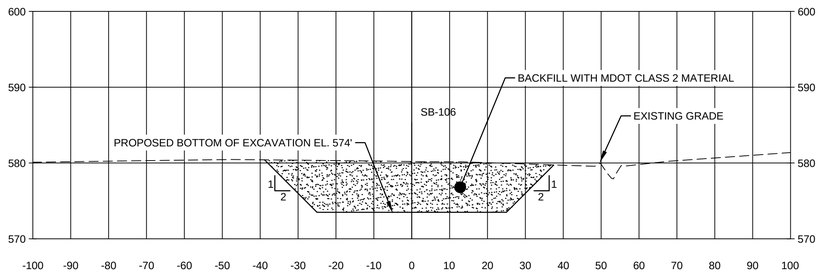
A DETAIL
\- SB-106 EXCAVATION

0 20 40
SCALE: 1" = 20'



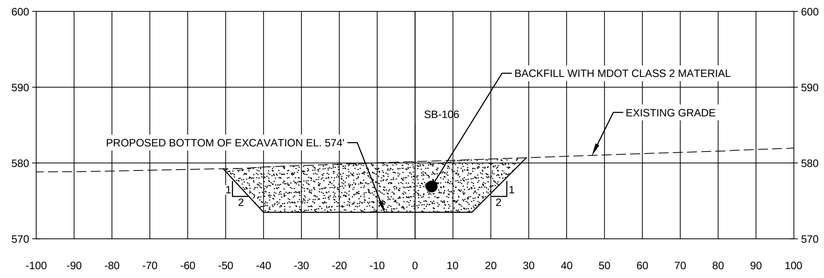
SB-106 SITE LOCATION
PLAN

0 100 200
SCALE: 1" = 100'



A-A C-12 SECTION
SB-106 EXCAVATION

0 20 40
SCALE: 1" = 20'



B-B C-12 SECTION
SB-106 EXCAVATION

0 20 40
SCALE: 1" = 20'

QUANTITIES	
EXCAVATION	775 CYD
FILL	775 CYD

NOTES:

1. SOIL AT THIS LOCATION CONTAINS SEVERAL CONTAMINANTS THAT EXCEED MDEQ PART 201 CLEANUP CRITERIA. SOIL RESULTS ARE INCLUDED IN THE SPECIFICATIONS.
2. SOIL EXCAVATED AT THE LOCATION SHOWN ON THIS SHEET SHALL BE DISPOSED OF AS HAZARDOUS WASTE AT A TYPE 2 LANDFILL.
3. CONTRACTOR SHALL TAKE ALL NECESSARY SAFETY PRECAUTIONS, INCLUDING BUT NOT LIMITED TO THOSE DESCRIBED IN THE SPECIFICATIONS.
4. BORING SB-106 IS LOCATED AT 650,669.97 N, 12,626,470.86 E

For Construction

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5225 EDGEWATER DRIVE
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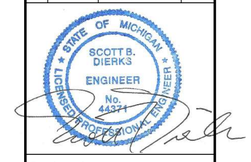

Designed:	B. Majka
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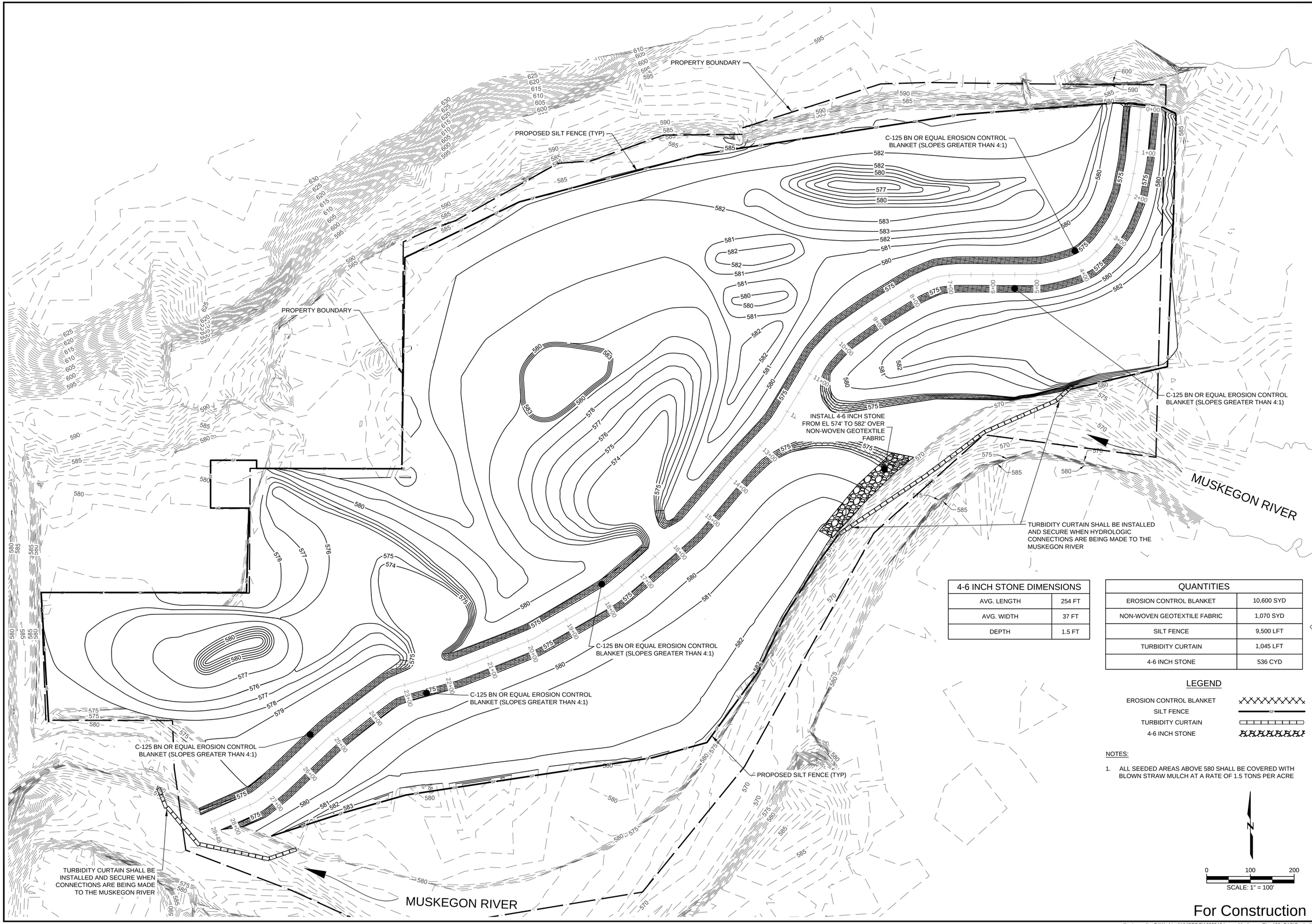
SB-106 SOIL REMOVAL DIAGRAM

GEI Project 1602940

DWG. NO.
C-12

SHEET NO.
14 OF 20

---- B:\Working\WMSRDC\1602940 Lower Muskegon River\00_CAD\Design\Production\PLTS_SB-106_Soil_Removal-C-12.dwg - 12/4/2018



4-6 INCH STONE DIMENSIONS	
AVG. LENGTH	254 FT
AVG. WIDTH	37 FT
DEPTH	1.5 FT

QUANTITIES	
EROSION CONTROL BLANKET	10,600 SYD
NON-WOVEN GEOTEXTILE FABRIC	1,070 SYD
SILT FENCE	9,500 LFT
TURBIDITY CURTAIN	1,045 LFT
4-6 INCH STONE	536 CYD

LEGEND

EROSION CONTROL BLANKET

SILT FENCE — SF

TURBIDITY CURTAIN

4-6 INCH STONE

NOTES:

1. ALL SEEDED AREAS ABOVE 580 SHALL BE COVERED WITH BLOWN STRAW MULCH AT A RATE OF 1.5 TONS PER ACRE

N

0 100 200

SCALE: 1" = 100'

For Construction

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WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

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STATE OF MICHIGAN · SCOTT B. DIERKS · ENGINEER · No. 44371 · PROFESSIONAL ENGINEER

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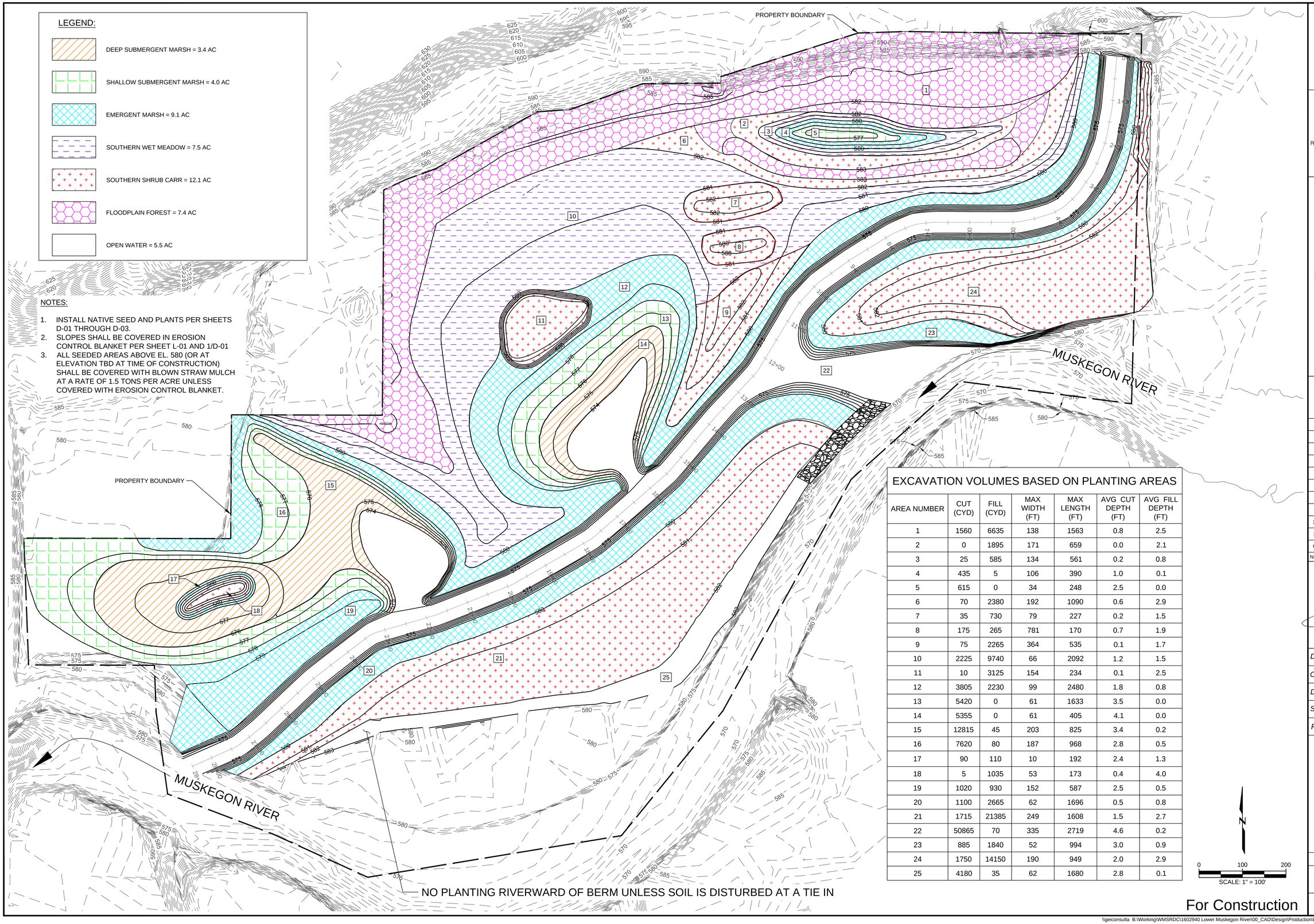
SOIL EROSION AND SEDIMENTATION CONTROL PLAN

GEI Project 1602940

DWG. NO.
L-01

SHEET NO.
15 OF 20



EXCAVATION VOLUMES BASED ON PLANTING AREAS

AREA NUMBER	CUT (CYD)	FILL (CYD)	MAX WIDTH (FT)	MAX LENGTH (FT)	AVG CUT DEPTH (FT)	AVG FILL DEPTH (FT)
1	1560	6635	138	1563	0.8	2.5
2	0	1895	171	659	0.0	2.1
3	25	585	134	561	0.2	0.8
4	435	5	106	390	1.0	0.1
5	615	0	34	248	2.5	0.0
6	70	2380	192	1090	0.6	2.9
7	35	730	79	227	0.2	1.5
8	175	265	781	170	0.7	1.9
9	75	2265	364	535	0.1	1.7
10	2225	9740	66	2092	1.2	1.5
11	10	3125	154	234	0.1	2.5
12	3805	2230	99	2480	1.8	0.8
13	5420	0	61	1633	3.5	0.0
14	5355	0	61	405	4.1	0.0
15	12815	45	203	825	3.4	0.2
16	7620	80	187	968	2.8	0.5
17	90	110	10	192	2.4	1.3
18	5	1035	53	173	0.4	4.0
19	1020	930	152	587	2.5	0.5
20	1100	2665	62	1696	0.5	0.8
21	1715	21385	249	1608	1.5	2.7
22	50865	70	335	2719	4.6	0.2
23	885	1840	52	994	3.0	0.9
24	1750	14150	190	949	2.0	2.9
25	4180	35	62	1680	2.8	0.1

For Construction

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LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

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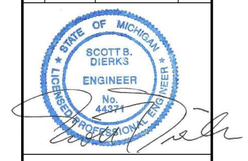

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P.E. No.:	*44371*

LANDSCAPING PLAN

GEI Project 1602940

DWG. NO.
L-02

SHEET NO.
16 OF 20

LEGEND:

- ELEVATION 574 - 576: DEEP SUBMERGENT MARSH
- ELEVATION 576 - 578: SHALLOW SUBMERGENT MARSH
- ELEVATION 578 - 580: EMERGENT MARSH
- ELEVATION 580 - 582: SOUTHERN SHRUB CARR
- ELEVATION 580 - 582: SOUTHERN WET MEADOW
- ELEVATION 582 - 583: FLOODPLAIN FOREST
- INVERTED ROOT WAD
- FREE STANDING SNAG
- ROOT WAD
- LOG STRUCTURE
- BRUSH OR LOG PILE
- OSPREY PLATFORM
- REPTILE HIBERNACULA
- 1 / D-02 DETAIL CALLOUT

PROPERTY BOUNDARY

MUSKEGON RIVER

1 D-02 · 2 D-02 · 3 D-02 · 4 D-02 · 5 D-02 · 7 D-01 · 5 D-01

0 100 200
SCALE: 1" = 100'

For Construction

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STATE OF MICHIGAN · SCOTT B. DIERKS · ENGINEER · No. 44371 · PROFESSIONAL ENGINEER

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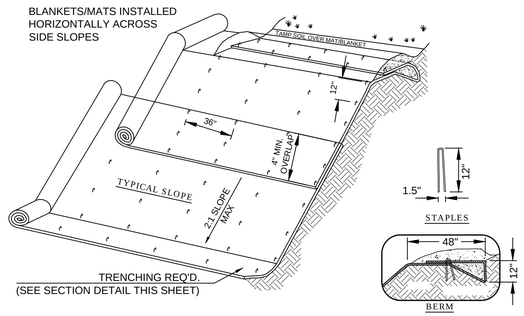
P.E. No.:	*44371*

WILDLIFE HABITAT STRUCTURES

GEI Project 1602940

DWG. NO.
L-03

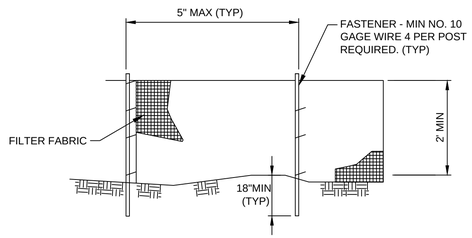
SHEET NO.
17 OF 20



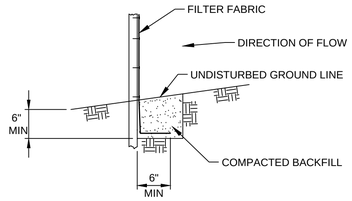
NOTES:

1. SLOPE SURFACE SHALL BE FREE OF ROCKS, CLODS, STICKS AND GRASS.
2. APPLY PERMANENT SEEDING BEFORE PLACING BLANKETS
3. LAY BLANKETS LOOSELY AND STAKE OR STAPLE TO MAINTAIN DIRECT CONTACT WITH THE SOIL. DO NOT STRETCH.

1 / L-01 — DETAIL - EROSION CONTROL BLANKET
NAG C-125BN OR EQUAL



ELEVATION

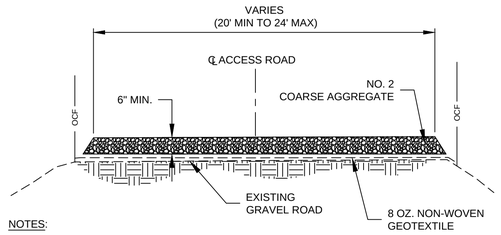


FABRIC ANCHOR DETAIL

NOTES:

1. TEMPORARY SEDIMENT FENCE SHALL BE INSTALLED PRIOR TO ANY GRADING WORK IN THE AREA TO BE PROTECTED. IT SHALL BE MAINTAINED THROUGHOUT THE CONSTRUCTION PERIOD AND REMOVED IN CONJUNCTION WITH THE FINAL GRADING AND SITE STABILIZATION.
2. FILTER FABRIC SHALL MEET THE REQUIREMENTS OF MATERIAL SPECIFICATION 592 GEOTEXTILE TABLE 1 OR 2, CLASS L WITH EQUIVALENT OPENING SIZE OF AT LEAST 30 FOR NONWOVEN AND 50 FOR WOVEN.
3. FENCE POSTS SHALL BE EITHER WOOD POST WITH A MINIMUM CROSS-SECTIONAL AREA OF 3.0 SQ. IN. OR A STANDARD STEEL POST.

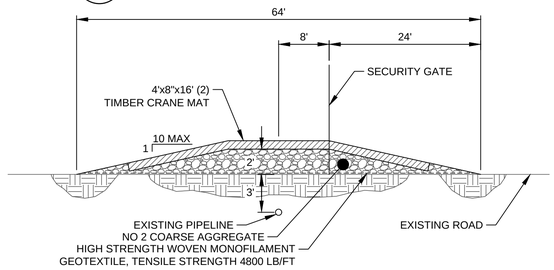
2 / - — DETAIL - SILT FENCE



NOTES:

1. IMPROVED ACCESS ROAD SHALL BE AS SHOWN OR AS APPROVED BY ENGINEER.
2. ACCESS ROAD TO BE CONSTRUCTED BY OTHERS. CONTRACTOR SHALL BE RESPONSIBLE FOR RESTORATION OF ACCESS ROADS TO PRE-CONSTRUCITON CONDITIONS AFTER CONSTRUCTION.
3. WIDTH OF IMPROVED ACCESS ROAD SHALL ALLOW FOR 1-WAY OR 2-WAY TRAFFIC AS NEEDED, OR AS LIMITED BY EXISTING ROADS.
4. PULLOFFS SHALL ALLOW FOR HAUL TRAFFIC TO PASS WHEN MEETING ON 1-WAY ROADS.

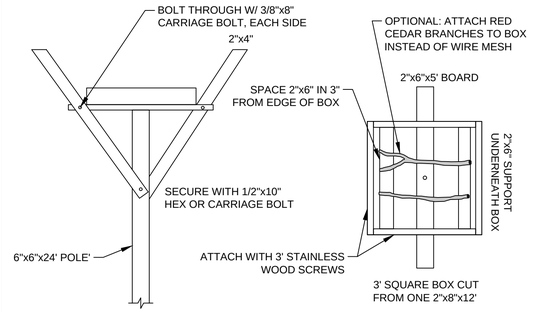
3 / C-03 — DETAIL - IMPROVED ACCESS ROAD

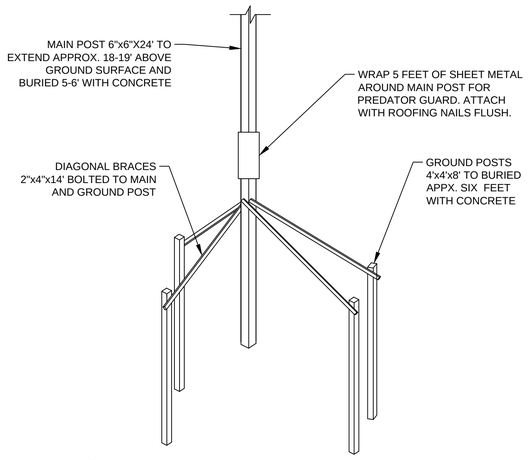


NOTES:

1. PIPELINE CROSSING TO BE CONSTRUCTED BY OTHERS. CONTRACTOR SHALL BE RESPONSIBLE FOR RESTORATION OF ACCESS ROADS TO PRE-CONSTRUCITON CONDITIONS AFTER CONSTRUCTION.
2. MAINTAIN A MINIMUM AGGREGATE THICKNESS OF 18" OVER PIPE AT ALL TIMES.

4 / C-03 — DETAIL - PIPELINE CROSSING

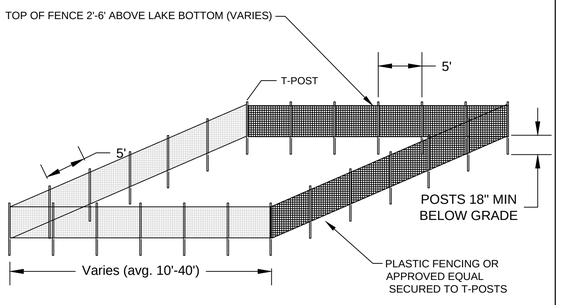




NOTE:

1. USE TREATED OR CEDAR LUMBER AND GALVANIZED HARDWARE

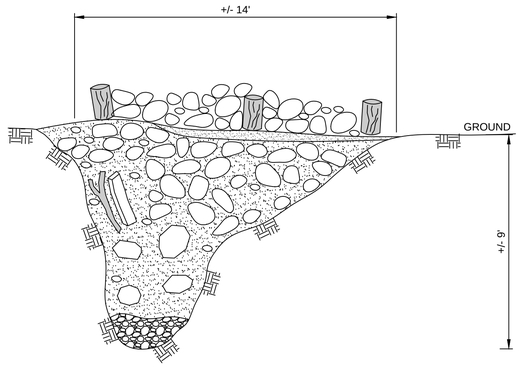
5 / L-03 — DETAIL - OSPREY PLATFORM



NOTES:

1. EXCLUSIONARY MEASURES SHALL CONSIST OF PLASTIC FENCING OR APPROVED EQUAL SECURED WITH 6' T-POSTS ON 5 FOOT INTERVALS. NETTING SHALL SURROUND INDIVIDUAL PLANT PODS. SET FENCE BOTTOM AT WETLAND BOTTOM, TOP OF FENCE MUST BE ABOVE SURFACE WATER ELEVATION THROUGHOUT THE DURATION OF THE GROWING SEASON. PODS NEED NOT BE PRECISELY SQUARE SHAPED--EXACT SIZE AND SHAPE MAY VARY. EXCLUSIONARY MEASURES SHALL REMAIN FOR 1 GROWING SEASON FOLLOWING PLANT INSTALLATION AND SHALL BE REMOVED DURING THE SEPTEMBER/OCTOBER FOLLOWING INSTALLATION.ALL EMERGENT PLANTINGS SHALL BE ENCLOSED IN PODS, AS SHOWN ON PLANS. EXACT SIZE AND QUANTITY OF PODS MAY VARY TO ACCOMMODATE ACTUAL SITE CONDITIONS.

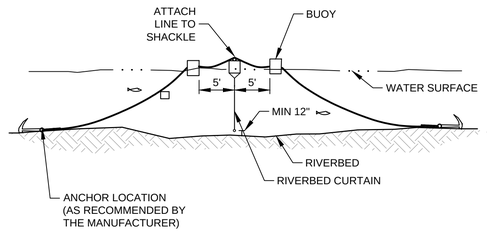
6 / - — DETAIL - ANIMAL EXCLUSION FENCING



NOTES:

1. THE HIBERNACULUM CAN BE SIZED TO FIT THE AVAILABLE SPACE WITH ENGINEER APPROVAL BUT MUST BE DEEPER THAN THE FROST LINE, APPROXIMATELY 8-9' DEEP.
2. SIDE SLOPE OF EXCAVATION SHOULD VARY BUT AND SHOULD BE MINIMUM OF 1H:1V. STEEP SIDE SLOPES CAN ALLOW COLD AIR TO SINK AND SETTLE, CREATING UNFAVORABLE TEMPERATURES WITHIN THE HIBERNACULUM.
3. PLACE LAYER OF 2-4" GRAVEL OF VARYING DEPTH (6"-1.5') AT THE BOTTOM OF THE HOLE.
4. ON TOP OF THE GRAVEL, PLACE CLEAN RUBBLE (OLD CINDER BLOCKS WITH OPENINGS, CONCRETE SLABS, 12-18" ANGULAR STONE), STUMPS, AND LARGE BRANCHES AT VARIOUS ANGLES UP TO THE APPROXIMATE FROST LINE OF 3' FROM THE SURFACE. PLACE MATERIAL TO CREATE OPENINGS AND CHAMBERS THROUGHOUT. IF NECESSARY, HAND PLACE THE MATERIALS TO ENSURE THAT A SPACE OR TUNNEL EXTENDS DOWN INTO THE BOTTOM OF THE PIT AT EACH OF THE CORNERS. CONTINUE TO FILL THE PIT WHILE MAINTAINING AS MANY OPENINGS AND CHAMBERS AS POSSIBLE.
5. PLACE AN INSULATING LAYER OF SMALLER ROCK (2"-12") AND BRANCHES/LOGS (2"-12" DIAMETER) FROM APPROXIMATELY 3' BELOW THE SURFACE TO THE GROUND SURFACE. BE SURE TO LEAVE THE ENTRANCES OPEN AND KEEP THE TOP CLEAR OF SHRUBS THAT MAY GROW AS THE SITE MATURES.
6. CAP THE HIBERNACULUM WITH BRANCH AND LOG (2"-12" DIAMETER) DEBRIS CREATING A 2'-3' TALL "BRUSH PILE".
7. THE ENGINEER MUST BE ON SITE DURING CONSTRUCTION.

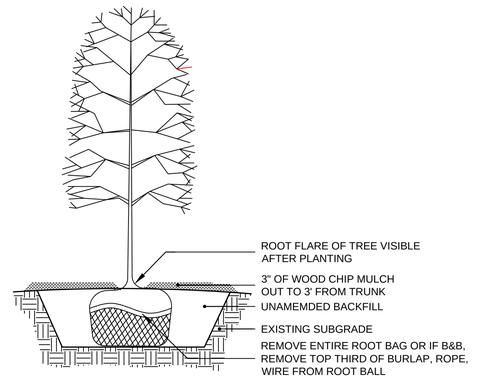
7 / L-03 — DETAIL - REPTILE HIBERNACULA



NOTES:

1. FLOATING TURBIDITY BARRIER CONSTRUCTION SHALL CONFORM WITH RELEVANT LOCAL AND STATE STANDARDS FOR SOIL EROSION AND SEDIMENT CONTROL.
2. FLOATING TURBIDITY BARRIER WILL BE INSPECTED AND MAINTAINED DAILY.

8 / L-01 — DETAIL - FLOATING TURBIDITY CURTAIN



NOTE:

1. WOOD CHIP MULCH WILL ONLY BE PLACED AROUND 2" DBH TREES.

9 / - — DETAIL - TREE/SHRUB INSTALLATION

For Construction

GEI Consultants
5225 EDGEWATER DRIVE
ALLENDALE, MI 49401
(616)384-2710

WMSRDC
WEST MICHIGAN SHORELINE REGIONAL DEVELOPMENT COMMISSION

LOWER MUSKEGON RIVER HYDROLOGIC RECONNECTION

Attention:
0 — 1"
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1	11/16/2018	JPA DRAWINGS	SD
0	6/1/2018	JPA DRAWINGS	SD

STATE OF MICHIGAN — SCOTT B. DIERKS — ENGINEER — No. 44371 — LICENSED PROFESSIONAL ENGINEER

Designed:	B. Majka
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

DETAILS
(1 OF 2)

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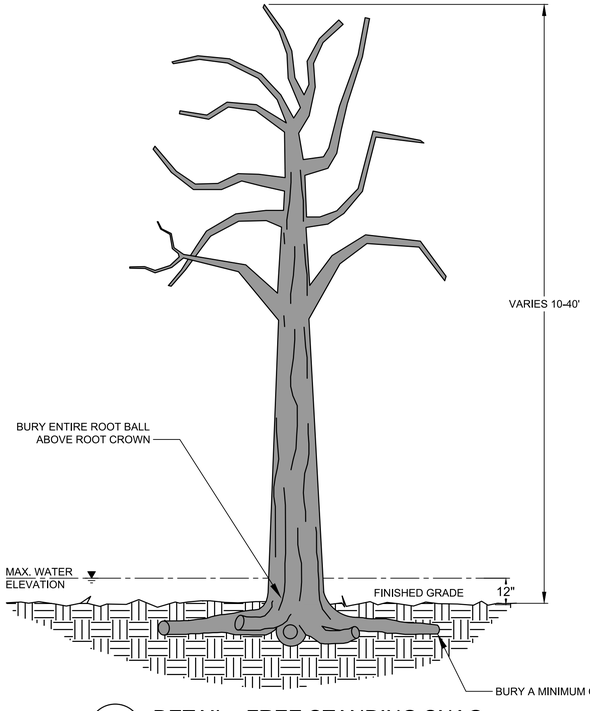
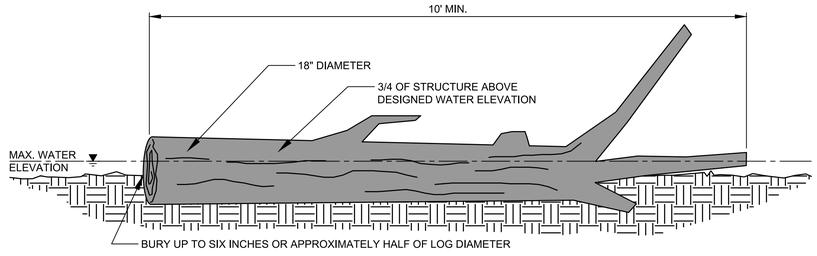
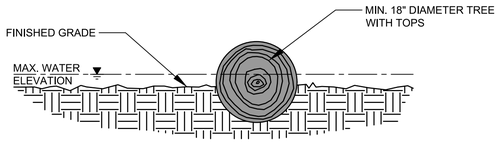


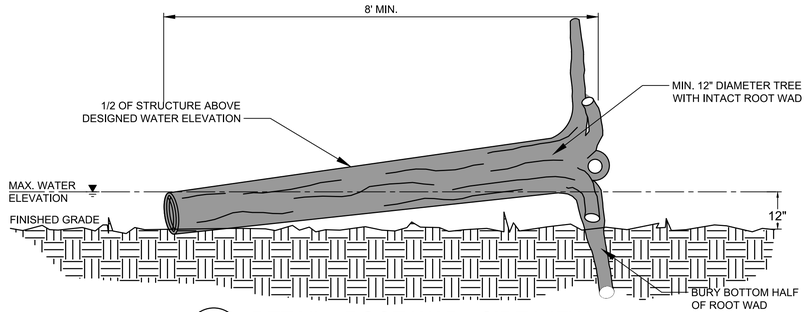
1 L-03 DETAIL - FREE STANDING SNAG
NOT TO SCALE



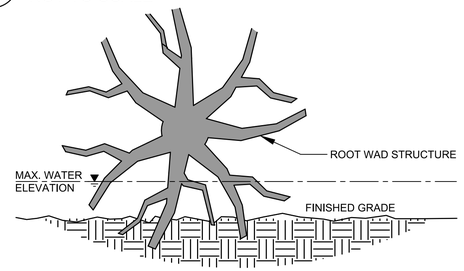
3 L-03 DETAIL - LOG STRUCTURE SIDE VIEW
NOT TO SCALE



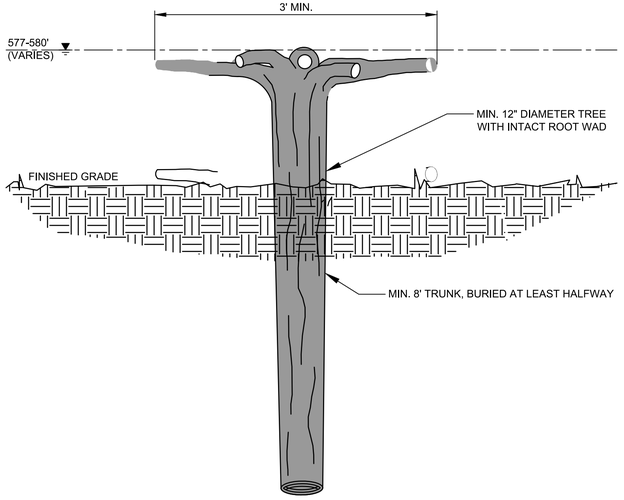
3 L-03 DETAIL - LOG STRUCTURE-LOOKING DOWN TRUNK
NOT TO SCALE



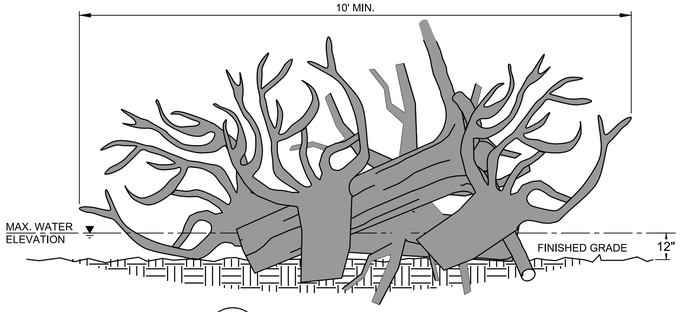
5 L-03 DETAIL - ROOT WAD - SIDE VIEW
NOT TO SCALE



5 L-02 DETAIL - ROOT WAD - LOOKING AT ROOTS
NOT TO SCALE



4 L-03 DETAIL - INVERTED ROOT WAD
NOT TO SCALE



2 L-03 DETAIL - BRUSH OR LOG PILE

SHEET NOTES:

1. WATER ELEVATIONS IN WETLANDS WILL VARY SEASONALLY.
2. ALL LARGE WOODY DEBRIS WILL BE PINNED WITH NATIVE MATERIAL AND/OR BURIED IN THE GROUND SUFFICIENTLY SO THEY WILL NOT FLOAT AWAY.

For Construction

GEI Consultants
5225 EDGEWATER DRIVE
ALLENDALE, MI 49401
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REGIONAL DEVELOPMENT COMMISSION

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STATE OF MICHIGAN
SCOTT B. DIERKS
ENGINEER
No. 44371
PROFESSIONAL ENGINEER

Designed:	B. Majka
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

DETAILS
(2 OF 3)

GEI Project 1602940
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D-02
SHEET NO.
19 OF 20

EMERGENT MARSH SEED MIX		
Scientific Name	**Common Name**	**PLS Oz Per Acre**
Acorus calamus	Sweet flag	4
Asclepias incarnata	Swamp milkweed	4
Avena sativa	Seed oats	512
Bidens cernua	Nodding bur marigold	2
Calamagrostis canadensis	Blue joint grass	2
Carex vulpinoidea	Brown fox sedge	4
Decodon verticillatus	Swamp loosestrife	0.25
Eleocharis acicularis	Needle spike rush	0.5
Eleocharis palustris	Great spike rush	1
Glyceria striata	Fowl manna grass	1
Hibiscus moscheutos	Swamp rose mallow	4
Iris virginica shrevei	Blue flag iris	6
Juncus canadensis	Canadian rush	1
Juncus effusus	Common rush	3
Juncus torreyi	Torrey's rush	0.25
Leersia oryzoides	Rice cut grass	2
Lolium multiflorum	Annual rye	160
Mimulus ringens	Monkey flower	1
Peltandra virginica	Arrow arum	6
Pontederia cordata	Pickerel weed	4
Rumex orbiculatus	Great water dock	1
Sagittaria latifolia	Common arrowhead	2
Saururus cernuus	Lizard's tail	0.5
Scirpus acutus	Hard-stemmed bulrush	2
Scirpus atrovirens	Dark green rush	2
Scirpus cyperinus	Wool grass	1
Scirpus fluviatilis	River bulrush	2
Scirpus pungens	Chairmaker's rush	3
Scirpus validus creber	Great bulrush	4
Sparganium eurycarpum	Common bur reed	2
Zizania aquatica	Wild rice	32
	Total PLS Ounces Per Acre	**769.50**
	Total PLS Pounds Per Acre	**48.09**

FLOODPLAIN FOREST SEED MIX		
Scientific Name	**Common Name**	**PLS Oz Per Acre**
Angelica atropurpurea	Great angelica	2
Asclepias incarnata	Swamp milkweed	1
Aster novae-angliae	New England aster	2
Avena sativa	Seed oats	512
Bidens cernua	Nodding bur marigold	2
Bidens frondosa	Common beggars tick	2
Bromus pubescens	Woodland brome	3
Calamagrostis canadensis	Blue joint grass	4
Carex crinita	Fringed sedge	2
Carex grayi	Common bur sedge	2
Carex lupulina	Common hop sedge	2
Carex muskingumensis	Swamp oval sedge	2
Carex vulpinoidea	Brown fox sedge	3
Cinna arundinacea	Common wood reed	2
Coreopsis tripteris	Tall coreopsis	1
Elymus riparius	Riverbank wild rye	12
Elymus virginicus	Virginia wild rye	32
Eupatorium maculatum	Spotted joe-pye weed	1
Glyceria striata	Fowl manna grass	2
Iris virginica shrevei	Blue flag iris	4
Leersia oryzoides	Rice cut grass	3
Lobelia cardinalis	Cardinal flower	0.5
Lobelia siphilitica	Great blue lobelia	1
Lolium multiflorum	Annual rye	160
Rudbeckia laciniata	Wild golden glow	3
Saururus cernuus	Lizard's tail	0.5
Thalictrum dasycarpum	Purple meadow rue	1
	Total PLS Ounces Per Acre	**762.00**
	Total PLS Pounds Per Acre	**47.63**

SOUTHERN WET MEADOW / SOUTHERN SHRUB CARR SEED MIX		
Scientific Name	**Common Name**	**PLS Oz Per Acre**
Acorus calamus	Sweet flag	2
Angelica atropurpurea	Great angelica	2
Asclepias incarnata	Swamp milkweed	4
Aster novae-angliae	New England aster	1
Avena sativa	Seed oats	512
Bidens cernua	Nodding bur marigold	2
Bromus ciliatus	Fringed brome	2
Calamagrostis canadensis	Blue joint grass	2
Carex comosa	Bristly sedge	2
Carex crinita	Fringed sedge	2
Carex hystericina	Porcupine sedge	2
Carex lupulina	Common hop sedge	2
Carex muskingumensis	Swamp oval sedge	2
Carex stricta	Common tussock sedge	0.5
Carex vulpinoidea	Brown fox sedge	2
Coreopsis tripteris	Tall coreopsis	1
Elymus virginicus	Virginia wild rye	16
Eupatorium maculatum	Spotted joe-pye weed	2
Eupatorium perfoliatum	Common boneset	2
Glyceria striata	Fowl manna grass	2
Hibiscus moscheutos	Swamp rose mallow	2
Iris virginica shrevei	Blue flag iris	5
Juncus effusus	Common rush	2
Leersia oryzoides	Rice cut grass	2
Liatris spicata	Marsh blazing star	1
Lobelia cardinalis	Cardinal flower	0.5
Lobelia siphilitica	Great blue lobelia	1
Lolium multiflorum	Annual rye	160
Mimulus ringens	Monkey flower	2
Monarda fistulosa	Wild bergamot	2
Pycnanthemum virginianum	Common mountain mint	1
Rosa palustris	Swamp rose	1
Sagittaria latifolia	Common arrowhead	1
Scirpus atrovirens	Dark green rush	1
Scirpus cyperinus	Wool grass	1
Solidago ohioensis	Ohio goldenrod	1
Spartina pectinata	Prairie cord grass	6
Thalictrum dasycarpum	Purple meadow rue	0.5
Verbena hastata	Blue vervain	2
Zizia aurea	Golden Alexanders	2
	Total PLS Ounces Per Acre	**756.50**
	Total PLS Pounds Per Acre	**47.28**

Scientific Name	Common Name	Wetland Indicator Status	Deep Submergent Marsh (3.7 ac)	Shallow Submergent Marsh (4.0 ac)	Emergent Marsh (8.6 ac)	Southern Shrub Carr (15.5 ac)	Southern Wet Meadow (7.3 ac)	Floodplain Forest (7.7 ac)
Asclepia incarnata	Swamp milkweed	OBL			125		100	
Eupatorium maculatum	Joe-Pye weed	OBL					100	
Iris virginica shrevei	Blue flag iris	OBL			125		100	
Liatris spicata	Marsh blazing star	FAC					100	
Lobelia cardinalis	Cardinal flower	OBL					100	
Lobelia siphilitica	Blue lobelia	FACW					100	
Mimulus ringens	Monkeyflower	OBL					100	
Nuphar advena	Spatterdock	OBL		500				
Nymphaea tuberosa	White water lily	OBL		500				
Peltandra virginica	Arrow arum	OBL			100			
Pontederia cordata	Pickerelweed	OBL		250	100			
Sagittaria latifolia	Arrowhead	OBL			100			
Saururus cernuus	Lizard's tail	OBL			50			
Solidago patula	Swamp goldenrod	OBL					100	
Vallisneria americana	Wild celery	OBL	1,000	300				
Calamagrostis canadensis	Blue joint grass	OBL					75	
Carex comosa	Bristly sedge	OBL					100	
Carex lacustris	Lake sedge	OBL			100			
Carex muskingumensis	Sand bracted sedge	OBL					150	
Carex vulpinoidea	Brown fox sedge	OBL						
Juncus effusus	Soft rush	OBL			50			
Schoenoplectus acutus	Hardstem bulrush	OBL			300			
Schoenoplectus pungens	Common threesquare	OBL			300			
Schoenoplectus tabernaemontani	Softstem bulrush	OBL			300			
Scirpus cyperinus	Wool Grass	OBL					100	
Sparganium eurycarpum	Common burreeed	OBL			100			
	Per-acreTotal		1,000	1,550	1,750	0	1,225	0
Shrubs								
Cephalanthus occidentalis	Buttonbush	OBL				50		
Cornus amomum	Silky dogwood	FACW				50		75
Cornus sericea	Red-osier dogwood	FACW				50		75
Rosa palustris	Swamp rose	OBL				50		
Sambucus canadensis	Elderberry	FACW				50		75
Spiraea alba	Meadowsweet	FACW				50		
Viburnum opulus v. americanum	American highbush cranberry	FACW				50		75
	Per-acreTotal		0	0	0	350	0	300
Trees (24-36" bare-root)								
Acer rubrum	Red maple	FAC						10
Nyssa sylvatica	Black gum	FACW						10
Platanus occidentalis	Sycamore	FACW						10
Quercus bicolor	Swamp white oak	FACW						10
Quercus palustris	Pin oak	FACW						10
Salix nigra	Black willow	OBL						10
	Per-acreTotal		0	0	0	0	0	60
Trees (2" caliper)								
Acer rubrum	Red maple	FAC						2
Acer saccharinum	Silver maple	FACW						2
Celtis occidentalis	Hackberry	FAC						2
Platanus occidentalis	Sycamore	FACW						2
Quercus bicolor	Swamp white oak	FACW						2
Quercus palustris	Pin oak	FACW						2
	Per-acreTotal							12

For Construction

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5225 EDGEWATER DRIVE
ALLENDALE, MI 49401
(616)384-2710

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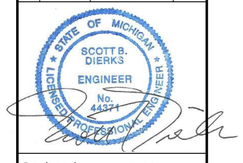

Designed:	B. Majka
Checked:	S. Dierks
Drawn:	I. Roberts
Submitted By:	B. Majka
P.E. No.:	*44371*

DETAILS
(3 OF 3)

GEI Project 1602940

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D-03

SHEET NO.
20 OF 20

Appendix B Site Monitoring Checklist

Habitat Monitoring and Management Evaluation Checklist

Date: _____

Site: _____

Monitored by: _____

Phone: _____ **Email:** _____

Lake/water body name: _____

Property Address: _____

Project installation date: _____

Project components:

Plants: ☐ Trees ☐ Shrubs ☐ Grasses/wildflowers ☐ Emergent/wetland vegetation

Planting stock: ☐ Seeds ☐ Plugs ☐ Bare-root plants ☐ Container plants ☐ B&B
☐ Live stakes ☐ Bush bundles

Erosion control/water quality elements: ☐ Erosion control blanket ☐ Coir fiber log
☐ Brush Bundles ☐ Rock riprap ☐ Filter strip/buffer ☐ Filter strip/buffer
☐ Rain garden ☐ Other

Has There Been Previous Site Management? If so, what?

Installed Vegetation:

Assessment of Upland Areas:

Assessment of Aquatic Areas:

Assessment of Trees and Shrubs:

Recommendations:

Invasive or undesirable plant species:

Are invasive plant species present in the project area: ☐ Yes ☐ No

Invasive or undesirable species present and density:

Are invasive plant species near but not yet established in the project area:

Upland area: ☐ Yes ☐ No Shoreline area: ☐ Yes ☐ No

Invasive or undesirable species present and density:

Management Recommendations:

Erosion/Bioengineering evaluation:

Overall assessment of bioengineering techniques:

Soil conditions (comment on soil stability and presence of erosion:

Comments on site erosion:

Nuisance animal species:

Wildlife Observations:

Water Quality Concerns:

Notes/Sketches:

Appendix C Representative Photos of Installed Vegetation

Common tussock sedge (*Carex stricta*)

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Environmental
Water Resources
Engineering

Representative Installed Native Vegetation

Buttonbush (*Cephalanthus occidentalis*)

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Environmental
Water Resources
Engineering

Representative Installed Native Vegetation

Red-osier dogwood (*Cornus sericea*)

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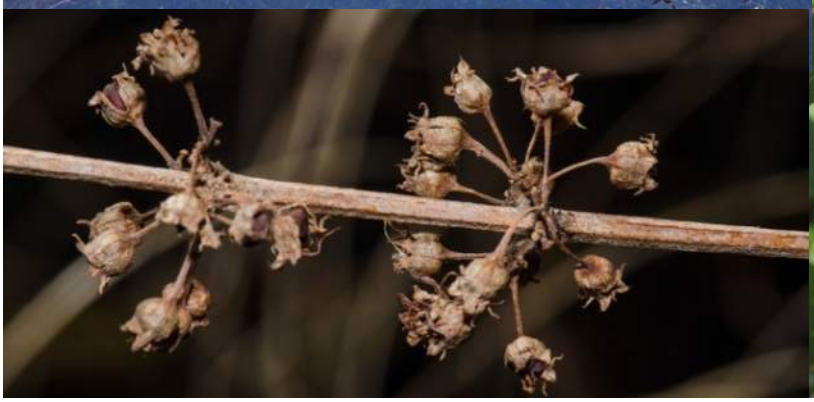
Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation







Swamp loosestrife (*Decodon verticillatus*)

GEI Consultants

Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation

Common boneset (*Eupatorium perfoliatum*)

GEI Consultants

Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation

Swamp rose mallow (*Hibiscus moscheutos*)

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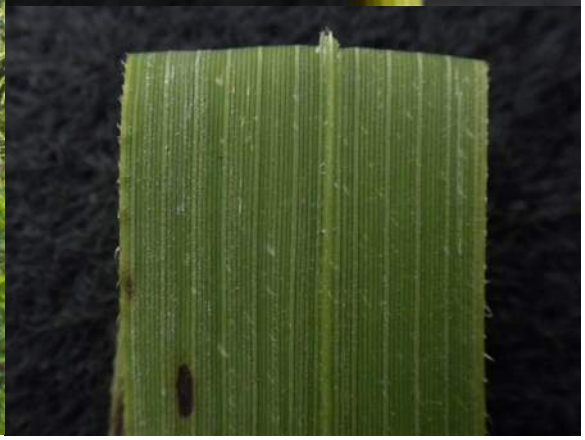
Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation



Rice cut grass (*Leersia oryzoides*)

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Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation





Marsh blazing star (*Liatris spicata*)

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Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation

Sycamore (*Platanus occidentalis*)

GEI Consultants

Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation

Swamp white oak (*Quercus bicolor*)

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Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation





Lizard's tail (*Saururus cernuus*)

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Engineering

Representative Installed Native Vegetation





Common threesquare (*Schoenoplectus pungens*)

Prairie cord grass (*Spartina pectinata*)

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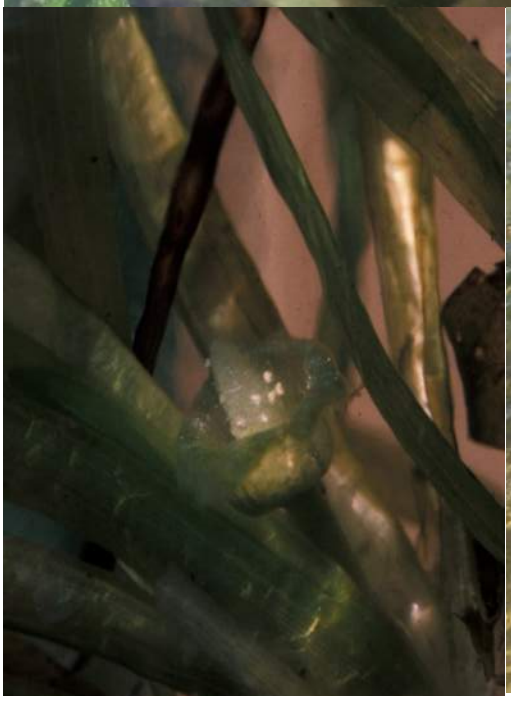
Geotechnical
Environmental
Water Resources
Engineering

Representative Installed Native Vegetation



Wild celery (*Vallisneria americana*)

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Wild rice (*Zizania aquatica*)

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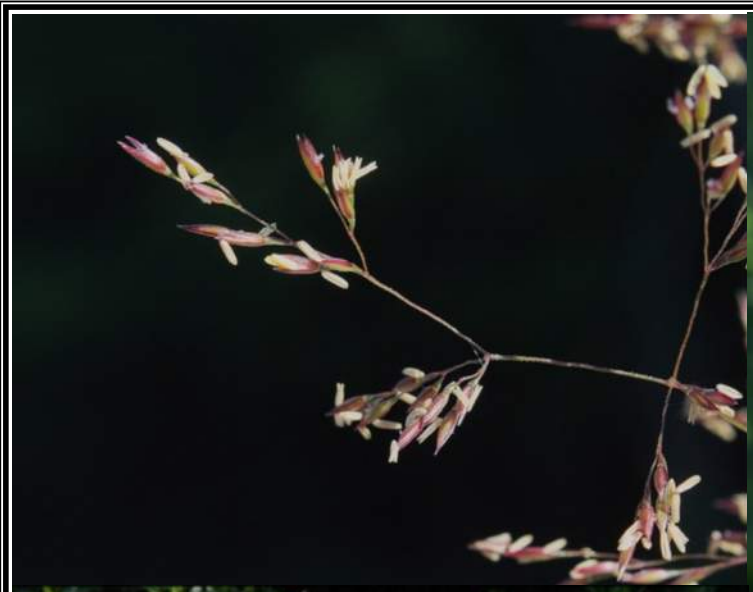
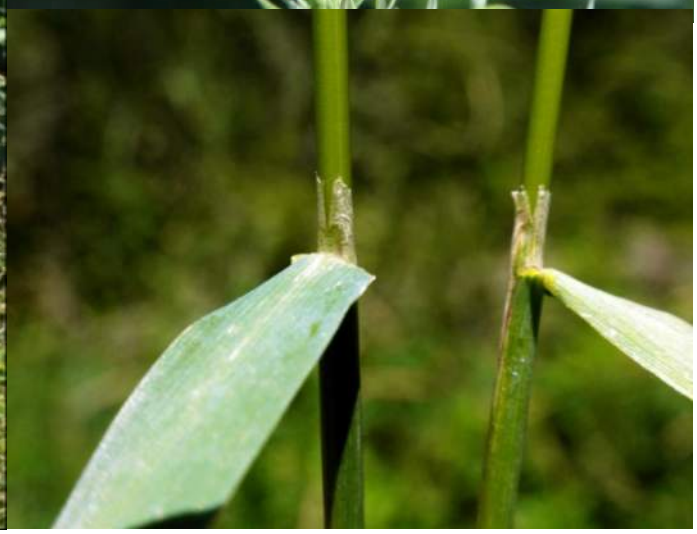
Appendix D Representative Photos of Invasive Plant Species





Redtop (*Agrostis gigantea*)

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Invasive Species Photographs

Common burdock (*Arctium minus*)

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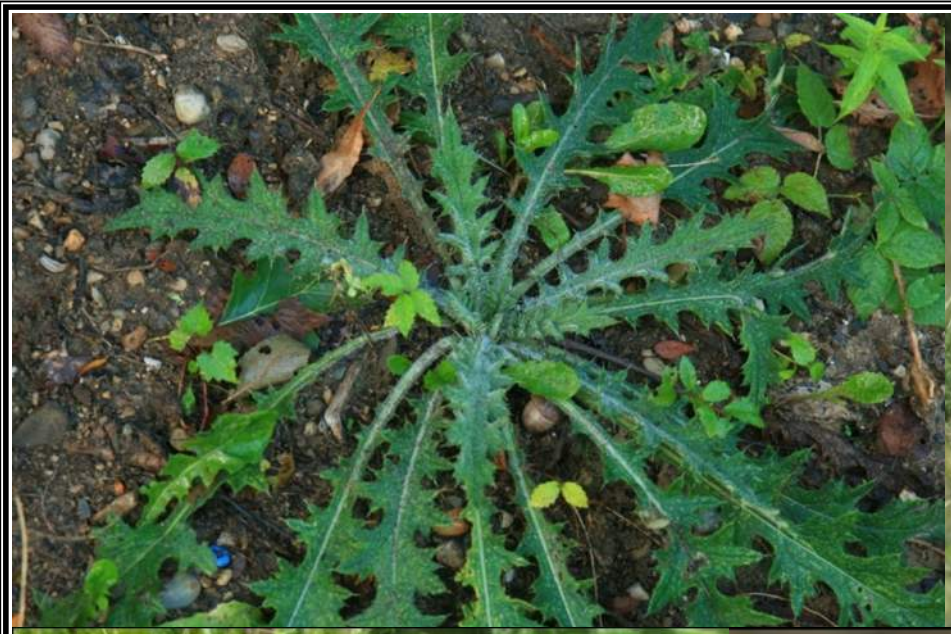
Invasive Species Photographs



Bull thistle (*Cirsium vulgare*)

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Queen Anne's lace (*Daucus carota*)

Purple loosestrife (*Lythrum salicaria*)





Reed canary grass (*Phalaris arundinacea*)

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Common reed (*Phragmites australis var. australis*)

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Curly dock (*Rumex crispus*)

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Soapwort (*Saponaria officinalis*)

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Bittersweet (*Solanum dulcamara*)

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Narrow-leaved cattail (*Typha angustifolia*) / Cattail hybrid (*Typha x glauca*)

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Common mullein (*Verbascum thapsus*)

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