Prepared for

Consumers Energy Company

CLOSURE PLAN
for the
CONSUMERS WEADOCK COMPLEX
J.C. WEADOCK SOLID WASTE DISPOSAL AREA
Essexville, Michigan
Site ID: MID040562597
WMD ID: 395457

Prepared by

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Project Number CHE8318
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1. INTRODUCTION

The D.E. Karn/J.C. Weadock Generating Complex consists of two power generating plants (Karn and Weadock), and is owned and operated by Consumers Energy Company (CEC). Most recently, the Weadock Complex consisted of two (2) remaining coal burning units designated as Units 7 and 8, which became operational in 1955 and 1958, respectively and were retired on April 15, 2016. The Karn Complex includes two (2) operating coal-fired units (Units 1&2) that became operational in 1959 and 1961, respectively. Coal Combustion Residuals (CCRs) generated from the power plant units are transported to the JC Weadock Solid Waste Disposal Area (Landfill).

The Landfill has an operating license issued by the Michigan Department of Environmental Quality (MDEQ) as a low-hazard industrial waste (Type III) landfill. The Landfill is regulated under Construction Permit No. 0260, dated April 21, 1992, and the Solid Waste Disposal Area Operating License No. 9440, dated June 26, 2015. The current permit establishes the maximum permissible waste grades and elevations and volume capacity.

The original disposal area consisted of a perimeter containment dike designed with an approximate top crest elevation of 590 feet (NAVD 88). In 1971, new perimeter dike construction along the eastern portion expanded the disposal area with elevations matching the original perimeter containment dikes of approximately 590 feet. The perimeter dike system is constructed with alternating layers of sand and clay material and also serves as a 20-ft wide perimeter access road. Internal dikes consisting of local borrow soils and fly ash also serve as roads within the Landfill. In 2008, a soil-bentonite slurry wall keyed into the underlying glacial clay till was constructed along the perimeter dike to mitigate the potential for migration of impacted groundwater.

Fly ash had historically been sluiced into the disposal area prior to the construction permit submitted April 1991. The Michigan Department of Natural Resources (MDNR) approved a vertical expansion permit for the Disposal Area in 1991 which consisted of continued hydraulic deposition of fly ash and added a dredge and stack operation prior to mechanical placement. The approved maximum ash elevation, including the vertical expansion, is 650 feet, which corresponds to a storage volume of approximately 11.2 million cubic yards of fly ash. Currently, about 10.6 million cubic yards of permitted storage volume is unoccupied.

In 2009, CEC moved exclusively to a dry fly ash handling system (DFA Silo) in which fly ash from Weadock Units 7 & 8 and Karn Units 1 & 2 was blown to a storage silo located immediately north of the Weadock bottom ash ponds. The fly ash was either directly marketed to a third party or moisture conditioned and hauled by truck to the Landfill DE Karn Units 1&2 began utilizing a dedicated collection silo for each unit once the Spray Dry Absorber (SDA) Air Quality Control Systems (AQCS) controls commenced in July 2014. The DFA Silo continued to collect ash from Weadock Units 7&8 until they were retired on April 15, 2016.

1.1 CCR Rule for Existing Landfills

The U.S. Environmental Protection Agency (USEPA) finalized regulations to manage CCRs for the first time under 40 CFR Parts 257 and 261 of the Resource Conservation and Recovery Act (RCRA) on April 17, 2015. Under these new Federal Rules, the Landfill is regulated under the federal Subtitle D (solid waste regulations) of RCRA and was receiving CCRs on or before the effective date of the rule.

1.2 Purpose

The purpose of this document is to present a written Closure Plan for the Landfill by leaving the CCR in place. The Closure Plan includes the proposed cover system structural components, construction, and estimated schedule in accordance with the requirements for CCR landfills under RCRA (40 CFR § 257.102(b)). The proposed final cover system for the Landfill is presented herein and is demonstrated to meet the requirements of 40 CFR § 257.102(d) and the physical constraints of the site. A certification statement of this written Closure Plan from a qualified professional engineer as required by 40 CFR § 257.102(b)(4) is located in **Section 4**.

This Closure Plan was prepared by Geosyntec Consultants (Geosyntec) for CEC; it was written by Yazen Khasawneh, Ph.D. and John Seymour, P.E. and peer reviewed in accordance with Geosyntec's quality policy.

2. NARRATIVE DESCRIPTION [40 CFR 257.102(B)(1)(I)]

2.1 Overview [40 CFR § 257.102(b)(1)(i)]

The DE Karn and JC Weadock Generating Complex is located along Lake Huron in Saginaw Bay just east of the mouth of the Saginaw River in Hampton Township approximately six (6) miles north of Bay City, Michigan (see **Figure 1**).

The JC Weadock disposal area is licensed for 292 acres. The perimeter embankment dike is 4.8-miles long and 20-ft wide that serves as a perimeter access road. The perimeter dike elevation ranges from approximately 593 feet in the northeastern corner to 588 feet in the southwestern corner (NAVD 88). The soil-bentonite slurry wall extends 4.5 miles over the perimeter of 4.8 miles for the Landfill.

The Landfill will be closed by:

- bringing the grades up to design grades using on site existing CCRs or supplemented, as necessary, with offsite CCRs or soils,
- construction of the final cover system,
- construction of surface water ditches and letdowns, and
- revegetating the disturbed areas.

The future configuration can be characterized by two distinct regions (see **Figure 2**):

1. There will be two separate fill areas, Areas A and B, on the west and east sides, respectively.
2. The second area encompasses all other areas outside of Areas A and B and within the boundaries of the existing slurry wall. Two transmission line corridors are located in this area; one dissects Areas A and B running north to south and another running parallel along the south edge of the solid waste boundary.

2.2 CCR Quantity [40 CFR § 257.102(b)(1)(iv-v)]

The maximum inventory of CCR that is licensed in the current licensed Landfill is 11.2 million cubic yards covering 292 acres. Based on the Landfill in the final configuration

(**Figure 2**) the maximum inventory is estimated at approximately 10.6 million cubic yards covering approximately 266 acres that will eventually require final cover.

2.3 Closure Construction Sequence [40 CFR § 257.102(b)(1)(i-iii)]

2.3.1 Closure Summary

Closing of the Landfill is anticipated to occur in the following sequence:

i. Final Cover Grades – The final CCR grades will be constructed by placing new CCR or recovering and regrading historically placed fly ash. Fly ash relocation may be used to establish grades that will facilitate the partial closure of some sections of the landfill.

ii. Preparation of Subgrade – After final grading, the CCR subgrade will be rolled with a smooth drum roller and materials will be removed that could be damaging to the cover system and to improve soft areas to reduce settlement. Any vegetation will be removed prior to smooth drum rolling to allow improved contact between the CCR subgrade and overlying cover layers.

iii. Installation of Cover System – The cover system will be installed following preparation of the subgrade and is described in more detail in Section 2.2.3.

iv. Installation of Surface Water Controls – Surface water ditches and letdowns (see **Figure 3a**) will be constructed to control erosion on and adjacent to the cover system.

2.3.2 Final Cover System [40 CFR § 257.102(b)(1)(iii)]

The final cover system for the Landfill is designed to minimize infiltration of surface water and erosion. A cross section of the final cover system design is presented in **Figure 3b**.

2.3.2.1 Summary

The proposed cover system consists of (bottom to top):

- A prepared subgrade comprised of CCR.

- A 40-mil thick linear low density polyethylene (LLDPE) flexible membrane liner (FML) as the infiltration barrier between the cover soil and CCR.

- In select locations, a geocomposite layer, consisting of non-woven geotextile bonded to geonet, as an infiltration layer for the lateral transmission of water infiltrated through the cover soils outside the slope areas.

- A 24-inch thick cover soil consisting of:

    - The bottom 18 inches will be composed of natural soils imported to the site. This rooting zone will support the propagation of root structure for the long term establishment of vegetation on the cover and to provide surface drainage.

    - The top 6 inches will be topsoil and contain sufficient organic matter to support the preparation of a seedbed and initial seed germination.

2.3.2.2 Grading

The proposed cover grades for the Landfill range from 2% to 25% in Areas A and B. The grading plan (see **Figure 2**) includes a maximum CCR disposal elevation of 650 feet (NAVD 88) along the crest centerline of Area A. Grades on the tops of the fill areas are designed for 2% slopes. The external side slopes of the fill areas will have grades of 25%. The new CCR in Areas A and B will be sloped to provide positive drainage to the letdowns.

2.3.2.3 Infiltration

The acceptable infiltration rate will be achieved by designing the final cover system based on the requirements of the rule as specified under 40 CFR § 257.102(d)(3)(i) which includes installation of the 40-mil FML and other layers prescribed by the CCR Rule.

2.3.2.4 Letdowns

Four letdown structures will be used to facilitate the drainage of surface water off of the Future Landfill final cover. The locations are shown in **Figure 2**. The letdown structures will daylight at close proximity from the cover edge, as shown in **Figure 3b**.

In areas that are not drained using the letdown structures, surface water will be directed through ditches to discharge through the exiting outfall structure.

2.3.2.5 Stability

Veneer and global stability analyses were performed for the Landfill. Veneer stability includes the stability of cover system layers and the stability of the cover system against sliding at the cover-CCR interface. Global stability includes static and seismic analysis of a deep failure surface seated through the perimeter embankment and foundation soils. It should be noted that the CCR Rules did not specify a minimum acceptable safety factor against veneer or global instability. The minimum acceptable safety factors for various instability modes and loading conditions were selected based on landfill design practice.

The adopted minimum acceptable safety factor against veneer instability was selected as 1.50 and 1.0 for static and seismic slope stability analyses, respectively, and 1.10 for the analysis involving shallow static saturated conditions.

Veneer stability (i.e. shallow translational slope stability) considers noncircular wedge-type potential slip surfaces that extend along a cover system. The critical interface for a liner system that incorporates geosynthetics typically occurs along an interface between a geosynthetic and an adjacent soil.

Veneer stability analyses were conducted to estimate the required interface friction angle between the geomembrane and the subgrade for the following cases:

- Dry slope under static loading with a factor of safety of 1.5 using the equation formulated by Giroud et al. (1995).
- Steady state flow in the cover system under static loading with a factor of safety of 1.1 using the equation formulated by Giroud et al. (1995).
- Dry slope under dynamic loading with a factor of safety of 1.0 using the equation formulated by Matasovic (1991).

For the above scenarios, the estimated minimum required interface angle between geomembrane and the subgrade was back-calculated to be 20º. The minimum required interface friction angle of the cover system components will be verified with a Direct Shear Box test (ASTM D3080) after materials selection and prior to placement.

Global stability was checked for both static and dynamic loading for the most critical section. The most critical section was identified based on combination of geometrical, stratification, and material properties, such as slope height, strength, and thickness of foundation soils. The stability under static loading was checked with both effective strength analysis (drained loading) and undrained strength analysis (undrained). The stability under the transient dynamic loading condition was performed with undrained strength parameters.

The seismic hazard used for Weadock includes a peak ground acceleration (PGA) in bedrock of 0.027 g and a design earthquake with a magnitude, M_w, of 6.02. These data were obtained from the USGS seismic hazard website for the Weadock Landfill. The selected PGA was in accordance with 40 CFR § 257.53 and corresponds to an event with about 2,500-year return period.

Minimum design loads were selected in accordance with ASCE (ASCE 7), site Class E was selected for the stability analyses with a corresponding $F_{PGA} = 2.5$ for PGA ≤ 0.10 and Site Class E). Therefore, for the dynamic analyses conducted herein, Geosyntec estimated the maximum PGA (PGA_M) as $PGA_M = 2.5 \times 0.027$ g = 0.068 g. Guidance provided in Duncan and Wright (2005) indicates that an appropriate pseudo-static coefficient corresponds to a half to two-thirds of the PGA_M; therefore, a pseudo-static coefficient of 0.045 was used for the seismic slope stability analyses.

The adopted minimum acceptable safety factor against global instability was selected according to typical landfill design practice, the minimum acceptable FS for the long-term (drained or “operational”) condition is 1.5, and for the short-term (undrained or “end of construction”) condition is 1.3. A FS value of 1.0 was used for pseudo static (i.e., seismic) slope stability analyses.

The resulted safety factor from the stability analyses are summarized in **Table 1**:

Table 1: Safety Factor Summary from Stability Analyses

Loading Condition	Analysis Type	Safety Factor	Target Safety Factor	Notes
Static	Effective Stress Analysis	2.01	1.50	OK
Static	Undrained Strength Analysis	2.42	1.30	OK
Dynamic	Undrained Strength Analysis	1.92	1.00	OK

2.3.2.6 Design and Performance [40 CFR § 257.102(d)(3)]

The final cover system for the Landfill must be designed and constructed to meet the performance criteria (A through D) promulgated under Federal Rule 40 CFR § 257.102(d)(3)(i).

Performance criteria 40 CFR § 257.102(d)(3)(i)(A) stipulates that the permeability of the final cover system must not be greater than the least of: (i) $1x10^{-5}$ centimeters per second (cm/s), (ii) any bottom liner system or natural subsoils present. The cutoff layer (natural subsoil) was identified below the Landfill with permeability on the order of 10^{-6} cm/sec. In addition, the slurry wall is expected to have an average permeability on the order of 1 x 10^{-9}cm/sec. Therefore, the proposed cover system includes a 40-mil linear low density polyethylene (LLDPE) flexible membrane liner (FML) above the subgrade with an estimated permeability of 4 x 10^{-13} cm/s.

Because the FML and overlying soil layers are in accordance with the CCR Rule, the proposed cover system meets the performance criteria under 40 CFR § 257.102(d)(3)(i)(A).

40 CFR § 257.102(d)(3)(i)(B) requires that the final cover system must use an infiltration layer containing a minimum of 18 inches of earthen material to minimize the infiltration of liquids. The proposed cover system for the Landfill includes an 18-inch earthen layer consisting of natural soil with permeability in the order of 4 x 10^{-3} cm/sec. Because the infiltration layer is in accordance with the CCR Rule, it meets the performance criteria under 40 CFR 257.102(d)(3)(i)(B).

40 CFR § 257.102(d)(3)(i)(C) requires that an erosion layer containing a minimum of six inches of earthen material that is capable of sustaining plant growth must be used to minimize erosion of the final cover system. The proposed system for the Landfill includes a six-inch layer of topsoil which will be specified to contain sufficient organic matter to support the preparation of a seedbed and seed germination. Because the erosion layer is in accordance with the CCR Rule, it meets the performance criteria under 40 CFR § 257.102(d)(3)(i)(C).

Under 40 CFR § 257.102(d)(3)(i)(D), the final cover system design must accommodate settling and subsidence to minimize the disruption of the integrity of the final cover system. Primary settlement of the CCR subgrade and the subsurface soils will manifest at the final grade surface during the placement of the subgrade in preparation of the cover installment. Because most of the fill will be placed over many years in advance of final closure, primary settlement will occur prior to placement of the final cover. After the construction of the cover, minimal loads are anticipated on the cover system, and limited settlement is anticipated. Therefore, the proposed cover system meets the performance criteria under 40 CFR § 257.102(d)(3)(i)(D).

2.3.3 Closure Performance [40 CFR § 257.102(d)(1)(i-iv)]

The closure for the Landfill must be performed to meet the closure performance standards required by 40 CFR § 257.102(d)(1) when CCR is left in place.

As required by 40 CFR § 257.102(d)(1)(i), the final cover system is designed to control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere. This requirement will be achieved as discussed in Section 2.3.2.1 through Section 2.3.2.3.

40 CFR § 257.102(d)(1)(ii) requires precluding the probability of future impoundment of water, sediment, or slurry. The requirement of this rule will be achieved as discussed in Section 2.3.2.

40 CFR § 257.102(d)(1)(iii) requires including measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period. The proposed cover system meets the requirement of this rules as discussed in Section 2.3.2.4.

The closure will include measures to limit future maintenance as required under 40 CFR § 257.102(d)(1)(iv). This will be accomplished with a cover system designed with a vegetated erosion protection layer (Section 2.3.2) and positive closure drainage (Section 2.3.2.3). Traffic on the cover during the post-closure care period will be limited to mowing. However, if maintenance is required it will be done in accordance with the Post-Closure Plan.

The facility has a groundwater monitoring (GWM) program in place that will be used in the Post-Closure period. The GWM Program will allow assessment of the entire facility, including the removal area.

3. SCHEDULE [40 CFR § 127.102(B)(1)(VI)]

3.1 Introduction

This Closure Plan schedule is intended to address the requirements for the Landfill under 40 CFR § 257.102(b)(1)(vi) and 40 CFR § 257.102(b)(1)(v).

Closure of the Landfill is expected to be completed by end of 2030. The estimated closure rate for the Landfill is on the order of 25 to 30 acres/year, assuming closure activities are only performed during the typical Michigan construction season from late spring to late fall. Based on this estimate, the final closure is anticipated to require 8 to 10 construction seasons for completion.

3.2 Closure Construction

The closure activities at the Landfill will be achieved according to the following milestones:

- Performing final design of the closure and permitting activities in 2019.
- Commencing incremental, partial capping activities of the areas that achieve the final grades in 2022 - 2030. This yields approximately 28.3 acres/year on average.
- Achieving final CCR disposal in the landfill in 2030
- Finishing all closure activities including the installation of the final cover, and construction of surface water ditches and letdowns by December 31, 2030.

3.3 Closure Construction Schedule

The closure construction schedule is developed assuming that the last active portion of the Dry Ash Landfill will be no more than 40 acres. **Table 2** indicates that 40 acres could be effectively closed within six months as required by 40 CFR 257.102(f)(1)(i).

Table 2: Closure Schedule Production Estimate

Closure Component	Quantity	Units	Construction Rate	Rate Units	Required Time in Days
40-mil LLDPE cap geomembrane	1,742,000	square feet	45,000	square feet per day	39
24-inch-thick cap infiltration layer	130,000	cubic yards	5,000	cubic yards per day	26
6-inch-thick erosion layer	32,500	cubic yards	5,000	cubic yards per day	7
Seed, fertilizer, mulch	1,742,000	square feet	300,000	square feet per day	6
				Workdays Required =	**78**

Closure construction of the landfill will begin on or before May 1, 2030 in order to comply with the closure schedule. Conservatively, assuming a start to finish construction schedule, the final cover construction will take approximately 16 weeks. Using these assumptions results in completion of the final cover construction at the endo of August 2030. Table 3 contains a list of milestone dates that were developed as part of the closure construction schedule to demonstrate that closure will be completed within the self-implementing closure schedule per 40 CFR 257.102(f)(1)(i).

Table 3: Conceptual Final Cover Construction Schedule Milestones

Closure Component	Start Date	End Date
Monitor groundwater	January 1, 2016	June 1, 2030
Notification of closure	NA	May 1, 2030
40-mil LLDPE cap geomembrane	May 2, 2030	June 24, 2030
24-inch-thick cap infiltration layer	June 27, 2030	August 3, 2030
6-inch-thick erosion layer	August 4, 2030	August 12, 2030
Seed, fertilizer, mulch	August 15, 2030	August 19, 2030
Closure activities complete	NA	August 19, 2030
Certified closure report	NA	December 31, 2030

4. CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this demonstration and all attached documents and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.102(b). I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

John Seymour, Michigan P.E. #6201033056

10/14/2016

Date

STATE OF MICHIGAN
JOHN P. SEYMOUR
ENGINEER
No. 33056
LICENSED PROFESSIONAL ENGINEER

5. REFERENCES

ASCE 7 (2013), "Minimum Design Loads for Buildings and Other Structures", American Society of Civil Engineers.

ASTM D3080, "Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions", 2011.

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Department of Environmental Quality (DEQ), Solid Waste Disposal Area Operating License, License No. 9233, October 15, 2009.

Giroud, J.P., Bachus, R.C., and Bonaparte, R. (1995). Influence of Water Flow on the Stability of Geosynthetic-Soil Layered Systems on Slopes. Geosynthetics International. 2 (6), 1149-1180.

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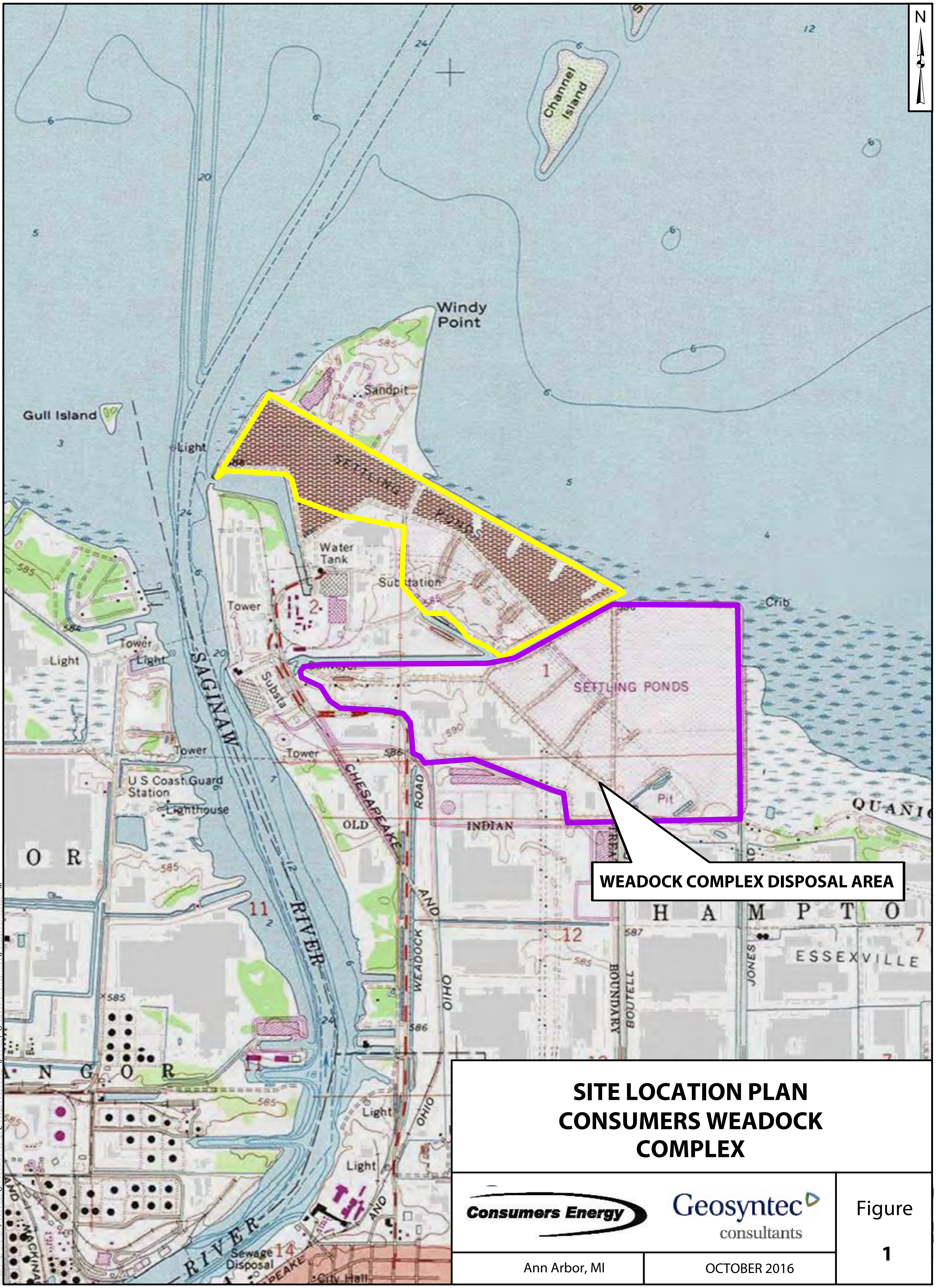
FIGURES



SITE LOCATION PLAN CONSUMERS WEADOCK COMPLEX

Consumers Energy

Geosyntec consultants

Figure 1

Ann Arbor, MI

OCTOBER 2016

LEGEND

640 (line)	TOP OF ASH CONTOUR
(line)	EXISTING TOPOGRAPHY CONTOUR (APRIL 2013)
(orange line)	EXISTING SLURRY WALL
(cyan line)	PROPOSED SLURRY WALL VENT CLOSURE
(hatched green)	NON-CONTACT STORMWATER (FINAL COVER AREA)
(green arrow)	STORMWATER FLOW / LETDOWN

NOTES:

1. INFORMATION SHOWN ON THIS DRAWING WERE TAKEN FROM AECOM'S DRAWING ENTITLED "PROPOSED ASH GRADES - PLAN VIEW"; DATED MAY 2011.
2. 1.5-FOOT THICK CAP VOLUME WAS NOT INCLUDED IN VOLUMES NOTED.
3. GRADES DEPICTED ON THIS FIGURE SHOW THE TYPICAL SLOPES OF FINAL COVER. ACTUAL FOOTPRINT AND GRADES WILL VARY. REFER TO WASTE RELOCATION PLAN IN THE REPORT FOR DETAILS.

ASH VOLUMES		
AREA A CAPACITY:	2,590,000	CY
AREA B CAPACITY:	8,050,000	CY
POND F DREDGING:	0	CY
OTHER RELOCATION:	0	CY
NET FILL VOLUME:	10,640,000	CY

AREAS / LENGTHS		
TOTAL FINAL COVER AREA:	266.10	AC
ISOLATION BERM:	0	LF
PROPOSED SLURRY WALL:	0	LF
SLURRY WALL VENT CLOSURE:	1,591	LF

SCALE 0' 100' 200' 400'

DATE:
DESIGNED BY:
DRAWN BY:
CHECKED BY:
APPROVED BY:

Geosyntec consultants

Consumers Energy

REV | DATE | REVISION DESCRIPTION

REVISIONS

LANDFILL FINAL GRADES AND STORM WATER CONCEPT

CONSUMERS WEADOCK COMPLEX

PROJECT NUMBER

SCALE

FIGURE

2

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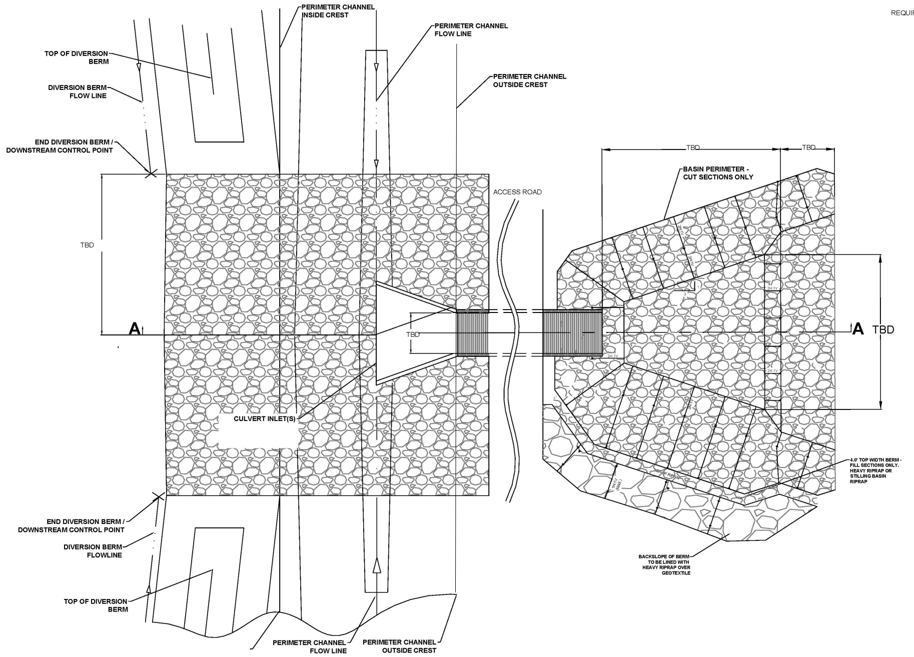
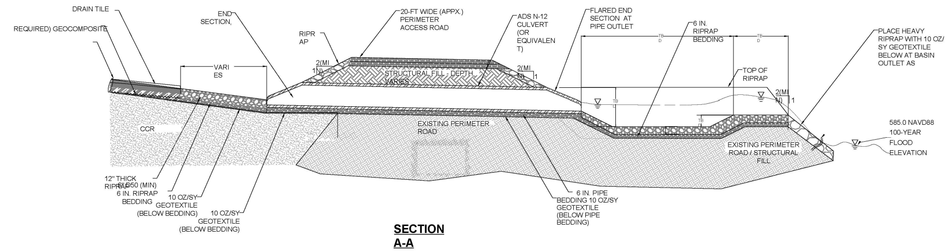
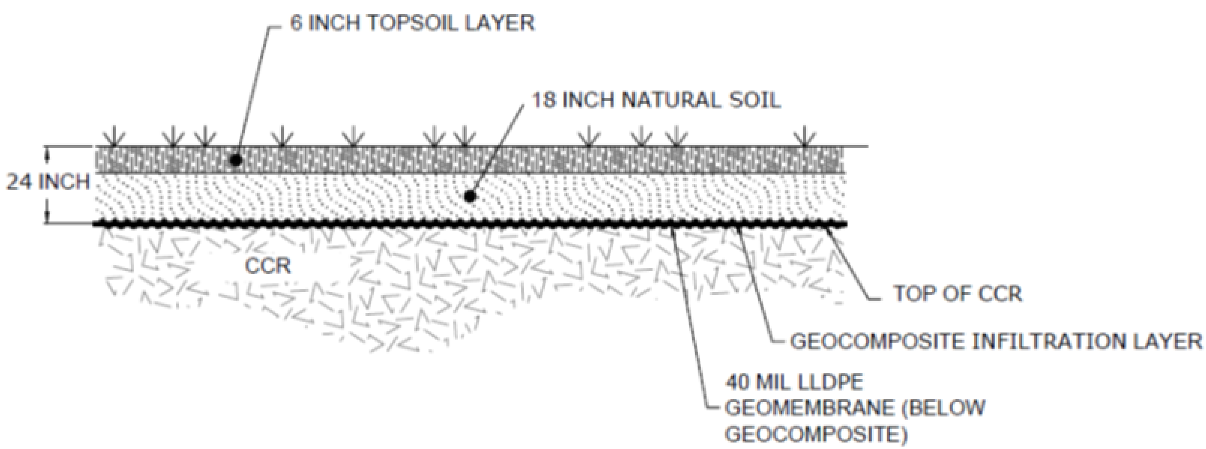




TBD: To be determined

LETDOWN DETAILS



COVER SYSTEM DETAILS

COVER AND LET DOWN DETAILS

CONSUMERS WEADOCK COMPLEX

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FIGURE 3

October 2016