Attachment A

Recorded Restrictive Covenants

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REGISTER OF DEEDS
BAY COUNTY, MICH.

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LIBER 885 PAGE 989

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DECLARATION OF RESTRICTIVE COVENANT

THIS INDENTURE made the 1st day of September, 1979, by and between, CONSUMERS POWER COMPANY, a Michigan corporation, whose address is: 212 West Michigan Avenue, Jackson, Michigan 49201, party of the first part; and Howard A. Tanner, Director of the Michigan Department of Natural Resources for and on behalf of the State of Michigan, whose address is: P.O. Box 30028, Lansing, Michigan 48909, party of the second part;

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1980 MAY -9 PM 2:44
REGISTER OF DEEDS
BAY COUNTY MICH

WITNESSETH THAT:

WHEREAS, application for licensure under provisions of 1978 PA 641, 1970 CL 299.401 et seq, for the purpose of conducting, managing, maintaining or operating a disposal area upon lands situated in the Township of Hampton, County of Bay, more particularly described as:

III #6

> A parcel of land in Section 1 and 2, T14N, R5E, Hampton Township, Bay County, Michigan, described as follows:
>
> To find the place of beginning of this description commence at the Northwest corner of the D. E. Karn Plant powerhourse, thence Northwesterly approximately 2400 feet to the Northeasterly intersection of two ash dike roads, (being on the Easterly shore of the Saginaw River and the North shore of the Karn Plant discharge channel), also being the place of beginning of this description, thence Northeasterly along the Southeasterly edge of an ash dike road approximately 1300 feet, thence Southeasterly along the Southwesterly edge of said road approximately 6200 feet, thence Southwesterly along the Northwesterly edge of said road approximately 1600 feet to shoreline of the standing water inside said dike, thence generally in a Northwest direction along said shoreline to a point approximately 250 feet East of the Southeast corner of the Karn Plant substation fence, thence in a Northerly direction approximately 1000 feet to the Northerly edge of a road, thence Northwesterly along the Northeasterly edge of said road approximately 600 feet, thence Southwesterly along the

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Hampton Twp. Bay Co.

Northwesterly edge of said road approximately 350 feet to the edge of the old shoreline on Saginaw Bay, thence generally in a Northwest direction along said shoreline to the Easterly edge of an ash dike road, thence Northerly along the Easterly edge of said road approximately 350 feet, thence Westerly along the Northerly edge of said road approximately 950 feet to the place of beginning.

Containing 152 Acres.

has been properly made; and

WHEREAS, the Director of the Department of Natural Resources, will contemporaneously issue such license; and

WHEREAS, 1978 PA 641, supra, Section 16 requires that at the time of licensing of a sanitary landfill, an instrument which imposes a restrictive covenant upon the land involved shall be executed by all the owners of the tract of land upon which the landfill is located and the director.

NOW THEREFORE, Consumers Power Company, the party of the first part, does for itself, its successors, lessees, or assigns declare, covenant and agree:

1. That the lands hereinbefore described have been or will hereafter be used as a sanitary landfill for ash disposal, and that neither they, nor their servants, agents, employees, nor any of the successors, lessees or assigns shall (or shall by their leave or sufferance permit others to) engage in filling, grading, excavating, drilling or mining of the lands and premises above described until 15 years after completion of all landfill activity

upon the same, unless written authorization thereof is obtained from the Director of the Department of Natural Resources; and that the State of Michigan or any municipality may in addition to any other remedy available at law bring an action for an injunction or other process against any person, county, or municipality to restrain or prevent any violation of the restrictive covenant hereby imposed upon the subject premises.

2. That at the time of the ensealing and delivery of these presents the above described premises are free from all encumbrances whatever, except easements, reservations, and restrictions of record and that certain Indenture of Mortgage between party of the first part and Citibank, N. A., as successor Trustee, dated September 1, 1945, and recorded September 24, 1945 in Liber 201 of Mortgages, at page 21, Bay County Register of Deeds, together with all supplements thereto.

The Director of the Department of Natural Resources does for and on behalf of the State of Michigan covenant and agree to execute, acknowledge, and deliver to the party of the first part a release of the within restrictive covenant, in suitable form upon the expiration of the 15 year period provided for herein.

Signed In Presence Of:

Linda K Carstens

Betty L. Bishop

CONSUMERS POWER COMPANY

By C R Bilby
C. R. Bilby
Its Vice President

Signed In Presence Of:

Nancy McDowell

Kathy M. Proctor
Kathy M. Proctor

STATE OF MICHIGAN

By Thomas O. Work

Thomas O. Work, Assistant Resource Recovery
Director of the Department of Chief (on
Natural Resources for the of the Dir
State of Michigan

STATE OF MICHIGAN)
) SS.
COUNTY OF JACKSON)

The foregoing instrument was acknowledged before me this ____ day of September, 1979, by C. R. Bilby, the Vice President of Consumers Power Company, a Michigan corporation, on behalf of the corporation.

Dorothy H. Barthus

Notary Public, Jackson County, Michigan
My Commission Expires: March 26, 1983

STATE OF MICHIGAN)
) SS.
COUNTY OF INGHAM)

The foregoing instrument was acknowledged before me this [illegible] day of [illegible], by [illegible], Director of the Department of Natural Resources, on behalf of the State of Michigan.

[illegible]

Notary Public, Ingham County, Michigan
My Commission Expires: [illegible]

Prepared by Jack I. [illegible]
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

5558-62542 07.00

6-1-82

DECLARATION OF RESTRICTIVE COVENANT

THIS INDENTURE made the 1st day of June, 1982, by and between, CONSUMERS POWER COMPANY, a Michigan corporation, whose address is 212 West Michigan Avenue, Jackson, Michigan 49201, party of the first part; and Howard A. Tanner, Director of the Michigan Department of Natural Resources for and on behalf of the State of Michigan, whose address is Lansing, Michigan, party of the second part;

WITNESSETH:

WHEREAS, application for licensure under provisions of 1978 PA 641, 1970 CL 299.401 et seq, for the purpose of conducting, managing, maintaining or operating a disposal area upon lands situated in the Township of Hampton, County of Bay, more particularly described as:

D. E. KARN PLANT ASH DISPOSAL AREA

A parcel of land in Sections 1 and 2, T14N, R5E, Hampton Township, Bay County, Michigan, described as follows:

To find the place of beginning of this description commence at the Northwest corner of the D. E. Karn Plant powerhouse; thence Northwesterly approximately 2400 feet to the Northeasterly intersection of two ash dike roads, (being on the Easterly shore of the Saginaw River and the North shore of the Karn Plant intake channel), also being the place of beginning of this description; thence Northeasterly along the Southeasterly edge of an ash dike road approximately 1300 feet; thence Southeasterly along the Southwesterly edge of said road approximately 6200 feet; thence Southwesterly along the Northwesterly edge of said road approximately 2000 feet to a point near the Northerly shore of the Karn Plant discharge channel; thence generally in a Northwest direction along said shoreline to a point approximately 250 feet East of the Southeast corner of the Karn Plant substation fence; thence in a Northerly direction approximately 800 feet; thence in a Westerly direction approximately 1400 feet; thence in a Northerly direction approximately 300 feet; thence in a Northwesterly direction approximately 350 feet to the centerline of an ash dike road near the Easterly edge of the intake channel for the Karn Plant; thence Northerly along said road approximately 400 feet; thence Westerly along the centerline of said road approximately 950 feet to the place of beginning.

Containing 174 acres.

Hampton Twp. Bay Co

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has been properly made; and

WHERERAS, the Director of the Department of Natural Resources, will contemporaneously issue such license; and

WHEREAS, 1978 PA 641, supra, Section 16 requires that at the time of licensing of a sanitary landfill, an instrument which imposes a restrictive covenant upon the land involved shall be executed by all the owners of the tract of land upon which the landfill is located and the director.

NOW THEREFORE, Consumers Power Company, the party of the first part, does for itself, its successors, lessees, or assigns declare, covenant and agree:

1. That the lands hereinbefore described have been or will hereafter be used as a sanitary landfill for ash disposal, and that neither they, nor their servants, agents, employees, nor any of the successors, lessees or assigns shall (or shall by their leave or sufferance permit others to) engage in filling, grading, excavating, drilling or mining of the lands and premises above described until 15 years after completion of all landfill activity upon the same, unless written authorization thereof is obtained from the Director of the Department of Natural Resources; and that the State of Michigan or any municipality may in addition to any other remedy available at law bring an action for an injunction or other process against any person, county, or municipality to restrain or prevent any violation of the restrictive covenant hereby imposed upon the subject premises.

2. That at the time of the ensealing and delivery of these presents the above described premises are free from all encumbrances whatever, except easements, reservations, and restrictions of record and that certain Indenture of Mortgage between party of the first part and Citibank, N. A., as successor Trustee, dated September 1, 1945, and recorded September 24, 1945 in Liber 201 of Mortgages, at page 21, Bay County Register of Deeds, together with all supplements thereto.

3. That this instrument is given for the purpose of correcting that certain Declaration of Restrictive Covenant dated September 1, 1979, and recorded at Liber, 885, page 789, of the Bay County records by correcting the description of lands intended to be restricted in connection with the aforesaid licensure.

The Director of the Department of Natural Resources does for and on behalf of the State of Michigan covenant and agree to execute, acknowledge, and deliver to the party of the first part a release of the within restrictive covenant, in suitable form upon the expiration of the 15 year period provided for herein.

Signed In Presence Of:

Helen R. Dempski
Helen R. Dempski

Patricia Furnival
Patricia Furnival

CONSUMERS POWER COMPANY
By
Its

APPROVED AS TO FORM
CONSUMERS POWER COMPANY
LEGAL DEPARTMENT

Signed In Presence Of:

Thomas O. Work

Nancy Kay McDowell

STATE OF MICHIGAN
By
Howard A. Tanner, Director
Director of the Department of
Natural Resources for the
State of Michigan

1982 OCT -6 PM 12: 36

REGISTER OF DEEDS
BAY COUNTY, MICHIGAN

RECORDED

STATE OF MICHIGAN)
) SS
COUNTY OF JACKSON)

The foregoing instrument was acknowledged before me this 1st day of June, 1982, by C R Bilby, the Vice President of Consumers Power Company, a Michigan corporation, on behalf of the corporation.

Dorothy H. Barthus
Notary Public, Jackson County, Michigan
My Commission Expires: March 26, 1983

STATE OF MICHIGAN)
) SS
COUNTY OF INGHAM)

The foregoing instrument was acknowledged before me this 22 day of July, 1982, by Howard Tanner, Director of the Department of Natural Resources, on behalf of the State of Michigan.

Janice M. Ferguson
Notary Public, Ingham County, Michigan
My Commission Expires:
JANICE M. FERGUSON
Notary Public, Ingham County, Mich.
My Comm. Expires March 5, 1984

Prepared by Jack D. Shumate
Consumers Power Company
212 West Michigan Avenue
Jackson, Michigan 49201

D.E. Karn

3-15-90

AMENDED DECLARATION OF RESTRICTIVE COVENANT

THIS INDENTURE, made this 15th day of March, 1990, by and between CONSUMERS POWER COMPANY, a Michigan corporation, whose address is 212 West Michigan Avenue, Jackson, Michigan 49201, party of the first party; and David Hales, Director of the Michigan Department of Natural Resources for and on behalf of the State of Michigan, whose address is Box 30028, Lansing, Mi. 48909, party of the second part;

WITNESSETH:

WHEREAS, Consumers Power Company has made proper application for licensure under provisions of 1978 PA 641, as amended by 1987 PA 209, MCL 299.401 et seq; MSA 13.29(1) et seq; for the purpose of conducting, managing, maintaining, or operating a disposal area upon land situated in the Township of Hampton, County of Bay, more particularly described as:

D.E. KARN PLANT ASH DISPOSAL AREA

A parcel of land in Sections 1 and 2, Township 14 North, Range 5 East, described as follows:

To find the place of beginning of this description commence at the Northwest corner of the D.E. Karn Plant powerhouse; thence Northwesterly approximately 2400 feet to the Northeasterly intersection of two ash dike roads (being on the Easterly shore of the Saginaw River and the North shore of the Karn Plant intake channel), also being the place of beginning of this description; thence Northeasterly along the Southeasterly edge of an ash dike road approximately 1300 feet; thence Southeasterly along the Southwesterly edge of said road approximately 6200 feet; thence Southwesterly along the Northwesterly edge of said road approximately 2000 feet to a point near the Northerly shore of the Karn Plant discharge channel; thence generally in a Northwest direction along said shoreline to a point approximately 250 feet East of the Southeast corner of the Karn Plant substation fence; thence in a Northerly direction approximately 800 feet; thence in a Westerly direction approximately 1400 feet; thence in a Northerly direction approximately 300 feet; thence in a Northwesterly direction approximately 350 feet to the centerline of an ash dike road near the Easterly edge of the intake channel for the Karn Plant; thence Northerly along said road approximately 400 feet; thence Westerly along the centerline of said road approximately 950 feet to the place of beginning.

Containing 174 acres.

WHEREAS, the Director of the Department of Natural Resources will contemporaneously issue such license; and

T14N, R5E Hampton Twp, Bay Co

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WHEREAS, Section 16 of 1978 PA 641, as amended, MCL 299.416; MSA 13.29(16) requires that at the time of licensing of a sanitary landfill, an instrument which imposes a restrictive covenant upon the land involved shall be executed by all the owners of the tract of land upon which the landfill is located and the Director;

NOW, THEREFORE, Consumers Power Company, the party of the first part, does for itself, its successors, lessees, and assigns, declare, covenant, and agree:

1. That the land hereinbefore described has been or will be used as a sanitary landfill for ash disposal.

2. That neither Consumers Power Company, its servants, agents, or employees, nor any of its successors, lessees, or assigns shall (or shall by their leave or sufferance permit others to) engage in filling, grading, excavating, drilling, or mining of the land above described during the first 50 years following completion of the landfill upon the land without written authorization of the Director of the Department of Natural Resources.

3. That the State of Michigan or any municipality may, in addition to any other remedy available at law, bring an action for an injunction or other process against any person, county, or municipality to restrain or prevent any violation of the restrictive covenant hereby imposed upon the subject premises.

4. That at the time of the ensealing and delivery of these presents the above described land is free from all encumbrances whatever, except easements, reservations, and restrictions of record and a mortgage now held by Manufacturers Hanover Trust Company, Trustee, dated September 1, 1945 and recorded September 24, 1945 in Liber 201 of Mortgages, at page 21, Bay County Register of Deeds, together with all amendments and supplements thereto.

5. That this instrument is given to amend that certain Declaration of Restrictive Covenant dated October 6, 1982, and recorded at Liber 926, page 452-454, of the Bay County records, to comply with Section 16 of 1978 PA 641, as amended, MCL 299.416; MSA 13.29(16).

The Director of the Department of Natural Resources does, for and on behalf of the State of Michigan, covenant and agree to execute, acknowledge, and deliver to the party of the first part a release of the within restrictive covenant, in suitable form, upon the expiration of the 50-year period provided for herein.

Signed in the Presence of:

Edward R Bradley
Edward R Bradley

Karen S Elkins
Karen S Elkins

CONSUMERS POWER COMPANY

By Roy A Wells
Roy A Wells, Jr
Vice President

APPROVED AS TO FORM
DRK
CONSUMERS POWER COMPANY
LEGAL DEPARTMENT
ERB

Margaret J. Curry

Mary Beth Thelen
Mary Beth Thelen

STATE OF MICHIGAN

ACTING

By ________________
Delbert Rector
Director of the Department of
Natural Resources for the
State of Michigan

STATE OF MICHIGAN)
) SS.
COUNTY OF JACKSON)

The foregoing instrument was acknowledged before me this 12th day of May, 1989, by Roy A Wells, Vice President of Consumers Power Company, a Michigan corporation, on behalf of the corporation.

Edward R Bradley
Edward R Bradley
Notary Public, Jackson County, Michigan
My Commission Expires: October 16, 1990

STATE OF MICHIGAN)
) SS.
COUNTY OF)

The foregoing instrument was acknowledged before me this 54 day of [illegible], 1989, by [illegible], Director of the Department of Natural Resources, on behalf of the State of Michigan.

____
Notary Public, ______ County, Michigan
My Commission Expires: __________

[illegible] 1991
[illegible] County, MI

Attachment B

D.E. Karn Generating Facility Corrective Action Feasibility Study

Feasibility Study

D.E. Karn Generating Facility

Prepared for
Consumers Energy Company

February 2021

3005 Boardwalk Street, Suite 100
Ann Arbor, MI 48108
734.922.4400
www.barr.com

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Abbreviations

µg/L	micrograms per liter
µM	micrometer
bgs	below ground surface
BOD	biochemical oxygen demand
CCR	coal combustion residual
CSBR	continuously stirred batch reactor
CSM	Conceptual Site Model
DO	dissolved oxygen
EGLE	Michigan Department of the Environment, Great Lakes, and Energy
EVS	Earth Volumetric Studio
FS	feasibility study
gpm	gallons per minute
GSI	groundwater-surface water interface
HMP	Hydrogeological Monitoring Plan
MDEQ	Michigan Department of Environmental Quality
MODFLOW	Modular Three-Dimensional Finite-Difference Groundwater Flow Model
mV	millivolts
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollution Discharge Elimination System
ORP	Oxygen Reduction Potential
PRB	Permeable Reactive Barrier
PSA	Pressure Swing Adsorption
QA/QC	Quality Assurance/Quality Control
RAP	Remedial Action Plan
RCRA	Resource Conservation and Recovery Act
SESC	Soil Erosion and Sedimentation Control
TOC	total organic carbon
ZVI	zerovalent iron

Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a licensed Professional Engineer under the laws of the state of Michigan.

Kathleen Lindstrom

Kathleen Lindstrom
PE license #: 6201061370

02/25/2021
Date

KATHLEEN
LINDSTROM
ENGINEER
No.
6201061370

Executive Summary

This feasibility study (FS) for the Consumers Energy Company's D.E. Karn Electrical Power Generating Facility (generating facility) describes a feasibility-level evaluation of corrective action options being considered to address arsenic-impacted groundwater related to the 171-acre, Type III, low-hazard industrial landfill (Karn Landfill) at the generating facility. The generating facility, closed Karn Landfill, closed Karn Bottom Ash Pond, and Karn Lined Impoundment make up what is herein referred to as the site. This feasibility study was performed to meet the State of Michigan Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act (NREPA), Public Act 451 of 1994, as amended and State of Michigan Part 201, Environmental Remediation, of the NREPA, Public Act 451 of 1994, as amended and the administrative rules promulgated pursuant thereto (Part 115 and Part 201 Rules, respectively).

Previous investigations have been performed at the site, and observations from previous investigations have been used to develop a detailed site understanding including a conceptual site model (CSM), groundwater flow model (groundwater model), and understanding of site constraints related to potential corrective actions. The CSM includes a description of the current understanding of geology, geotechnical characteristics, hydrogeology, hydrology, and groundwater quality at the site. A groundwater model was developed to assist with evaluating corrective action options that were identified to be carried forward from a corrective action options assessment (options assessment), and a summary of the groundwater model development is included in Appendix A.

The five corrective action options evaluated in the options assessment were 1) installing a low-permeability subaqueous cap; 2) excavating coal combustion residual (CCR) material from the Karn Landfill; 3) optimizing the existing groundwater extraction and treatment system and installing a barrier wall; 4) installing an air sparging system; and 5) installing a permeable reactive barrier (PRB) with zero-valent iron (ZVI). A groundwater extraction system, air sparging system, and PRB were recommended to be carried forward to this FS, and those corrective action options were further refined based on additional evaluations.

This FS includes detailed evaluations of each of the three corrective action options, including summaries of bench testing and groundwater modeling results and an assessment of the short- and long-term effectiveness, implementability, permitting and community considerations, schedule, range of costs, and advantages and disadvantages for each corrective action option. Based on the results of these evaluations, a PRB is the recommended corrective action to move forward into a remedial action plan, because ZVI has been proven to attenuate arsenic in both its more soluble oxidation state (As^{+3}) and less soluble oxidation state (As^{+5}) by adsorption onto the surface of the ZVI particles and co-precipitation of arsenic with iron (reference (1)); results from bench testing show that ZVI is effective at mitigating arsenic impacts from site groundwater (Appendix F); it provides short- and long-term effectiveness in attenuating arsenic in groundwater; it is implementable with low operation and maintenance requirements relative to other corrective action options; there are few permitting and community concerns; the schedule for implementation is reasonable; and the cost is low, relative to other corrective action options.

1 Introduction and Corrective Action Objectives

This feasibility study (FS) for the Consumers Energy Company's (Consumers') D.E. Karn Electrical Power Generating Facility (generating facility) describes a feasibility-level evaluation of corrective action options being considered to address arsenic-impacted groundwater related to the 171-acre, Type III, low-hazard industrial landfill (Karn Landfill) at the generating facility. The generating facility is located at 2742 N. Weadock Highway in Essexville, Michigan east of the Saginaw River (river) on the south end of the Saginaw Bay (bay) (Figure 1). The site is comprises the generating facility; a closed 171-acre, Type III, low-hazard industrial landfill (Karn Landfill); the clean-closed Karn Bottom Ash Pond; and the Karn Lined Impoundment (Figure 2). Together, these components make up what is herein referred to as the site. This FS has been completed to meet the requirements of State of Michigan Part 115, Solid Waste Management, of the Natural Resources and Environmental Protection Act (NREPA), Public Act 451 of 1994, as amended (Part 115, reference (2)) and State of Michigan Part 201, Environmental Remediation, of NREPA, Public Act 451 of 1994, as amended (Part 201, reference (3)) and the administrative rules promulgated pursuant thereto (Part 115 and Part 201 Rules). Specifically, this FS is being pursued under R 299.4319(6)(e) and in compliance with the provisions of section 20120 of Part 201.

Consumers performs routine groundwater monitoring pursuant to the Hydrogeological Monitoring Plan (HMP) (reference (4)) and Resource Conservation and Recovery Act (RCRA) monitoring programs. In 2002, concerns were raised by the Michigan Department of Environmental Quality (MDEQ, since renamed to the Michigan Department of Environment, Great Lakes, and Energy [EGLE]) relating to possible groundwater quality issues associated with CCR materials, including arsenic, venting into the bay (reference (5)). Following this, Consumers discontinued hydraulic fly ash sluicing at the site in 2009, executed a Groundwater-Surface Water Interface (GSI) Compliance Monitoring Program consistent with the requirements set forth in a 2009 letter from EGLE (reference (6)), and installed an interim system of six groundwater extraction wells on the northern border of the Karn Landfill near the bay in late 2016 where the greatest groundwater quality concerns have historically been observed (reference (4)). Since 2015, arsenic, boron, chromium (based on GSI criteria for hexavalent chromium), molybdenum, and selenium have been detected in groundwater above Part 201 generic GSI criteria. Arsenic and boron are the two parameters that are most consistently detected at concentrations above generic GSI criteria at the site, and arsenic is the parameter that exceeds chronic mixing zone-based concentration values in monitoring wells. While the existing groundwater extraction system helps maintain compliance with groundwater quality standards, Barr Engineering Co. (Barr) is assisting Consumers with an evaluation of corrective action options to recommend a long-term solution for maintaining compliance at the Karn Landfill.

A corrective action options assessment (options assessment) was completed to evaluate potential corrective action options for addressing arsenic-impacted groundwater related to the Karn Landfill and recommend corrective action options to be carried forward for further assessment in this FS. The five corrective action options evaluated in the options assessment were 1) installing a low-permeability subaqueous cap; 2) excavating CCR material from the Karn Landfill; 3) optimizing the existing groundwater extraction and treatment system and installing a barrier wall; 4) installing an air sparging system; and 5) installing a permeable reactive barrier (PRB) with zero-valent iron (ZVI). Relative advantages and disadvantages, implementability, effectiveness at meeting corrective action objectives, estimated costs, schedule, and data gaps were compared for each corrective action option. Installing a subaqueous cap was not retained for further evaluation because effectiveness was uncertain and it would have a relatively high cost, and excavating CCR material from the Karn Landfill was not retained for further evaluation because the construction duration would be years and it was expected to have a relatively high cost. Optimization of the existing groundwater extraction system, along with installation of a barrier wall; an air sparging system; and a permeable reactive barrier were recommended to be carried forward for further assessment based on the following primary advantages:

- **Groundwater extraction system with barrier wall** – an existing system is in place, performance of the existing system can potentially be increased by optimizing how the system is operated and constructing a low-permeability barrier wall, and overall costs were relatively low compared to other options.
- **Air sparging** – preliminary bench-scale testing by others indicated that the aquifer is suitable for air sparging (reference (7)), routine maintenance would be less than other options, and costs were relatively low compared to other options.
- **Permeable reactive barrier** – preliminary bench-scale testing indicated that typical permeable reactive barrier amendments are capable of reducing arsenic concentrations (reference (8)), no regular operation and maintenance would be required, and though overall costs were greater than the groundwater extraction and air sparging options, they were much lower than the subaqueous cap and excavation options.

Feasibility-level data gaps for these three corrective action options have been addressed, and this FS includes a further evaluation of the three recommended corrective action options based on additional data collected since the options assessment.

1.1 Corrective Action Objectives and Report Organization

The primary corrective action objective is to meet and maintain long-term compliance during post-closure care of the Karn Landfill with mixing zone-based GSI criteria for arsenic in groundwater venting from the Karn Landfill to the bay. Site-specific chronic and acute mixing zone-based concentration values for arsenic are 100 micrograms per liter (µg/L) and 680 µg/L, respectively. Balancing criteria used to evaluate each of the corrective action options were short- and long-term effectiveness in meeting the primary corrective action objective; implementability, including the degree of difficulty, operational reliability, availability of equipment and specialists, and practicable capability to perform the corrective action; permitting and community considerations; schedule; costs; and advantages and disadvantages relative to other corrective action options.

The corrective action area is defined as the portion of the northern boundary of the Karn Landfill immediately upgradient of the GSI (Figure 2) where arsenic concentrations in groundwater have exceeded chronic and acute mixing zone-based values (i.e., Transects 2 through 5). Implementation and construction of the three corrective action options evaluated in this FS would be performed within this corrective action area.

This FS is organized as follows:

Section 2 Site Understanding Summary: This section includes a summary of the current CSM, groundwater flow model (groundwater model), and potential site constraints for corrective action implementation.

Section 3 Corrective Action Options Evaluation: This section includes an overview of common elements between the corrective action options and an evaluation of the options.

Section 4 Conclusions and Recommendations: This section summarizes results of the evaluation, identifies a recommended option to carry forward to the remedial action plan (RAP), and outlines recommended next steps.

Section 5 References

2 Site Understanding Summary

A CSM and a groundwater model have been prepared to develop a detailed site understanding and to facilitate the evaluation of potential corrective actions. The Groundwater Modeling Report is in Appendix A. The following sections summarize key findings from the CSM and Groundwater Modeling Report and an provide an evaluation of potential site constraints related to corrective action implementation.

2.1 Conceptual Site Model

CCR materials have been placed in three different locations within the site: the Karn Landfill, the Karn Bottom Ash Pond, and the Karn Lined Impoundment.

- The Karn Landfill received sluiced bottom ash and fly ash from the coal-fired units at the generating facility starting in the late 1950s but converted to dry fly ash handling operations in 2009. Consumers started to close portions of the Karn Landfill in 2012 after the final closure plan was revised to incorporate a geomembrane cover. Additional revisions of the closure plan were submitted in 2014 that included a revised final cover grading plan at “minimum grades” (reference (9)). Upon approval of the responses to comments of the 2014 revised plan culminating in the final 2015 revised closure plan (reference (10)), closure activities focused on rebalancing existing grades of coal ash/CCR within the Karn Landfill. Effectively, the Karn Landfill ceased receiving CCR materials for disposal once the placement of any new materials in the Karn Landfill was limited to Spray Dry Absorber commingled with Fly Ash (SDA/FA) and/or bottom ash that was utilized as a direct substitute for soil to stabilize and construct the subgrade to a sufficient bearing capacity to support the final cover construction in accordance with the approved engineering specifications and drawings of the 2015 revised closure plan (reference (11)). There are approximately 6.7 million cubic yards of ash and fill material remaining in the Karn Landfill; the thickness of the ash/fill ranges from approximately 1 to 56 feet, with a typical thickness of approximately 20 feet throughout the Karn Landfill.

- The Karn Bottom Ash Pond historically received and managed bottom ash and was closed in 2018 by excavating CCR materials to a depth meeting health-based criteria certified through multiple lines of evidence from the pond (reference (12)). Excavated material was taken to the Weadock Solid Waste Disposal Area (Weadock Landfill) for disposal. At this time, bottom ash management transitioned from the Karn Bottom Ash Pond to the Karn Lined Impoundment. The Karn Lined Impoundment is a double-lined, double-composite storage pond that includes a leachate collection system and is the only structure at the site which currently receives CCR materials in the form of hydraulically sluiced bottom ash and various process waters. The Karn Lined Impoundment is periodically dredged, and removed CCR materials are stacked and allowed to dewater before being taken to the Weadock Landfill for disposal.

The Karn Landfill was originally constructed by building breakwater dikes from the shoreline at the plant lakeward to enclose shallow, submerged, bay-bottom land (reference (5)). The perimeter dikes were constructed using native materials ranging from silty clay to coarse sand, were topped with bottom ash, and are armored on the shoreward and channel side with riprap (reference (13)). Installation of a final cover over the landfill was completed in 2019, and the typical construction of the cover includes a 40 mil high-density polyethylene (HDPE) textured geomembrane liner, a nonwoven geotextile fabric, rooting zone soil (that also encompasses drain tile systems), topsoil, and the establishment of vegetation. Consumers received certification of closure from EGLE in summer 2020 (reference (14)), and the Karn Landfill has entered into a 30-year post-closure care period.

The primary geologic units under the Karn Landfill are ash and other fill materials and sand, silt, and clay. A three-dimensional (3D) model of stratigraphy was created using Earth Volumetric Studio (EVS) software, developed by C Tech Development Corporation. Boring data from select D. E. Karn and J. C. Weadock site borings were used to interpolate stratigraphic contacts across the model extent, and a cross section along the northern perimeter dike depicting site features and stratigraphy from the 3D model is included on Figure 3. The fill/native sand unit is the primary conduit of impacted groundwater flow. Native sands are present as two units separated by an intermediate silt/clay layer on the west side of the landfill, but the lower sand pinches out to zero thickness toward the east, in the corrective action area. The upper sand ranges in thickness from approximately 33 feet on the west side of the landfill to less than 10 feet on the east side. A continuous, native, hard silty clay unit, deposited as glacial till, exists beneath the sand and intermediate silt/clay units. The top of this unit is relatively flat throughout the eastern portion of the landfill, at an elevation of approximately 575 feet, but slopes downward to the west under the river to an elevation of 515 feet, and the unit extends to bedrock at an elevation of approximately 500 to 520 feet.

Multiple geotechnical investigations have previously been completed at the site, and one investigation of note was a slope stability analysis conducted in 2010 by NTH that stated that further slope stabilization to the dikes would likely be required prior to installing a soil-bentonite wall (reference (15)). Based on this evaluation and previous recommendations, Consumers regraded the dike slopes along the intake channel and installed a geotextile liner and riprap on the dike slope bordering the discharge channel (reference (16)). Consumers also implemented a long-term monitoring plan for the perimeter dike (reference (17)).

Groundwater at the site flows radially outward towards the bay, river, intake channel, and discharge channel (Figure 4). Following the closure of the Karn Bottom Ash Pond and the installation of final cover over the landfill, a reduction in hydraulic gradients and groundwater elevations has been observed. Groundwater is still in contact with the ash in the Karn Landfill, and the thickness of saturated ash ranges from approximately 0 to 13 feet (Figure 4). A system of six groundwater extraction wells, shown in Figure 2, were installed to capture arsenic-impacted groundwater for treatment and discharge through the site's National Pollutant Discharge Elimination System (NPDES) outfall. Hydrogeologic data and operational records show that the system experiences regular intervals of downtime due to maintenance issues, and the system runtime and total pumping rate have been lower than anticipated. The minimum design pumping rate was expected to produce a system total of 18 gallons per minute (gpm). The observed flow rate from the groundwater extraction system, based on observations from June and November 2019, is 10 gpm combined for all six extraction wells (see Appendix A for additional details).

Average surface water elevations at the National Oceanic and Atmospheric Administration (NOAA) Essexville gauge station increased by approximately 1 foot in 2020 compared to 2019. Great Lake water levels fluctuated over a range of 3 to 6 feet since the nineteenth century and, in the future, more rapid fluctuations between extreme low and extreme high water levels are expected, due to increasingly volatile trends in regional precipitation and temperature attributed to climate change (reference (18)). Flood control at the site is maintained with the perimeter dike system to prevent inflow from the river and bay, and a series of drainage ditches to control runoff from precipitation that falls within the Karn Landfill. Precipitation and runoff in the Karn Landfill is handled by a series of lined drainage ditches which ultimately discharge to surface water.

There are CCR-related constituents in groundwater at the site and Consumers performs routine groundwater monitoring pursuant to the HMP (reference (4)) and RCRA monitoring programs. The HMP prescribes a GSI Compliance Monitoring program that consists of quarterly groundwater samples collected from 10 monitoring wells, quarterly porewater samples collected along 6 transects (Figure 2) in the bay, and annual field leachate samples collected from 2 leachate head wells screened in ash. It is expected that field leachate sampling under the HMP will be discontinued during the 30-year post-closure care period, and groundwater and porewater monitoring frequency under the HMP may be reduced in the future. The laboratory leachate program has been discontinued since the landfill no longer receives materials. Under the RCRA monitoring programs for the Karn Bottom Ash Pond and Karn Lined Impoundment, semiannual groundwater samples are also collected from 10 additional onsite monitoring wells and 4 offsite background monitoring wells.

Groundwater from the site vents into the bay, and the GSI is the primary exposure pathway at the site. Since 2015, arsenic, boron, chromium (based on GSI criteria for hexavalent chromium), molybdenum, and selenium have been detected in groundwater above Michigan generic GSI criteria, and arsenic and boron are the two parameters that are most consistently detected at concentrations above generic GSI criteria at the site (reference (13)). Of these parameters, arsenic is the primary CCR parameter of interest at the site, because it has been observed above the acute mixing zone-based concentration criteria (680 µg/L) in perimeter dike monitoring wells upgradient of where GSI is monitored for compliance at Transects 3 and 5 (Figure 2, Figure 5).

Arsenic concentrations are typically highest at the GSI within the flux zones of Transects 2, 3, 4, and 5 (Figure 2, Figure 5). Compliance with applicable mixing zone-based GSI criteria has been documented to be achieved on a quarterly basis since 2010, consistent with the requirements set forth in the Revisions to GSI Criteria and Facility Relicensing for Consumers Energy's Weadock and Karn Landfills, Bay County letter sent by EGLE on August 26, 2009 ((reference (6)), but arsenic levels have been observed above the chronic mixing zone-based concentration value of 100 µg/L at the alternative monitoring points for compliance (i.e., GSI transect point at water's edge) at Transects 3 through 5. Therefore, Consumers has demonstrated compliance by evaluating the total chronic loading based on contribution from each compliance monitoring location with respect to the total flux observed in the mixing zone (reference (19)). In the event that one or more alternative monitoring points cannot be used for compliance (e.g., snow or ice prevent the safe collection of samples), the perimeter embankment dike monitoring well(s) become the

GSI points of compliance. Groundwater monitoring results for arsenic at wells located on the perimeter embankment dike have been as high as a factor of 10-times the chronic mixing zone-based value.

Arsenic concentrations in MW-14 upgradient of Transect 5 have historically had the highest arsenic concentrations in groundwater but have shown a decreasing trend in arsenic concentrations in recent years, potentially due to closure capping and the implementation of the groundwater extraction system. Perimeter dike wells including MW-6 and MW-16 upgradient of Transects 1 and 6, respectively, also showed statistically significant decreasing arsenic trends from 2015-2020, indicating arsenic concentrations in groundwater are improving with time in these areas. Updated trend analysis completed at porewater transects (i.e., T1-3GSI through T6-3GSI) using data from 2015-2020 did not show any significant arsenic trends in the GSI porewater transects, and arsenic concentrations are typically highest at the GSI within the flux zones of Transects 2 through 5.

2.2 Groundwater Flow Model

A groundwater model was developed for the Karn Landfill and surrounding area using Modular Three-Dimensional Finite-Difference Groundwater Flow Model (MODFLOW) 6 (v 6.1.1, reference (20), (21)). MODFLOW 6 is the most recent core version of MODFLOW published by the U.S. Geological Survey. The groundwater model has uniform grid spacing of 25 feet by 25 feet (7.62 m). The grid is rotated 32 degrees counterclockwise to align with the primary direction of groundwater flow from the landfill.

The geologic model developed in EVS software (described in Section 2.1)was used to assign layer elevations to the fill and native units in the model domain. From top to bottom, the units represented in the groundwater model are ash and other fill materials, the upper native sand unit, the organic silt unit, and the lower native sand unit. The bottom of the groundwater model was represented as a no-flow boundary corresponding to the top of glacial till. The organic silt and lower native sand units are only present under the western side of the landfill, near the river, and were represented as discontinuous layers in the groundwater model.

Similar to previous groundwater modeling efforts by others (reference (22); Attachment B of Appendix F of reference (4)), the river was used as the western boundary of the modeled area and the bay was used as the northern and eastern boundaries. The southern boundary of the model domain is near the south end of the Weadock generating facility and was represented with a combination of no-flow and general-head boundaries.

The groundwater model was calibrated to measured water levels in site wells in June 2010, March 2016, and fall 2019. The fall 2019 dataset used static water levels from a site-wide water level monitoring event on October 7 and water levels collected with Level TROLLs® in some wells near the extraction system at midnight on November 8th. The extraction system wells were known to be pumping on November 7-8, so the combined dataset included wells with observed drawdown. Wells too far from the extraction system to have measurable drawdown had similar water levels on October 7 and November 8.

The calibrated groundwater model was used to evaluate the effectiveness of corrective action options, as described in Sections 3.2.4, 3.3.4, and 3.4.4. The hydrologic conditions represented in the fall 2019 period of model calibration were assumed for initial predictive modeling scenarios. These conditions included no recharge to the Karn Landfill due to the final cover system being in place and a relatively high surface water elevation for the bay (581.80 feet). The uncertainty of future Saginaw Bay water levels was assessed by running additional predictive scenarios with Saginaw Bay at the minimum observed water level (576 feet) and at the 100-year flood level (585 feet). Particle tracking in MODPATH (reference (23); reference (24)) was used to visualize groundwater flow of each simulated corrective action option.

2.3 Potential Site Constraints

This section summarizes potential constraints resulting from existing conditions at the site that will need to be considered during the corrective action design. This includes the perimeter dikes, existing infrastructure, and the Karn Landfill final cover system. Approximate locations of these potential constraints are shown on Figure 6.

2.3.1 Perimeter Dikes

The northern perimeter dike contains areas of relatively steep slopes from the dike to the bay. Since implementation and construction of the three corrective action options would be performed along the northern perimeter dike in the vicinity of Transects 2, 3, 4, and 5 (Figure 2), spatial constraints, slope stability, equipment loading, and potential dike improvements will need to be considered in remedy design.

2.3.2 Utilities and Other Infrastructure

The following utilities and infrastructure are known to be present in the proposed construction area along the northern perimeter dike in the vicinity of Transects 2, 3, 4, and 5:

- High voltage power transmission lines and towers are located approximately 50 feet south of the proposed construction area.
- Monitoring wells and piezometers are located next to and within the proposed construction area.
- Stormwater culverts are located within the proposed construction area.
- The existing groundwater extraction system is located in the proposed construction area, and also includes subgrade transmission piping, power and data cables, and overhead power lines. Depending on the corrective action implemented, some or all of this infrastructure may be removed as part of the remedy.

During remedy design, the location of the utilities and other infrastructure will need to be verified and caution will be required when working in these areas.

2.3.3 Karn Landfill Final Cover System

Protection of the final cover system must be considered during remedy design and construction, and for this evaluation it has been assumed that equipment operation on the final cover or disturbance of the final cover cannot occur.

3 Corrective Action Options Evaluation

The three corrective action options are evaluated in this section based on their effectiveness, implementability, advantages, disadvantages, permitting considerations, reliability, community considerations, schedule, and feasibility-level costs in general accordance with section 20120 of Part 201.

3.1 Common Corrective Action Elements

The three corrective action options carried forward from the options assessment include the following common elements:

- Geotechnical evaluation;
- Protectiveness under variable surface water elevation;
- Protection of existing infrastructure; and
- Long-term monitoring.

3.1.1 Geotechnical Evaluation

Each corrective action option would include the installation of subsurface structures through the dike, likely using trenching equipment or long-reach excavators in addition to drilling equipment for the groundwater extraction option. A geotechnical evaluation was performed to assess the stability of the dike under construction equipment loading. Post-installation, subsurface structures will remain in place, so long-term stability was included in the geotechnical evaluation. The geotechnical evaluation of the dike was performed by developing a geotechnical model in SLOPE/W, a two-dimensional slope stability modeling software (reference (25)), using data from previous geotechnical investigations ((reference (26)) (reference (27)), (reference (28)), (reference (29)).

Two sections were evaluated for construction (undrained) and long-term (drained) conditions. The two sections selected as critical sections for the geotechnical evaluation were along Transect 4, where there is a steep slope into the bay with a limited beach, and through Pond A East (consistent with Section I-I' from a prior report (reference (29)) where there is a shallower overall slope but a wider area between the toe of the slope and the bay and greater overall elevation change. Initial stratigraphic information for the geotechnical model was generated from the existing EVS model for the site. The initial stratigraphy was refined based on information in previous evaluations (references (30) and (29)).

Conservative values for the bay surface water elevation were used in the geotechnical model. Recent low lake levels (reference (31)) were used for the downstream condition at Transect 4, where a low water condition is critical due to the lack of water buttressing the toe of the slope in the water. At Pond A East, the water level at the downstream toe was set at the beach elevation (581 feet) rather than the recent low lake level (576 feet), because dropping the water lower than the beach would result in less conservative conditions (i.e., a higher effective stress at the toe). For both model sections, the bay elevation is within the historical range recorded by NOAA Great Lakes Environmental Research Laboratory (576 ft [January 2013] to 582 ft [July 2020] (reference (31)).

Simulated loading at the two sections consisted of two discrete surcharge loads to represent tracks of either one-pass trenching equipment or a conventional long-arm excavator. With this loading, the factor of safety for both the construction loading (undrained) and long-term (drained) cases were acceptable. The factor of safety was found to be greater than 2.0 for all examined cases, which is greater than the recommended minimum factor of safety of 1.3 and 1.5 for construction and long-term conditions, respectively; therefore, it is anticipated that each of the proposed construction activities for corrective action options would not destabilize the dike or cause slope failure.

Additional details about the geotechnical models and input assumptions, such as hydraulic conditions, material parameters, and model results are in Appendix B.

3.1.2 Protectiveness under Variable Surface Water Elevation

Bay water levels are currently at record high levels and continued swings between extreme high and extreme low water levels in the Great Lakes are expected over the duration of the post-closure care period. Corrective action options must consider these fluctuations so that changes in surface water elevations do not negatively impact compliance with site-specific chronic and acute mixing zone-based values.

With the appropriate design, the three corrective action options can address groundwater quality concerns from the base of the unconfined aquifer at the site (i.e., the top of the confining clay layer at approximately 575 feet), to near the ground surface of the perimeter dike of 595 feet, which is approximately 10 feet above the 100-year bay flood elevation of 585 feet (reference (32)).

At lower bay surface water elevations, the hydraulic gradient may increase, which would lead to higher groundwater flow velocities, decreasing the residence time of groundwater in the PRB or air sparging trench and potentially bypassing the groundwater extraction system. The PRB or air sparging options would intercept groundwater flow at lower groundwater elevations than currently observed at the site, but reliability of the groundwater extraction system may decrease during these conditions if the groundwater elevation drops below the tops of the extraction well screens. Pumping rates could be reduced to avoid aeration of extraction well screens; however, this could reduce groundwater capture by the groundwater extraction system.

If the bay surface water elevations increase to 100-year bay flood surface water levels, groundwater elevations may rise, but overall long-term flow patterns at the site are not expected to change significantly, and the corrective action options are expected to be protective of the GSI at 100-year bay flood surface water levels based on groundwater modelling under these conditions.

As noted in the Section 3.1.1, stability of the perimeter dike in response to 100-year surface water elevations is not a concern due to the high factor of safety maintained after installation of any of the three corrective action options.

3.1.3 Modifications to Existing Infrastructure

Overhead utilities, final cover, and major buried utilities are not present along the proposed corrective action area along the northern perimeter dike. Construction impacts from any of the corrective action options would be expected to include:

- modifications to, or removal and re-installation of, stormwater culverts that cross the perimeter dike in the corrective action area;

- modifications to, or removal and potential re-installation of, existing groundwater monitoring wells and piezometers; and

- abandonment of the existing groundwater extraction wells and extraction system piping and wiring if the infrastructure is not utilized for the implemented corrective action.

3.1.4 Long-Term Monitoring

The corrective action options evaluated in this FS will require long-term groundwater monitoring pursuant to the Michigan Part 115 Solid Waste Management Rules (reference (2)). The corrective action options being considered do not provide source removal; therefore, long-term groundwater monitoring is expected be required for the duration of the Karn Landfill's post-closure care period, which is established as 30 years from the time of closure by Part 115 R 299.4318. For any of the corrective action options selected, a long-term monitoring program to monitor performance and effectiveness of the selected technology will be established in the RAP.

3.2 Groundwater Extraction System

One of the corrective action options recommended to be carried forward in the corrective action options assessment was optimization of the existing groundwater extraction system (i.e., extraction wells, treatment system, and associated groundwater conveyance piping) and the addition of a barrier wall to increase capture. Since that document was written, additional groundwater level assessments, groundwater modeling simulations, and bench testing were performed to assess this corrective action option.

The groundwater extraction evaluation results indicate that the existing groundwater extraction system cannot meet the remedial objectives, because the construction of the groundwater extraction wells does not allow for sufficient groundwater drawdown and capture needed to achieve remedial objectives without operational challenges due to aeration of the extraction well screens. Additionally, groundwater modeling results for an extraction system option with a low-permeability barrier wall in place showed that a barrier wall would reduce the flow rate needed to achieve capture, but it was not a significant enough reduction to balance the costs of a low-permeability barrier wall and did not address challenges related to aeration of the extraction well screens. Based on the results of recent evaluations, the scope of this corrective action option was modified to remove further consideration of a low-permeability barrier wall, abandon the existing extraction well network, and design and install a new extraction well network to mitigate operational challenges due to aeration of the extraction well screens.

Bench testing was performed to evaluate effectiveness of the existing treatment system, and results show that a new treatment system would be required to increase residence time within the system to reliably reduce arsenic concentrations below mixing zone-based GSI criteria, so the scope of this corrective action option was further refined to include installation of a new treatment system.

A detailed evaluation of this corrective action option is included in the following sections, and general findings from the evaluation include:

- Groundwater treatment to mitigate arsenic impacts prior to off-site discharge is a reliable and effective method to mitigate arsenic impacts; however, the effectiveness is dependent on the ability of the extraction system to operate continuously within the thin saturated sand unit present at the site.
- An operationally reliable, and in turn effective, extraction system is potentially not implementable due to the thin saturated sand unit and uncertainties regarding changing groundwater elevations with time (e.g., due to changes in lake elevations), actual well efficiencies, and localized aquifer heterogeneities. These are the primary disadvantages of the groundwater extraction system option.

3.2.1 Corrective Action Scope and Concept

New groundwater extraction wells would be installed along the northern perimeter dike, evenly spaced from approximately Transect 2 to Transect 5. The layout and a conceptual drawing of the conceptual groundwater extraction system is shown on Figure 7. The groundwater extraction option would include:

- installing seven new groundwater extraction wells along the northern perimeter dike, each with a screened interval located immediately above the clay layer and a sump below the top of the clay layer to increase the available drawdown relative to the existing extraction wells, and operating the extraction wells at a combined flow rate of approximately 7 gpm;
- installing piping, or tying into existing piping where feasible, to transfer water from the extraction wells to a new treatment system;
- a new treatment system for treating arsenic-impacted groundwater produced by the extraction wells;
- constructing a new building to house the treatment system at the location of the existing treatment system;
- installing piping, or tying into existing piping where feasible, to convey water from the treatment system to the NPDES outfall; and
- operating and maintaining the extraction system throughout the post-closure period.

3.2.2 Bench Testing Results

Samples were collected from the influent and effluent of the existing treatment system in November 2019, June 2020, and July 2020 to evaluate the effectiveness of the existing treatment system in reducing arsenic concentrations to below mixing zone-based values. The analytical results are tabulated in Appendix C-1, and the laboratory analytical results are presented in Appendix C-2a through E-2c. The quality assurance and quality control (QA/QC) data were reviewed to assess the validity of the analytical results, and the QA/QC data evaluations are in Appendix C-3. Results show that the existing treatment system does not effectively treat arsenic to concentrations below mixing zone-based GSI criteria. However, it should be noted that treatment of arsenic to below mixing zone-based GSI criteria is not a requirement of the existing system, and compliance with the current NPDES permit is maintained by continuing treatment system operations consistent with the short-term characterization study for the NPDES outfall monitoring (reference (33)). Modifications to the treatment system to improve the treatment of arsenic would include increasing the residence time to allow for further precipitation/co-precipitation of arsenic and potentially adding a polishing treatment step. The existing treatment building is not adequately sized to house larger settling tanks or a treatment polishing step, so a new treatment system would be required as part of a groundwater extraction system to reliably treat arsenic to below mixing zone-based GSI criteria, which is the overall objective during the post-closure period.

3.2.3 Groundwater Modeling Results

Groundwater modeling was conducted to evaluate the potential capture zone of a groundwater extraction system, and particle tracking results are shown in Figure 8. Particle tracking results show that capture of groundwater from areas upgradient of the corrective action area is achievable with a groundwater extraction system operating at a total flow rate of approximately 7 gpm. Backwards particle tracking shows that some of the water being captured by the extraction wells would be from the bay, which could be mitigated by the installing a low-permeability barrier wall downgradient of the extraction wells. However, model results for a scenario with a low-permeability barrier wall in place showed a total flow rate of approximately 3 gpm (Appendix A), which is not expected to be a significant enough reduction in flow rate to balance the costs of a low-permeability barrier wall.

3.2.4 Effectiveness

It is expected that a treatment system can be designed and implemented to provide effective treatment of arsenic concentrations such that arsenic concentrations in the effluent from the treatment systems meet the corrective action objective; however, the general effectiveness of this corrective action option is expected to be limited due to the thin saturated sand layer at the site. The thickness of the saturated sand layer near the existing and proposed extraction wells is generally 8 feet but ranges from 1 foot to 14 feet. Groundwater extraction wells would be installed with up to 5-foot long screen intervals at the bottom of the saturated sand layer. This would result in approximately 0 to 3 feet of allowable drawdown at the extraction well locations in order to prevent drawdown below the well screen interval, which could cause fouling of the well screen. Based on groundwater modeling results, drawdown of approximately 0.5 feet is needed across the corrective action area (i.e., between the extraction wells), which results in a modeled drawdown of at least 1 foot at the extraction wells, to provide capture of arsenic-impacted groundwater.

Well inefficiencies would act to increase the amount of drawdown within the extraction well relative to the amount of drawdown in the aquifer, and fouling of the well screens over time would further increase drawdown within the wells throughout the operational life of the extraction system.

Maintaining drawdown of at least 0.5 feet across the corrective action area while preventing drawdown below the well screen at extraction well locations is expected to be difficult due to the thin saturated sand layer. Robust, real-time monitoring of water levels and the ability to remotely modify groundwater extraction system operations based on real-time monitoring results may allow for effective implementation of a groundwater extraction system; however, uncertainties in long-term water levels and localized heterogeneities may prevent successful implementation of this option despite robust monitoring and operation. It is further assumed that mechanical issues or failure to prevent drawdown below the well screen would periodically require the system to be shut down, which would result in near-instantaneous bypass of groundwater from the Karn Landfill to the bay and limit the overall effectiveness.

Implementation of a groundwater extraction system would not control the source of arsenic-impacted groundwater at the Karn Landfill (i.e., CCR materials). It is presumed that with a groundwater extraction system in place, arsenic and other constituents would continue to leach from the CCR materials into the groundwater.

3.2.5 Implementability

3.2.5.1 Degree of Difficulty

Construction of a groundwater extraction system is expected to be a low degree of difficulty relative to the other remedial technologies evaluated in this feasibility study. Installation of groundwater extraction wells is expected to be of low complexity due to the availability of construction equipment capable of implementing this work, accessibility to proposed extraction well areas, and success of previous drilling activities at the site. Construction of a treatment system and associated treatment building is expected to be of low to moderate complexity due to limited site constraints and availability of mechanical and civil contractors capable of installing a treatment system and constructing an associated treatment building similar to what is proposed.

Operation and maintenance of a groundwater extraction system is expected to be a high degree of difficulty due to the thorough monitoring and control needed to maintain operation of a groundwater extraction system within the thin, saturated sand layer present at the site.

3.2.5.2 Operational Reliability

A groundwater extraction system is expected to have relatively low reliability of continual operation due to difficulties inherent to operating an extraction system in a thin aquifer and potential mechanical malfunctions of either the extraction or treatment system equipment. Performance of the extraction wells would be assessed by real-time monitoring of water levels in extraction wells and nearby monitoring wells, and performance of the treatment system would be assessed through regular (e.g., monthly) monitoring of the effluent from the treatment system. It is expected that periodic preventative maintenance would be required for the extraction wells and treatment system to increase operational reliability and periodic refreshment of chemical feeds for the treatment system would be required to allow the treatment system to run continuously.

3.2.5.3 Availability of Equipment and Specialists

Equipment and specialists needed for installing extraction wells are expected to be readily available (i.e., mobilization for installation could take place within weeks of subcontracting). Equipment and specialists needed for installing a treatment system are expected to be available, and mobilization for construction of a treatment system could take place within weeks of subcontracting depending on equipment availability.

3.2.5.4 Owner's Practicable Capability to Perform Corrective Action

Consumers is expected to be well positioned for installing a groundwater extraction system due to their familiarity with managing the implementation of similar corrective actions at the Karn Landfill and other project sites.

Operation and maintenance of a groundwater extraction system would require real-time water level monitoring, periodic extraction system sampling, and periodic maintenance to mechanical aspects of the extraction system (e.g., extraction wells, pumps within the treatment system). Initially, Consumers is expected to be capable of performing ongoing operation and maintenance of the corrective action due to having staff on site that can tend to the extraction system quickly, if needed, with support of a third party responsible for overall operation of the system. Consumers' long-term capability of performing ongoing operation and maintenance activities is expected to be reduced when few staff are regularly on site after the generating facility is decommissioned, and a third party would need to be responsible for operation of the system and available to address maintenance concerns quickly.

3.2.6 Permitting Considerations

The proposed construction area for the extraction system is within 500 feet of the bay, a protected body of water; therefore, a Soil Erosion and Sedimentation Control (SESC) permit will be required.

Operation of the groundwater extraction system will require maintaining a NPDES permit for discharge from the extraction system. Initially it is expected that discharge from the extraction system could be permitted under the existing NPDES permit for the site, but a new NPDES permit would be needed for discharge from the extraction system when the generating facility is retired and industrial treatment and discharge is no longer occurring.

A Joint Permit may be required for the groundwater extraction system since the project would be subject to Part 315 Dam Safety Regulations; however, Part 315 includes an exemption for Part 115 impoundments, so a preapplication meeting with EGLE is recommended to verify that the project meets the exemption and a Joint Permit would not be required for construction activities.

3.2.7 Community Consideration

Active construction of a groundwater extraction system presents limited, temporary community considerations. Construction vehicle traffic to the site may increase during the construction, but is not expected to be a significant concern due to existing and historical vehicular traffic required for the operation of the generating facility and Karn and Weadock Landfills.

Implementation of the groundwater extraction system is expected to have negligible effects on the surrounding community once installed. The groundwater extraction system does not present concerns for adverse offsite effects (e.g., noise, decreased air quality, changes to the landscape) once installed, and the proposed location is within a secured site that is not accessible to the public.

Overall, it is expected that the community would have a moderate view of this corrective action option, because the short and long-term community impacts are negligible, but the community may prefer a more sustainable and dependable corrective action that requires less reliance on continual operation and maintenance along with reduced energy and chemical inputs.

3.2.8 Schedule Considerations and Range of Costs

Based on the general availability of equipment and specialists needed for installation of an extraction system and the expected installation timeframe, it is expected that the system could be installed within a year of finalizing a design and selecting a subcontractor to perform the work.

The estimated total cost to install the extraction system and operate and maintain it for 30 years are expected to range from $8,000,000 to 18,000,000. Detailed cost estimates are in Appendix D.

3.2.9 Advantages and Disadvantages

The primary advantages of a groundwater extraction system are:

- ex-situ treatment of arsenic-impacted groundwater by precipitation/co-precipitation is a well-established treatment method that can produce consistent results;
- implementing this corrective action option is expected to have a low-degree of difficulty;
- equipment and specialists capable of performing this work are expected to be readily available;
- initially it is expected that the owner will be capable of performing and operating this corrective action option; and,
- initial construction costs are expected to be low relative to other corrective action options.

The primary disadvantages of a groundwater extraction system are:

- the thin saturated sand layer at the site limits the available drawdown within the extraction wells, and, therefore, the factor of safety that can be applied to the reliability of the extraction well design. That is, while the extraction wells could be designed to overcome the drawdown limitation, uncertainties in changing groundwater elevations over time, actual well efficiencies, or localized heterogeneity in the sand layer could result in an ineffective design, unreliable system operation, and noncompliance with groundwater quality standards;

- long-term implementation and operation of this corrective action option is expected to have a high degree of difficulty due to thorough evaluation of performance data and changes to system operation that would be required to balance a minimum drawdown to capture groundwater while preventing drawdown of groundwater below the well screen, which would reduce likelihood of fouling the well screen;
- the owner’s practical capability of implementing this corrective action option is expected to be reduced over time as the generating facility is retired and the number of onsite staff is reduced;
- Significant modifications to the NPDES permitting following closure of the D.E. Karn Units 1&2 will be required; and
- long-term operation and maintenance costs are expected to be high relative to other corrective action options. This also conflicts with the owner’s planned reduction of personnel available to the site once the facility is retired.

3.3 Air Sparging

Air sparging using ambient air was one of the corrective action options recommended to be carried forward from the options assessment. Bench testing (i.e., sampling and laboratory analysis) was performed to evaluate the current geochemical properties of the unconfined aquifer, and results indicate that sparging with ambient air may not be capable of meeting the remedial objectives, because redox conditions in groundwater remain moderately to strongly reducing, and microbial pathways may be present that could scavenge oxygen pumped into the subsurface. The analytical results indicate that the sparged air will need to be enhanced using an oxygen generator to overcome the observed oxygen demand and reliably attenuate arsenic to concentrations below mixing zone-based GSI criteria; therefore, the scope of this corrective action option was modified to include sparging with enhanced air.

A detailed evaluation of this corrective action option is included in the following sections, and general findings from the evaluation include:

- Air sparging is an effective method to mitigate arsenic impacts; however, the effectiveness of this corrective action option is dependent on the ability of the air sparging system to operate continuously, because the potential exists for arsenic re-solubilization and contaminant rebound to occur if the system is shut down.
- The implementability and operational reliability, and in turn effectiveness, of the air sparging system are reliant on routine operation and monitoring requirements with significant power demands which are the primary disadvantages and cost drivers for this corrective action option.

3.3.1 Corrective Action Scope and Concept

An air sparging trench and associated system components would be installed along the northern perimeter dike from approximately Transect 2 to Transect 5, upgradient of the GSI. Air sparging is a documented means of attenuating arsenic (reference (34)). Air sparging increases the available oxygen within its zone of influence, oxidizing arsenic from its more soluble oxidation state, arsenite (As^{+3}), to its less soluble oxidation state, arsenate (As^{+5}). This change in oxidation state promotes arsenic co-precipitation with iron and carbon substrates, if iron or carbon are present in sufficient amounts, and adsorbed to soil surfaces, removing it from the dissolved phase. Implementation of an air sparging trench along the perimeter dike would promote the co-precipitation and a decrease in dissolved-phase arsenic concentrations before the groundwater discharges to the bay. The layout and a conceptual drawing of the air sparging option is shown on Figure 9. The air sparging option would include:

- constructing a 3,000-feet-long by 20-feet-deep by 2-feet-wide air sparging trench using a one-pass method along the perimeter dike perpendicular to groundwater flow;
- installing perforated HDPE air sparge pipes in the trench and backfilling with a gravel and sand mixture in a continuous and simultaneous process;
- constructing a 2-feet-deep by 15-feet-wide by 3,000-feet-long bench to receive excavated materials;
- staging excavated materials on the bench to dewater and transport to the Weadock Landfill for disposal;
- installing a pressure swing adsorption oxygen generator to produce oxygen for enhancing the air sparging stream;
- installing a compressor and blower unit to supply air to the air sparge pipes; and
- constructing a building to house the equipment.

3.3.2 Bench Testing Results

In July 2020, 10 soil borings were advanced and temporary monitoring wells were installed along the perimeter dike, and soil and groundwater samples were collected to further evaluate the air sparging corrective action option. The borings were advanced to the clay layer using a Geoprobe® direct-push drilling rig with continuous sample collection between Transects 2 and 5 at approximately 300-foot intervals. Temporary 1-inch-diameter PVC monitoring wells with 5-foot-long mill-slotted screens were set in the soil borings and were developed using surging and over-pumping methods. The location of the borings and temporary monitoring wells are shown on Figure G-1 of Appendix E-1, and the boring logs are included as Appendix E-2. One saturated soil sample and one groundwater sample were collected from each location and submitted to Eurofins TestAmerica for analysis of iron, arsenic, and general parameters. The soil and groundwater analytical results are tabulated in Appendix E-3, and the laboratory analytical results are presented in Appendix E-4. The QA/QC data were reviewed to assess the validity of the analytical results, and the QA/QC data evaluations are in Appendix E-5.

The soil and groundwater data collected in 2020 was used to evaluate the potential effectiveness of arsenic removal through air sparging under current conditions. Previous bench and pilot testing of air sparging to address arsenic-impacted groundwater at the Karn Landfill was performed by others in 2014 (reference (8)) and 2015 (reference (7)), respectively. However, in the time since that pilot study was conducted, closure of the Karn Bottom Ash Pond and installation of the final cover over the Karn Landfill could have changed some geochemical properties of the unconfined aquifer, so additional sampling was performed to evaluate current conditions. Key findings from the soil and groundwater sampling conducted in 2020 are:

- Clay was encountered between approximately 19 and 25 feet below the ground surface (bgs) during drilling, and groundwater was observed between approximately 9 and 14 feet bgs. This results in a saturated thickness of approximately 5 to 16 feet, which is generally consistent, but slightly higher than previous observations in the corrective action area.
- Total organic carbon (TOC) in soils ranged from 1,430 mg/kg to 3,580 mg/kg with a median TOC concentration of 2,220 mg/kg in soil. Elevated TOC in soils may limit the capacity for arsenic sorption onto iron oxyhydroxides, as organic compounds can compete with arsenic and other metals for sorption surfaces; however, the TOC concentrations indicate that dissolved oxygen (DO) competition from TOC would be relatively low.
- Median total and dissolved arsenic concentrations in groundwater were each 470 µg/L, and the median total and dissolved iron concentrations measured in groundwater were 4,095 µg/L and 3,940 µg/L, respectively, indicating that nearly all of the arsenic and iron is dissolved. Arsenic removal by co-precipitation with iron occurs at a molar ratio of approximately 2 (dissolved iron to dissolved arsenic), and the molar ratio of dissolved iron to dissolved arsenic in groundwater at the site is approximately 11, so there is sufficient dissolved iron present to theoretically remove arsenic by co-precipitation (reference (35)).
- Biochemical oxygen demand (BOD) was non-detect (<2 milligrams per liter [mg/L] or <60 mg/L) in all groundwater samples. The chemical oxygen demand was non-detect (<10 mg/L) in five of the 10 groundwater samples, and the median concentration in the wells with detections was 11.7 mg/L. The relatively low to non-detect BOD and COD values indicate that there are low oxygen demands from organic sources; however, the median DO concentration was 1.27 mg/L and the median oxidation-reduction potential (ORP) value measured in groundwater was -247 millivolts (mV), indicating moderately to strongly reducing groundwater conditions are present. The redox data suggests that there may be additional oxygen demand from inorganic compounds (e.g., sulfide) in the aquifer that may prevent arsenic co-precipitation with iron from occurring.

The results from the 2020 sampling were also evaluated against results from previous evaluations to evaluate effectiveness of the air sparging system, and are further discussed in Section 3.3.4.

3.3.3 Groundwater Modeling Results

Air sparging was not simulated using the groundwater model, because implementation of this corrective action option is not expected to alter groundwater flow at the site.

3.3.4 Effectiveness

Results of the soil and groundwater sampling conducted in 2020 were compared to results from the previous air sparging pilot test (reference (7)) and a biogeochemical characterization study (reference (36)) to evaluate the effectiveness of the air sparging option. The data collected in 2020 show that redox conditions in groundwater remain moderately to strongly reducing, and microbial pathways may be present that could scavenge oxygen pumped into the subsurface; therefore, oxygen amendments may be necessary for an air sparging system to decrease arsenic concentrations below the chronic mixing zone-based concentration of 100 µg/L. The following is a list of previous findings and biogeochemical conditions that may limit the effectiveness of an air sparging system with ambient air:

- During baseline sampling prior to an air sparging pilot test at Transect 5 in 2015, DO concentrations were measured at 0.8 mg/L in both wells within the treatment zone (TMW-1 and TMW-2), and ORP values of -81.9 mV and -80.6 mV were observed in TMW-1 and TMW-2, respectively, which indicates moderate to strongly reducing conditions.
- During a two-month air sparging pilot test using ambient air, DO and ORP levels increased in TMW-2 with median DO concentrations rising to 2.92 mg/L and median ORP values increasing to -31.7 mV. DO and ORP levels did not respond to air sparging in TMW-1, with median DO concentrations of 0.45 mg/L and median ORP values of -66.4 mV observed during the pilot study.
- Arsenic concentrations were reduced by approximately 50%, from 902 µg/L to 462 µg/L, at TMW-2, and approximately 27% at TMW-1, from 812 µg/L to 590 µg/L, over the two-month air sparging pilot test.
- The 2015 pilot study found that localized geology and oxygen demand from organic carbon and sulfide likely limited air sparging efficiency with ambient air.
- A site-wide biogeochemical characterization completed in 2019 (reference (36)) showed moderately to strongly reducing conditions in groundwater with evidence of oxygen-, nitrate-, arsenic-, iron-, and sulfate-reducing bacteria present. The presence of these bacteria indicate that there may be competing demands for the oxygen pumped into the subsurface.
- Sampling completed by Barr in 2020 showed moderately to strongly reducing groundwater conditions with a median DO concentration of 1.27 mg/L and a median ORP of -247 mV in 10 temporary wells from Transect 2 to Transect 5. The median arsenic concentration in these wells was 470 µg/L.

The results of the previous pilot-scale test (reference (7)), the biogeochemical characterization study (reference (36)), and the evaluation of the 2020 bench testing results indicate that arsenic reduction is feasible, because there is sufficient iron available in groundwater and soils to sequester arsenic via sorption onto iron oxyhydroxides under iron-oxidizing conditions; however, biogeochemical conditions at the site are typically iron-reducing, and there are several microbial pathways capable of scavenging DO. Moderate to strongly reducing groundwater conditions and DO-scavenging by microbial activity limit the effectiveness of air sparging using ambient air, and may require oxygen amendments to facilitate the co-precipitation of arsenic with iron and decrease arsenic concentrations below the mixing-zone based value. One specific oxygen amendment strategy that can be used to increase oxygen levels in the aquifer is sparging with enhanced air. Enhanced air, in this case, involves increasing the oxygen levels of the sparge air by feeding a stream of high-purity oxygen generated using a pressure swing adsorption (PSA) unit into the sparge air stream. Should this corrective action option be selected for implementation, an additional long-term pilot-scale test is recommended to evaluate efficacy of air sparging using enhanced air and for design data collection.

Upon startup of the air sparging system, air sparging is not expected to immediately begin attenuating dissolved arsenic, because the aquifer conditions would need to change from anaerobic to aerobic, and competing oxygen-consuming bacteria that are present would need to be overcome before arsenic attenuation is observed.

Once the aquifer conditions change from anaerobic to aerobic, an air sparge system is expected to remain effective at attenuating arsenic long-term if this system is operated continuously. Changes in lake levels and aquifer geochemistry may have the potential to impact the long-term effectiveness of an air sparging system, but modifications to the system operation (e.g., optimizing air pressure and flow rates) can be made to optimize the system performance based on ongoing data collection and evaluation. While air sparging with enhanced air is expected to be an effective corrective action option, if the system is shut down, the potential exists for contaminant rebound and arsenic re-solubilization to occur. Rebound is not expected to occur if the system is shut down for short periods of time (i.e., less than a few weeks) for maintenance, but rebound may occur once the system is shut down for more than a few weeks or permanently.

Implementation of an air sparging system would not control the source of arsenic impacted groundwater at the Karn Landfill (i.e., CCR materials). It is presumed that arsenic and other constituents would continue to leach from the CCR materials into the groundwater.

3.3.5 Implementability

3.3.5.1 Degree of Difficulty

Construction of an air sparging system is expected to be of a low degree of difficulty relative to other corrective action options evaluated in this feasibility study due to the availability of construction equipment capable of implementing this work (e.g., a long-reach excavator or one-pass trenching equipment), the relative lack of site constraints in the proposed construction area, and results from the geotechnical evaluation of the perimeter dike which suggests dike stability would not be a concern for this corrective action option. Installation of the PSA system is expected to be of low complexity due to the availability of manufacturers to install and start-up the system and train personnel on operation.

3.3.5.2 Operational Reliability

Air sparging systems have been documented as reliable and have been used in a variety of applications and sites to meet both short- and long-term remediation objectives (reference (34)). Routine operation and maintenance is required to maintain the reliability of the system and is expected to include monitoring of pressure, flow rates, and the performance of the compressor on approximately a weekly basis. Less frequent (i.e., on the order of years) cleaning of the system is also required to prevent iron fouling of the air sparging well screens and keep the system operating reliably over time.

3.3.5.3 Availability of Equipment and Specialists

Installation of an air sparging system requires contractors with specialized equipment and experience (e.g., one-pass trenching or open cut excavations). Several contractors capable of performing the work have been identified in the region who would likely be capable of performing the work.

The PSA system that would be used to increase the oxygen content of the sparged air would be designed specifically for this application based on existing conditions and project-specific requirements, which will require coordination with manufacturers and vendors. Several vendors capable of designing, assisting with installing these systems, training personnel on operation, and providing long-term operational support have been identified and are expected to be capable of performing the work.

3.3.5.4 Owner’s Practicable Capability to Perform Corrective Action

Implementation of the air sparging system would require coordinating with contractors and vendors to install the air system and PSA. Consumers is expected to be well positioned for implementation of an air sparging system, because construction and PSA contractors and vendors capable of performing the work have been identified, air sparging is an established remediation technology (reference (34)), and Consumers has familiarity with managing the implementation of corrective actions with a similar degree of difficulty at other project sites.

Operation of an air sparging system would require routine operation and maintenance, periodic cleaning of the air sparging pipes, periodic collection of groundwater quality data, and routine evaluation of the performance of the air sparging system based groundwater quality data and observations from routine operation and maintenance. Initially Consumers is expected to be capable of performing ongoing operation and maintenance of the corrective action due to having staff on site that can tend to the air sparging system quickly if needed, with support of a third party responsible for overall operation of the system, and their familiarity with managing groundwater and porewater monitoring programs at the site. Consumers’ long-term capability of performing ongoing operation and maintenance activities is expected to be reduced when few staff are regularly on site after the generating facility is decommissioned, and a third party would need to be responsible for operation of the system and available to address maintenance concerns quickly.

3.3.6 Permitting Considerations

An air sparging system at the Karn Landfill is expected to be exempt from the Air Permit to Install (reference (37)) because the sparged air would be emitted back to the atmosphere (i.e., through natural diffusion and not through an extraction system).

Construction of an air sparging system would occur within 500 feet of the bay; therefore, an SESC permit will be required.

A Joint Permit may be required for an air sparging system since the project would be subject to Part 315 Dam Safety Regulations, however, Part 315 includes an exemption for Part 115 impoundments, so a preapplication meeting with EGLE is recommend to verify that the project meets the exemption and a Joint Permit would not be required for construction activities.

3.3.7 Community Consideration

Active construction of an air sparging system presents limited, temporary community considerations. Construction vehicle traffic to the site may increase during the construction of an air sparging system, but is not expected to be a significant concern due to existing and historical vehicular traffic required for the operation of the generating facility and Karn and Weadock Landfills.

Operation of an air sparging system at the site is expected to have negligible effects on the surrounding community once installed. The air sparging system does not present concerns for adverse offsite effects (e.g., noise, decreased air quality, changes to the landscape) once installed, and the proposed location is within a secured site that is not accessible to the public.

Overall it is expected that the community would have a moderate view of this corrective action option, because the short- and long-term community impacts are negligible, but the community may prefer a more sustainable and dependable corrective action option that requires less reliance on continual operation and maintenance and reduced energy inputs.

3.3.8 Schedule Considerations and Range of Costs

It is anticipated that construction of the air sparging system including the PSA unit could be completed in approximately two to four months. The estimated total cost to install the air sparging system and operate and maintain it for 30 years are expected to range from $13,000,000 to $29,000,000. Detailed cost estimates are in Appendix D.

3.3.9 Advantages and Disadvantages

The primary advantages of the air sparging system are:

- air sparging is a reliable and effective method to mitigate arsenic impacts;
- the aquifer appears suitable for sparging based on the groundwater level and iron to arsenic molar ratio;
- air sparging would not produce water for treatment/management;
- implementing this corrective action option is expected to have a low-degree of difficulty;
- equipment and specialists capable of performing this work are expected to be readily available;

- initially it is expected that the owner will be capable of performing and operating this corrective action option; and,
- permitting requirements for this corrective action option are expected to be minor.

The primary disadvantages of the air sparging system corrective action option are:

- the potential exists for contaminant rebound to occur if the system is shut down;
- the air sparging system transforms arsenic mass, but does not remove it, leaving the potential for the arsenic re-solubilization to occur;
- the air sparging system requires frequent and long-term operation and maintenance;
- the air sparging system would have a significant power demand and long-term operation and maintenance costs are expected to be high relative to other corrective action options; and,
- the owner's practical capability of implementing this corrective action option is expected to be reduced over time as the generating facility is retired and the number of onsite staff is reduced. This also conflicts with the owner's planned reduction of personnel available to the site once the facility is retired.

3.4 Permeable Reactive Barrier

A PRB amended with ZVI was one of the corrective action options recommended to be carried forward from the options assessment. Bench testing to evaluate ZVI treatment effectiveness and treatment lifespan of a PRB amended with ZVI has been performed since that time. Results from bench testing indicate that a PRB could meet the remedial objectives, because ZVI effectively attenuated dissolved arsenic concentrations from 385 µg/L to below mixing zone-based GSI values in site groundwater during bench testing that simulated decades of groundwater treatment.

A detailed evaluation of this corrective action option is included in the following sections, and general findings from the evaluation include:

- A PRB amended with ZVI is an effective method to mitigate arsenic impacts in site groundwater; however, the effectiveness of this corrective action option can potentially still be limited by plugging and fouling of the PRB and further evaluation of the potential for adverse outcomes due to plugging and fouling is needed.
- The implementability and cost effectiveness of a PRB are reliant on the effective treatment lifespan of the PRB under in-situ conditions, and uncertainties related to the treatment lifespan have resulted in conservative assumptions of ongoing costs for PRB refreshment during the post-closure care period based on available data.

3.4.1 Corrective Action Scope and Concept

A PRB amended with ZVI would be installed along the northern perimeter dike from approximately Transect 2 to Transect 5, upgradient of the GSI. A PRB amended with ZVI primarily attenuates arsenic in both its more soluble oxidation state (As^{+3}) and less soluble oxidation state (As^{+5}) by adsorption onto the surface of the ZVI particles and co-precipitation of arsenic with iron (reference (1)). Arsenic is preferentially sorbed onto ZVI corrosion products (ferrous hydroxide, ferric oxyhydroxides, mixed-valence iron oxides and hydroxides), which continuously form on the ZVI particles' surfaces over the treatment lifespan of the PRB (reference (1)). Implementation of the PRB would promote sorption of the dissolved arsenic onto ZVI particles and co-precipitation of arsenic with available iron phases, attenuating the arsenic within the PRB before groundwater is discharged into the bay.

The layout and a conceptual drawing of the PRB option is shown on Figure 10. The PRB option would include:

- construction of an approximately 3,000-feet-long by 25-feet-deep by 1.5-feet-wide PRB using a one-pass trenching method along the perimeter dike perpendicular to groundwater flow;
- construction of a 2-feet-deep by 15-foot-wide by 3,000-feet-long bench to receive excavated materials;
- staging excavated materials on the bench to dewater before transport to the Weadock Landfill for impoundment;
- restoration of the haul road that is located on top of the perimeter dike; and
- refreshing the reactive media approximately 10 years after initial installation and 20 years after initial installation.

The following sections describe the bench testing and groundwater modeling results, effectiveness, implementability, advantages, disadvantages, permitting considerations, community considerations, schedule, feasibility-level costs, and data gaps for the PRB corrective action option.

3.4.2 Bench Testing Results

Barr completed ZVI bench testing to evaluate the effectiveness of a ZVI-amended PRB for treatment of arsenic, the potential treatment lifespan of a PRB, and design data collection needs for a PRB.

Work performed by others in 2014 evaluated the ability of ZVI, activated alumina, and ferric-sulfide coated activated alumina to mitigate arsenic concentrations in sodium-arsenite-spiked porewater. The spiked porewater, soils from the site, and varying masses of the amendments were allowed to react in continuously stirred batch reactors (CSBRs). Results indicated that all three amendments were capable of removing arsenic from solution, the ZVI most effectively removed arsenic, and there were not major concerns identified regarding adverse effects from the installation of a ZVI-amended PRB at the Karn Landfill (reference (8)).

The results of this work were used by Barr to design two bench testing experiments. The first experiment was performed to evaluate the kinetic rate of the reaction between site groundwater and ZVI by varying the amount of time that reaction was allowed to occur. The second experiment used CSBRs to assess the effectiveness and treatment capacity of ZVI exposed to site groundwater by reacting two masses of ZVI with successive batches of site groundwater.

Groundwater used in the experiments was collected from MW-10 using low-flow sampling methods and was transported and stored under a nitrogen blanket to limit aeration and, therefore, a shift in oxidation state of arsenic in the groundwater. The ZVI used was for both tests was Peerless Metal Inc. 8/50 ZVI, which is a pure, oil-free ZVI designed for implementation in PRBs. The kinetic rate experiment and CSBR experiments are detailed below.

3.4.2.1 Kinetic Rate Evaluation Experiment

The kinetic rate evaluation experiment was designed to evaluate reaction kinetics between ZVI and site groundwater and inform the design of the CSBR experiment. During the kinetic rate experiment, six vials containing groundwater and ZVI were placed on a vial spinner and allowed to react for either 1, 3, 5, 9, or 12 hours. Five vials contained 47.5 mL of groundwater and 2.5 grams of ZVI, and the sixth vial acted as a control, containing only site groundwater. At each designated time interval, effluent water was collected from the appropriate vial for laboratory analysis of dissolved arsenic and dissolved arsenic analysis by a Hach® low-range arsenic field test (Hach® test). Due to limited sample volume, the Hach tests were performed with a 2:1 dilution of two parts de-ionized water and one part effluent sample water.

Tabulated analytical results, the laboratory analytical report, and photos documenting Hach® test results are included in Appendix E. Analytical results indicate that at each interval, the reacted water was non-detect for dissolved arsenic; however, the analytical results for this test were likely affected by the formation of a precipitate in the samples. During sample collection, the samples were filtered through a 45 micrometer (µM) filter and initially appeared clear, but after storage overnight, a reddish-brown precipitate formed. It is believed that this precipitate is likely an iron compound due to its coloration and because it was not observed in the control vial (which was not reacted with ZVI). This indicates that dissolved iron and arsenic continued to react after the sample was collected, and additional arsenic was precipitated out of solution after sample collection. Because of this potential qualification to the analytical sample results, the Hach® tests were relied on for evaluation of arsenic concentrations. Hach® test results were obtained immediately after sample collection so results are more representative of conditions compared to analytical sample results, and results from the Hach® test generally agree with available literature on similar experimental setups (reference (38)).

Results of the experiment indicated the following:

- the Hach® tests collected during the experiment suggest that the ZVI is capable of reducing dissolved arsenic concentrations from greater than 300 µg/L to approximately 10 to 30 µg/L within one hour of reaction time;
- arsenic was non-detect in the effluent water within nine hours of reaction time;

- arsenic concentrations were not significantly reduced in the control sample indicating that the reaction with ZVI was the main method of arsenic removal; and
- Hach® test results and analytical results for the control sample generally agree.

3.4.2.2 Continuously Stirred Batch Reactor Experiment

A CSBR experiment was performed by Barr to evaluate the potential treatment capacity of the ZVI and treatment lifespan of a ZVI-amended PRB at the Karn Landfill. Two different batch reactors were operated during the experiment, one containing 5 grams of ZVI and one containing 10 grams of ZVI. Fourteen batches for each mass of ZVI were run by allowing 4,000 mL of groundwater to react with the ZVI for 12 hours while being constantly mixed by overhead stirrers in vessels that were open to the atmosphere.

The 5-gram and 10-gram ZVI masses used in the experiment were chosen based on the ratio of an obtainable volume of groundwater for the experiment to masses of ZVI that would allow for simulating decades of groundwater flow through a PRB. Assumptions for the simulated PRB design were based on the evaluation performed in the corrective action options assessment, which assumed a 1.5-foot thick PRB, amended at a ratio of 30% ZVI by mass. A groundwater flux through the proposed location of the PRB of 370 gallons per square foot per year was assumed based on the groundwater flux evaluation performed by others as part of the first quarter 2020 Groundwater Monitoring Report (reference (39)). A residence time of groundwater in the PRB was calculated based on the groundwater flux and PRB thickness, and the mass loading of ZVI within the PRB was used to estimate a volumetric flow of groundwater per unit mass of ZVI per year. The results of this evaluation indicated that each 4,000 mL batch of groundwater would represent approximately 5.6 years of in-situ groundwater flow in a 10-gram ZVI CSBR, and 11.2 years in a 5-gram ZVI CSBR. These values are directly related to the mass loading of ZVI and thickness of the PRB (e.g., doubling the assumed PRB thickness would double the time simulated by each batch) and the values are inversely related to the groundwater flux.

The 12-hour reaction time used in the experiment was based on the kinetic rate experiment, which suggests that 12 hours is sufficient to reach equilibrium in the reaction between the groundwater and ZVI under mixing conditions, and literature documenting similar experiments (reference (38)).

After 12 hours, effluent samples were collected from each batch through a 45 µM filter, Hach® tests were performed on the reacted water, and water quality field parameters of the reacted water were taken with a YSI Pro DSS® water quality meter. The batch reactors were then drained while retaining the ZVI, and 4,000 mL of unreacted groundwater was added to begin the next batch. The ZVI in the batch reactors was not replaced or supplemented with fresh ZVI during the experiment.

Analytical results, field parameters, and an image showing the Hach® field test results are in Appendix F (Appendix F-2a through Appendix F-3), and Figure 11 presents the dissolved arsenic analytical results from the experiment. The QA/QC data were reviewed to assess the validity of the analytical results, and the QA/QC data evaluations are included in Appendix F-4. The results of the CSBR experiment suggest that a PRB amended with ZVI has the potential to attenuate arsenic in groundwater at the Karn Landfill for an extended period of time before needing refreshment based on the following observations:

- Groundwater collected from MW-10 had an arsenic concentration of approximately 450 μg/L, and arsenic was primarily in the arsenite (As^{+3}) form.

- Arsenite was oxidized to arsenate (As^{+5}) during collection, transport, and storage of the groundwater despite the use of nitrogen blanketing, and the dissolved arsenic concentration was reduced to approximately 385 μg/L. Literature suggests that arsenite and arsenate are both effectively removed by a ZVI-amended PRB (reference (1)), and results from the CSBR experiment are expected to be adequately representative of in-situ ZVI-driven arsenic attenuation, despite the oxidation of the groundwater.

- The ZVI in both the 5-gram and 10-gram batches was capable of reducing influent arsenic concentrations by approximately 90% or more over the course of 4 and 8 batches, respectively, representing approximately 45 years of treatment for both masses of ZVI tested.

- Effluent water quality observations did not present concerns for adverse changes to groundwater downgradient of the PRB based on the following:

    - effluent iron concentrations were below the influent iron concentration of 22 μg/L in all samples except one where an effluent iron concentration of 33 μg/L was reported which is approximately an order of magnitude below groundwater quality standards; and

    - the pH of the effluent water did rise from approximately 7.3 standard units (s.u.) to an average of approximately 8.0 s.u. and maximum observed value of approximately 8.7 s.u. during the experiment. An increase of pH is expected from treatment with ZVI, and is exaggerated by CSBR testing due to the relative high availability of oxygen in a CSBR, but treated water was not observed to exceed groundwater quality criteria of 9.0 s.u.

- Both batches of ZVI treated 56 L of water during the course of the experiment and did not reach exhaustion of their treatment capacity; however, the treatment capacity of the ZVI was reduced over the course of the experiment, indicating refreshment of the ZVI media during the post-closure period would likely be required to maintain compliance with the mixing zone-based value arsenic.

Groundwater used in the experiment had an arsenic concentration of approximately 385 μg/L after transportation and storage, but concentrations of greater than 1,000 μg/L have been observed within the corrective action area. To estimate the potential treatment lifespan of the PRB, the percent-removal of arsenic by ZVI in the experiment was used to estimate a conservative treatment lifespan of the ZVI (i.e., an upper estimate based on relatively ideal conditions in the CSBR). To treat groundwater to below the mixing zone-based concentration criteria of 100 μg/L for arsenic, a PRB must provide at least 90% attenuation of arsenic in the most impacted areas of the corrective action area. A removal efficiency of approximately 90% was observed through the first four batches in the 5-gram CSBR, and first eight batches in the 10-gram CSBR, representing approximately 45 years of treatment by both masses of ZVI.

Due to the constraints of a batch testing experiment in evaluating PRB performance, these results are meant only to represent a proof of concept for groundwater treatment by ZVI and demonstrate a treatment capacity of ZVI under experimental conditions. Other in-situ conditions such as plugging and fouling of the PRB by mineral precipitation and reaction kinetics under non-mixed conditions may reduce the treatment lifespan of the PRB relative to the conservative estimate of 45 years. These factors will be further evaluated during a flow-through column study that will be performed by Barr during the fourth quarter of 2020.

3.4.3 Groundwater Modeling Results

A fully permeable PRB was not simulated using the groundwater model, because implementation of that design is not expected to alter groundwater flow at the site, but a simulation was performed to assess the feasibility of a funnel-and-gate PRB.

A funnel-and-gate PRB is constructed by installing low-permeability barrier walls (e.g., soil-bentonite cutoff walls) with strategically placed permeable sections containing reactive materials. The goal of the low-permeability barrier walls is to direct groundwater flow through the reactive gates, which can have advantages including:

- lowering the total amount of reactive materials required to address groundwater concerns; and
- reducing the level of effort required to replace the PRB.

Potential disadvantages of a funnel-and-gate design compared to a fully permeable PRB include:

- requiring a greater overall footprint to adequately capture groundwater flow;
- causing greater changes to groundwater flow patterns at the site adding greater uncertainty of system performance during the design phase;
- accelerating groundwater flux through the permeable sections of the PRB which potentially decreases treatment effectiveness and increases the rate of PRB material aging, necessitating more frequent replacement; and
- increasing the costs of the initial construction.

The funnel-and-gate PRB was modelled as single 1,500-foot permeable reactive gate between two low-permeability cutoff walls with a combined length of approximately 2,800 feet. Modeling results for the PRB option are shown in Figure 12, and indicate the following:

- the low-permeability cutoff walls would potentially need to extend beyond the corrective action area to provide complete treatment of impacted groundwater in the corrective action area due to groundwater flow around the impermeable cutoff walls;

- the low-permeability cutoff walls could increase groundwater elevations upgradient of the PRB and could cause daylighting of groundwater along sections of the PRB;
- some groundwater would flow through the low-permeability barrier as indicated by the particle flow paths that pass through the low-permeability barrier in the northwest portion of the barrier shown on Figure 12; and
- groundwater flow would be accelerated at the interfaces of the impermeable cutoff walls and reactive gate, which would reduce the residence time of the groundwater in the reactive media and potentially accelerate aging of portions of the permeable reactive gates.

Based on these modeling results and the estimated PRB treatment lifespan, a funnel-and-gate design is not considered cost effective compared to a fully permeable PRB, and a fully permeable PRB has been assumed for this feasibility study. If a PRB is chosen for implementation, further evaluation of a funnel-and-gate PRB may be performed as part of the design phase if warranted based on results of design data collection efforts.

3.4.4 Effectiveness

Bench testing performed by Barr and work by others (reference (8)) were used to evaluate the effectiveness of the PRB option. Bench testing suggests that a ZVI-amended PRB would effectively remove arsenic from groundwater for an extended period of time. Results from the bench testing and work by others also indicate that adverse changes to the groundwater downgradient of a ZVI-amended PRB are not expected (reference (8)).

A PRB amended with ZVI is expected to have the ability to attenuate arsenic immediately following installation. Due to the velocity of groundwater in the corrective action area, which is on the order of 0.1 feet per day, the effects of a PRB installation 100 feet or more upgradient from the GSI would not be observed at the GSI transect sampling locations for two to three years. PRB performance is also expected to increase in the short-term due to the natural corrosion of the ZVI in the PRB caused by contact of the ZVI with the dissolved oxygen within the groundwater. This corrosion is expected to take place over a period of days to months, and would result in the formation of ferrous hydroxide, ferric oxyhydroxides, mixed-valence iron oxides, and hydroxides coatings on the surface of ZVI particles which would promote adsorption of arsenic within the PRB.

A PRB amended with ZVI is expected to have the ability to treat arsenic-impacted groundwater for a period of years to decades based on preliminary bench-scale testing performed by Barr, and available literature concerning the use of ZVI-amended PRBs for the control of arsenic (reference (1)). Performance of the PRB is expected to decrease over time due to exhaustion of the treatment capacity of the ZVI and plugging/fouling of the PRB due to the buildup of precipitates in the PRB. Exhaustion of the ZVI creates the potential for groundwater exiting the PRB to reach the GSI with arsenic concentrations above mixing zone-based criteria. Plugging and fouling of the PRB creates the potential for groundwater to preferentially flow around the PRB and/or experience inadequate residence time in the PRB due to preferential pathing through the PRB, both of which could also lead to exceedances of mixing zone-based criteria at the GSI.

Implementation of a PRB would not control the source of arsenic impacted groundwater at the Karn Landfill (i.e., CCR materials). It is presumed that arsenic and other constituents would continue to leach from the CCR materials into the groundwater with a PRB in place. Arsenic and other groundwater impacts that are attenuated within the PRB and adsorbed to the ZVI would be removed during periodic refreshment of the PRB as the exhausted PRB material would be excavated and disposed of offsite as non-hazardous waste during each refreshment event.

3.4.5 Implementability

3.4.5.1 Degree of Difficulty

Implementation of a PRB is expected to be of moderate difficulty compared to the other remedial technologies evaluated in this feasibility study. PRB performance is dependent on the interaction of many different site-specific, localized factors, making long-term in-situ performance difficult to evaluate based on bench-scale and pilot-scale testing (reference (1)). Design of a PRB would require a robust understanding of site conditions (i.e., groundwater chemistry and hydrogeologic conditions), and it is likely that uncertainties related to the effective treatment lifespan, the potential for plugging and fouling of the PRB, and the lifetime costs associated with a PRB would remain during implementation of this corrective action option.

Construction of a PRB is expected to be of low complexity due to the availability of construction equipment capable of implementing this work (e.g., a long-reach excavator or one-pass trenching equipment), the relative lack of site constraints in the proposed construction area, and results from the geotechnical evaluation of the perimeter dike suggesting dike stability would not be a concern for this corrective action option.

3.4.5.2 Operational Reliability

A PRB is considered a passive remedial technology, and regular operations and maintenance of the PRB would not be required. PRB performance will be assessed through regular (e.g., semiannual) groundwater monitoring events that measure groundwater quality upgradient and downgradient of the PRB and within the PRB media. The hydraulic characteristics of the PRB may be evaluated during routine groundwater elevation monitoring at the site, and potentially by non-routine hydrogeologic investigations of the PRB media (e.g. core sampling) to evaluate plugging and fouling of the PRB. Performance of the PRB is expected to diminish over time, and periodic refreshment of PRB materials may be required to meet the mixing zone-based value. Refreshment of the PRB is expected to be achieved by replacement-in-kind of the permeable reactive sections of the PRB, which would require coordination with a contractor, mobilization for construction activities, excavation and disposal of spent PRB materials, and installation of new PRB materials in a manner similar to the initial installation event.

3.4.5.3 Availability of Equipment and Specialists

Installation of a PRB through one-pass trenching or long-reach excavator methods requires contractors with specialized equipment and experience. Several contractors have been identified in the region who would likely be capable of performing the work.

3.4.5.4 Owner's Practicable Capability to Perform Corrective Action

Operation of a PRB would require periodic collection of groundwater quality data, evaluation of the performance of the PRB based on groundwater quality and hydrogeologic data, and periodic coordination with contractors for refreshment of the PRB. Consumers is expected to be well positioned for the operation of a PRB due to their familiarity with managing the implementation and operation of groundwater monitoring programs at the site and the limited operation and maintenance requirements due to the passive nature of a PRB.

3.4.6 Permitting Considerations

The proposed construction area for the PRB is within 500 feet of the bay, a protected body of water, and would require a SESC permit from Bay County for construction activities.

A Joint Permit may be required for a groundwater extraction system since the project would be subject to Part 315 Dam Safety Regulations, however, Part 315 includes an exemption for Part 115 impoundments, so a preapplication meeting with EGLE is recommend to verify that the project meets the exemption and a Joint Permit would not be required for construction activities.

3.4.7 Community Consideration

Active construction of a PRB presents limited, temporary community considerations. Construction vehicle traffic to the site may increase during the construction of a PRB, but is not expected to be a significant concern due to existing and historical vehicular traffic required for the operation of the Karn Generating Facility and Karn and Weadock Landfills.

Implementation of a PRB is expected to have negligible effects on the surrounding community once installed. PRBs, due to their nature as subgrade, passive treatment systems, do not present concerns for adverse off-site effects (e.g., noise, decreased air quality, changes to the landscape) once installed, and the proposed location of the PRB is within a secured site that is not accessible to the public.

Overall it is expected that the community would have a positive view of this corrective action option, because the short-term and long-term community impacts are negligible, and a PRB does not rely on continual operations and maintenance and does not require energy input for treatment of the groundwater.

3.4.8 Schedule Considerations and Range of Costs

It is anticipated that construction of the PRB could be completed in approximately two to three months. The estimated total cost to install the PRB and maintain it for 30 years are expected to range from $8,000,000 to $18,000,000. Detailed cost estimates are in Appendix D.

The range of costs were based on the assumption that that periodic in-kind replacement of the PRB would be required at a frequency of every 10 years over the 30-year post-closure care period to maintain effective arsenic attenuation. The assumption of a 10-year treatment lifespan of the PRB was made due to uncertainties concerning the potential for fouling and plugging of the PRB. The rate and effects of fouling and plugging of a PRB cannot be effectively evaluated by CSBR testing (reference (1)), but can potentially be evaluated by flow-through column testing and/or field scale pilot testing.

3.4.9 Advantages and Disadvantages

The primary advantages of a PRB are:

- the PRB is a passive remedial technology and would not require regular operation and maintenance, and would likely be more reliable than other technologies that depend on the operation of mechanical equipment for treatment;
- additional sections of PRB can be added to the perimeter dike during the post-closure period if new areas of concern are observed, where in contrast, a groundwater extraction system or air sparging trench would require major upgrades, or would need to be over-sized during the initial installation, to address new concerns that may arise during the post-closure care period; and
- a PRB would not produce water for management or treatment.

The primary disadvantages of a PRB are:

- PRBs are an emerging technology and there is a relative lack of industry experience and case studies of long-term performance compared to other remedial technologies resulting in a higher degree of difficulty for implementation;
- periodic refreshment of the PRB may be required if its ability to attenuate arsenic diminishes over time;
- the magnitude and effects of plugging and fouling of the PRB would require periodic evaluation of performance to assess refreshment needs; and
- a PRB may cause adverse changes to downgradient groundwater chemistry, although this is unlikely based on observations from batch testing.

4 Conclusions and Recommendations

An options assessment was completed to evaluate potential corrective action options for addressing arsenic-impacted groundwater at the northern boundary of the Karn Landfill, and groundwater extraction, air sparging, and PRB options were carried forward for further assessment in this FS. This FS includes an updated CSM, summary of the groundwater model for the site, and an identification of potential site constraints, all of which contributed to the current site understanding that was used as the basis for evaluating the three corrective action options.

Corrective action options were evaluated on the basis of effectiveness, implementability, advantages, disadvantages, permitting considerations, community considerations, schedule, and feasibility-level costs, and in general accordance with section 20120 of Part 201. Common elements among the corrective action options include maintaining the stability of the perimeter dike; designing to accommodate variation in the water level of the bay; protecting existing infrastructure; long-term monitoring; and material handling, dewatering, and disposal. A summary comparison of the evaluation results for each corrective action option is in Table 1.

The preferred corrective action option to meet the corrective action objective is a PRB because bench testing results show that it is an effective method to attenuate arsenic impacts prior to groundwater discharge into the bay; groundwater modeling results indicate a PRB could be installed along the length of the corrective action area (Figure 12) to attenuate groundwater with elevated arsenic concentrations that would potentially flow into the bay; it provides short- and long-term effectiveness; it is implementable with low operation and maintenance requirements relative to other corrective action options; there are few permitting and community considerations; the schedule for implementation is suitable in meeting the corrective action objectives; and the cost is low relative to other corrective action options.

Table 1 **Options Comparison Matrix**

		Effectiveness			Implementability				Permits	Community	Schedule	Costs	
Remedial Option	Description	Short-Term Effectiveness	Long-Term Effectiveness	Source Control	Degree of Difficulty	Operational Reliability	Availability of Equipment and Specialists	Owner's Capability to Implement	Permitting Considerations	Community Considerations	Time to Implement	Construction Costs	Operation & Maintenance Costs
Groundwater Extraction System	Seven groundwater extraction wells would be installed along the northern perimeter dike upgradient of the GSI to capture groundwater between Transects 2 and 5, and groundwater captured by the system will be treated in an onsite treatment system discharged through the site's NPDES permitted outfall.	Effective	Limited Effectiveness	Not Effective	Medium	Low	High	Capable	Moderate	Minor	Less than 6 months	Low	High
Enhanced Air Sparging	An air sparging trench would be installed along the northern dike between Transects 2 and 5 which would include air sparging galleries capable of delivering high-oxygen-content air from a compressor and oxygen generator into the aquifer. The high oxygen content will oxidize As(III) into the less soluble As(V), promoting co-precipitation of arsenic and iron and carbon substrates.	Not Effective	Limited Effectiveness	Not Effective	Low	Medium	High	Capable	Minor	Minor	Less than 6 months	Moderate	High
Permeable Reactive Barrier (PRB)	A PRB, with ZVI as the reactive media, will be installed along the northern perimeter dike between Transects 2 and 5. Groundwater would naturally flow through the barrier, and the ZVI would attenuate arsenic primarily through adsorption to the ZVI.	Limited Effectiveness	Effective	Limited Effectiveness	Medium	High	High	Highly Capable	Minor	Minor	Less than 6 months	Moderate	Low

5 References

References in this document are presented in ISO 690-Numerical Reference citation style. References below that begin with a "—" indicate that the author is the same as the one listed above it in bold. For example, the author of reference (2) is the same as the author of reference (1) (i.e., Legislative Council, State of Michigan).

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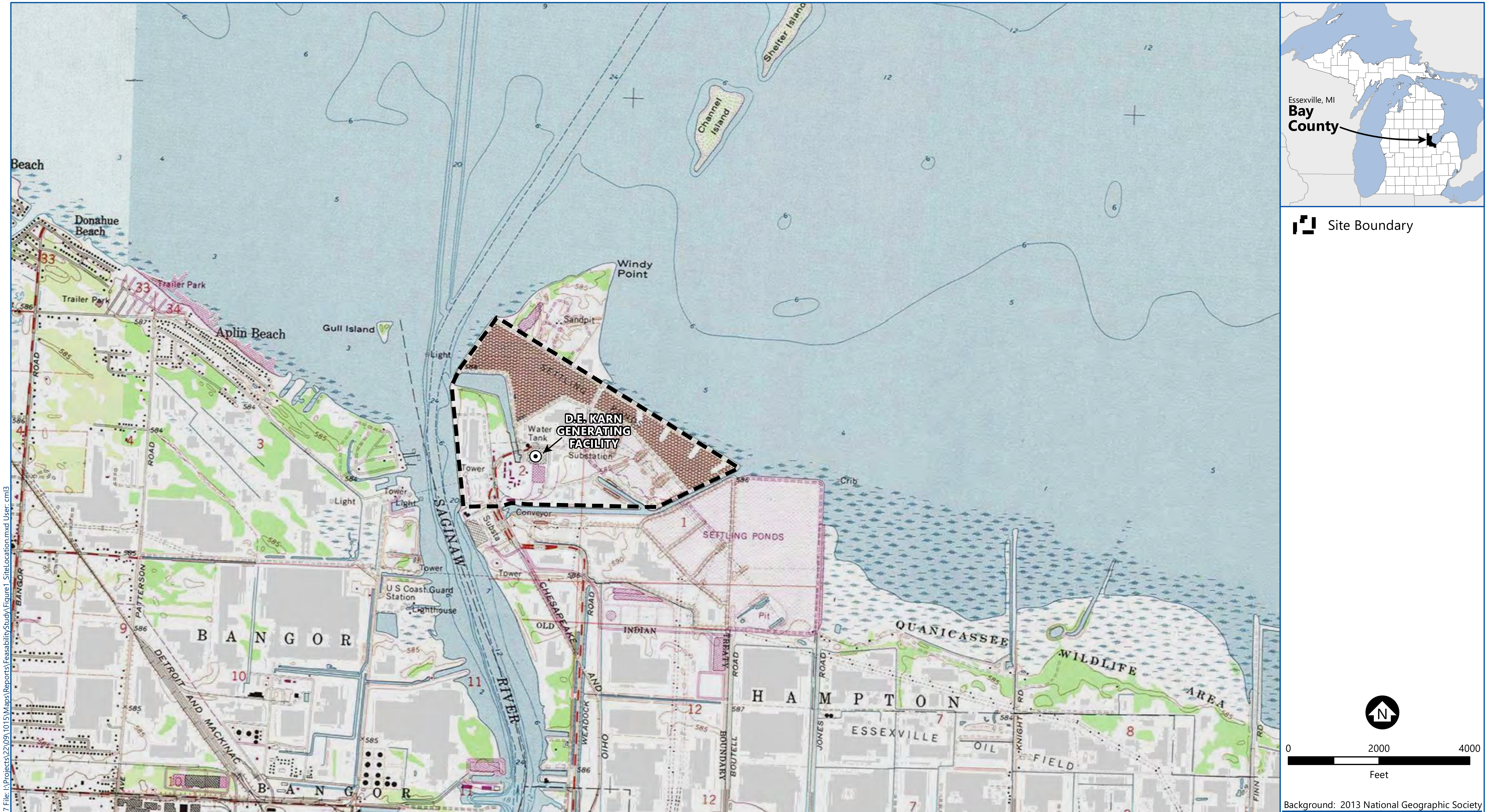
Figures



Background: 2013 National Geographic Society

SITE LOCATION
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 1

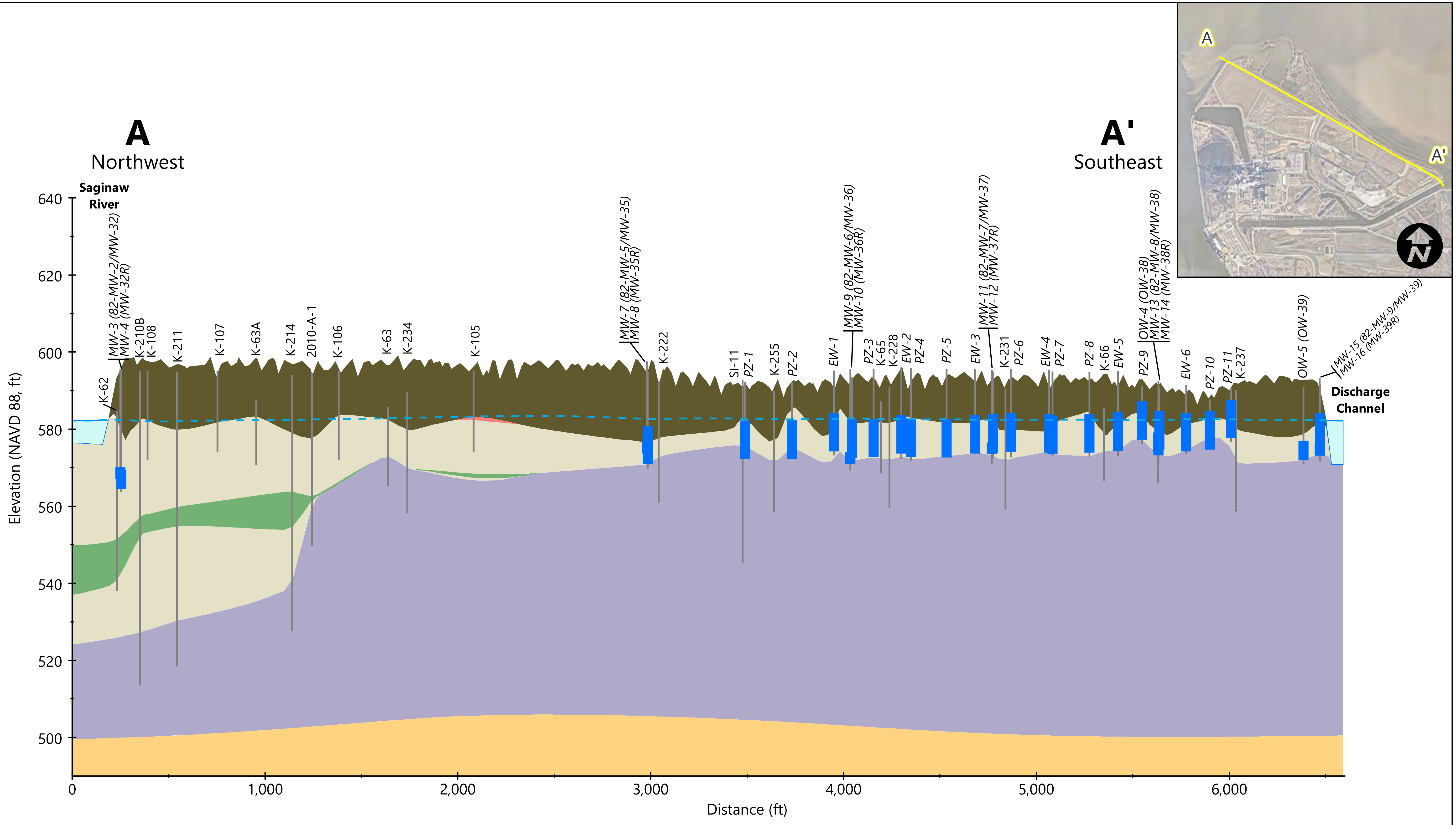
BARR

Notes:
- GSI = Groundwater-Surface Water Interface

Aerial Image: Nearmap 3/23/2018

SITE LAYOUT
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 2



Stratigraphy

- ▨ Ash/Fill
- ▨ Peat/Organics
- ▨ Sand
- ▨ Intermediate Clay/Silt with Organics
- ▨ Clay
- ▨ Bedrock

- - - Water Table (May 2020)

▮ Well/Piezometer Screen (Italicized Boring Label If Installed)

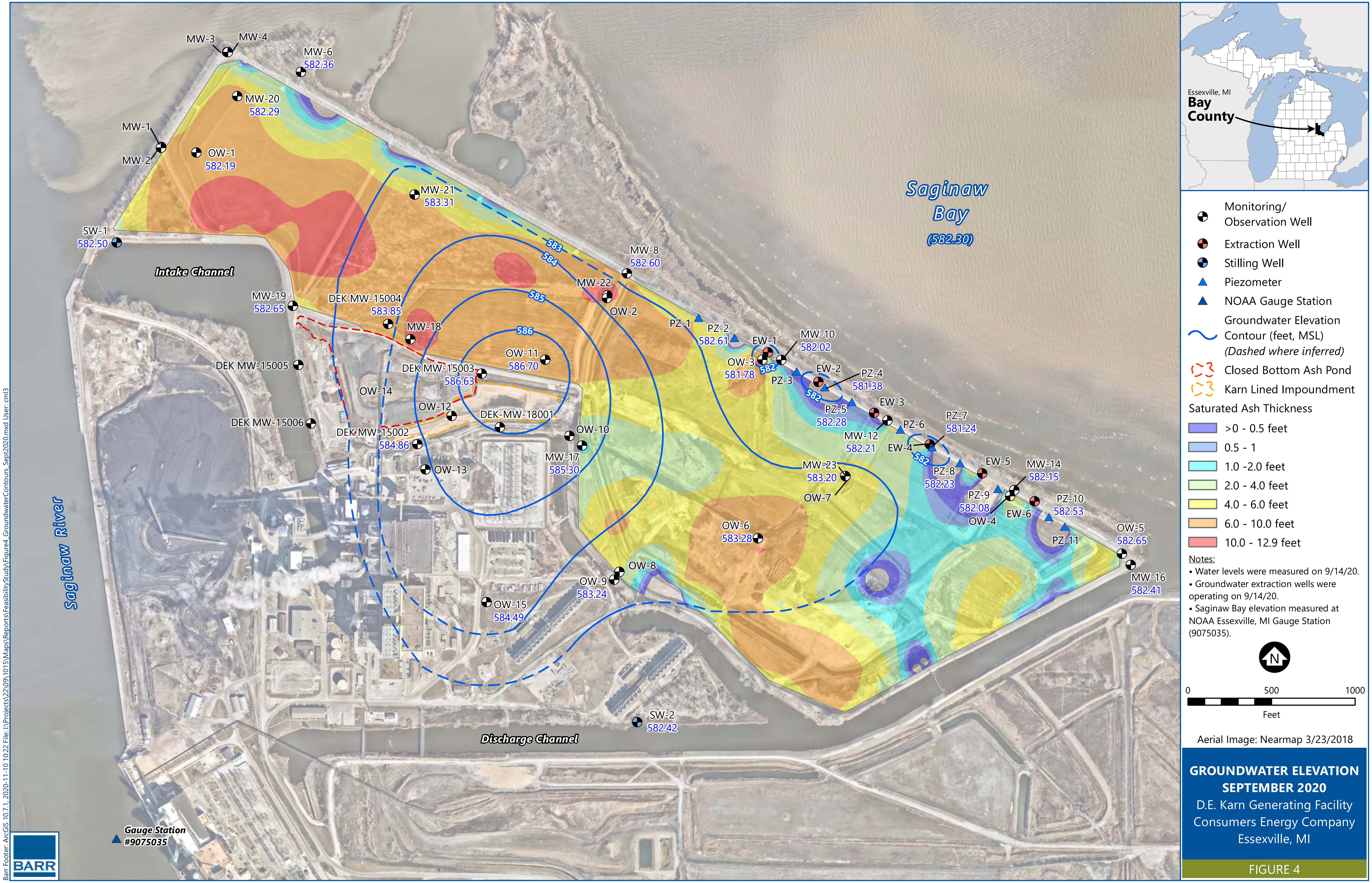
| Boring

NOTES

- The cross section is a two-dimensional slice through a three-dimensional interpolation of available site data.
- Borings within 50 feet of the cross section line are projected onto this cross section. Due to the projection, the surveyed ground surface at a boring may not match the ground surface shown on the cross section.
- Water table is approximate and based on water levels measured in May 2020.
- Grid based modeling has inherent limitations to accurately represent steep slopes. Constructed slopes are approximate and may not exactly match constructed grades.

GEOLOGIC CROSS SECTION A-A'
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 3



⊕ Monitoring/ Observation Well

⊕ Extraction Well

⊕ Stilling Well

▲ Piezometer

▲ NOAA Gauge Station

～ Groundwater Elevation Contour (feet, MSL) *(Dashed where inferred)*

⬚ Closed Bottom Ash Pond

⬚ Karn Lined Impoundment

Saturated Ash Thickness

🟪	>0 - 0.5 feet
🟦	0.5 - 1
🟦	1.0 -2.0 feet
🟩	2.0 - 4.0 feet
🟨	4.0 - 6.0 feet
🟧	6.0 - 10.0 feet
🟥	10.0 - 12.9 feet

Notes:
- Water levels were measured on 9/14/20.
- Groundwater extraction wells were operating on 9/14/20.
- Saginaw Bay elevation measured at NOAA Essexville, MI Gauge Station (9075035).

Aerial Image: Nearmap 3/23/2018

GROUNDWATER ELEVATION SEPTEMBER 2020

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 4

● Monitoring/ Observation Well

● Porewater Sample Location

○ Exceeds Chronic Mixing Zone-Based GSI Value (100 ug/L)

○ Exceeds Final Acute Mixing-Zone Based GSI Value (680 ug/L)

- - - Approximate GSI Transect Location

Notes:
- Concentrations displayed in ug/L.
- Chronic and acute mixing zone-based GSI values for arsenic are 100 ug/L and 680 ug/L, respectively.
- Concentrations measured August 2020, except for MW-20, MW-21, and OW-1, which were measured Septemeber 2020.
- GSI = Groundwater-Surface Water Interface

* Porewater sampling location; concentration not representative of groundwater conditions.

** Well is screened in ash; concentration is not representative of groundwater conditions in native sand.

N

0 500 1000
Feet

Aerial Image: Nearmap 3/23/2018

TOTAL ARSENIC CONCENTRATIONS AUGUST 2020

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 5

Monitoring/ Observation Well

Existing Extraction Well

Piezometer

Temporary Piezometer

Karn Landfill Final Cover System

Closed Karn Bottom Ash Pond

Karn Lined Impoundment

Perimeter Dike

Culvert

Utilities

Underground Electric

Overhead Electric

Overhead Electric Tower

Notes:
- All utility locations are approximate. Utilities shown on this figure do not represent all utilities present at the site.
- Karn Landfill Final Cover System extent based on construction drawings provided by Consumers Energy.

Aerial Image: Nearmap 3/23/2018

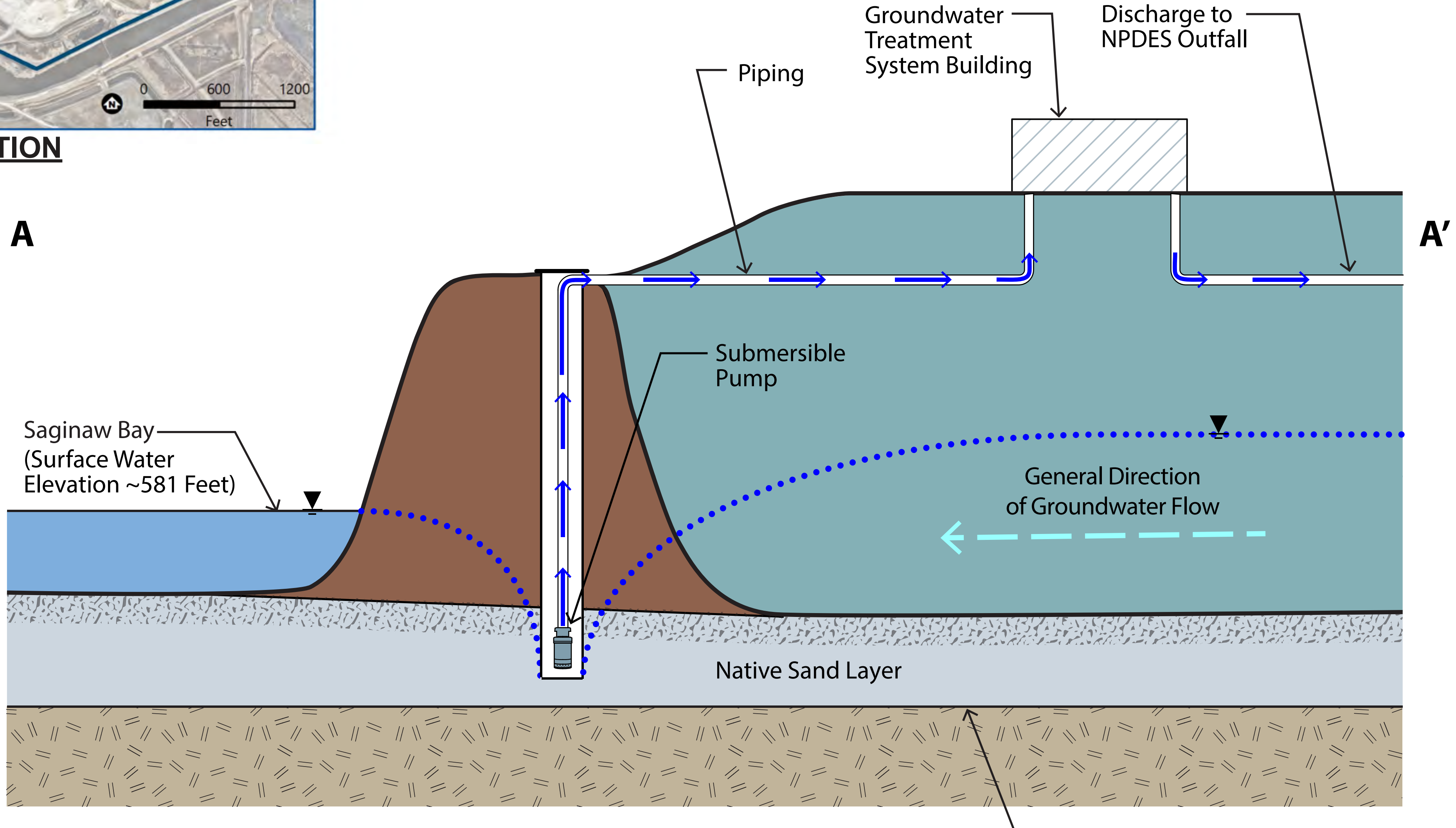
POTENTIAL SITE CONSTRAINTS

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 6

Note:
Exisiting extraction wells will be abandoned and replaced.

PLAN VIEW EXTENT OF REMEDIAL OPTION



CONCEPTUAL CROSS SECTION

*Not to scale

GROUNDWATER EXTRACTION SYSTEM OPTION OVERVIEW
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 7

P:\Ann Arbor\22 MI\09\22091015 DE Karn Corrective Action\WorkFiles\Feasibility Study\Figures\Adobe Illustrator Files\GW_Extraction_CrossSection.ai

Aerial Image: Nearmap 3/23/2018

GROUNDWATER EXTRACTION SYSTEM MODEL RESULTS

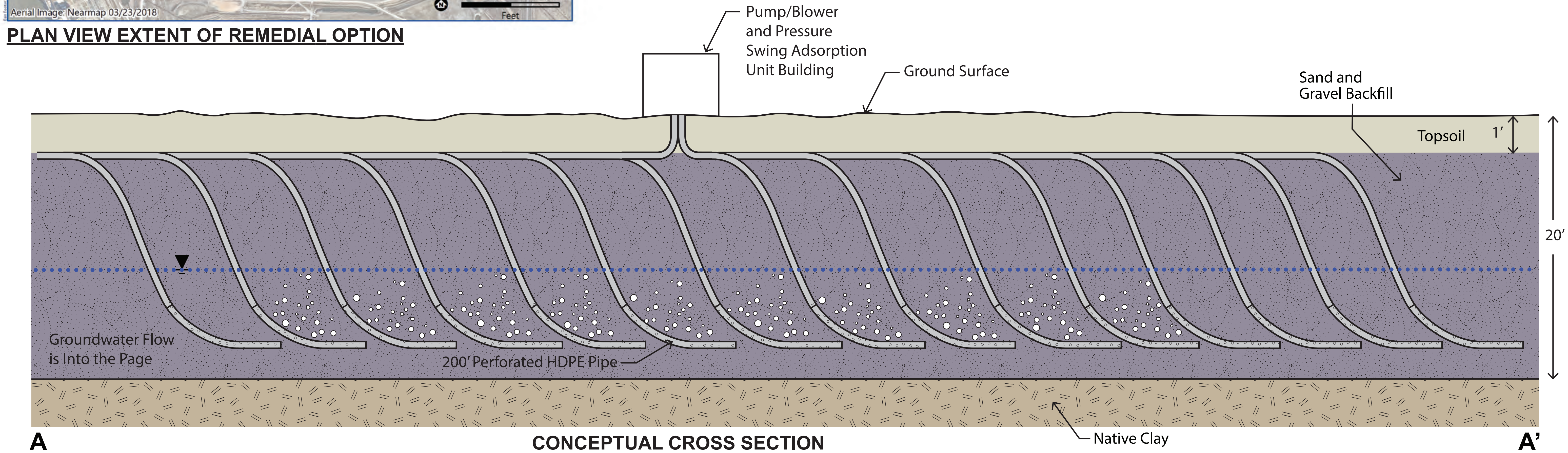
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 8

Plan View Legend

- ▭ Karn Landfill
- 🟥 Air Sparging Trench
- ----- Approximate GSI Transect Location

PLAN VIEW EXTENT OF REMEDIAL OPTION



CONCEPTUAL CROSS SECTION

*Not to scale

AIR SPARGING SYSTEM OPTION OVERIVEW
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 9

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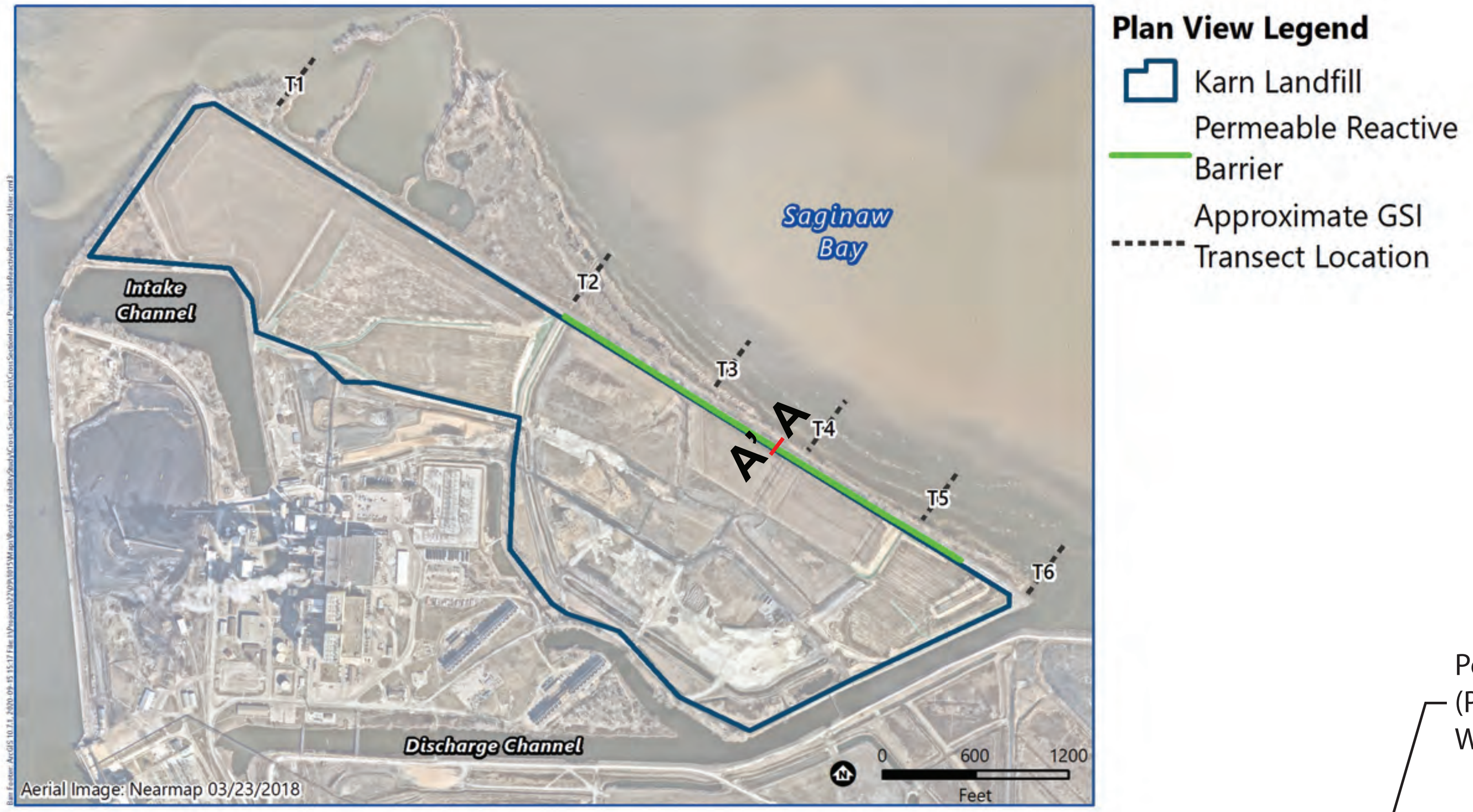
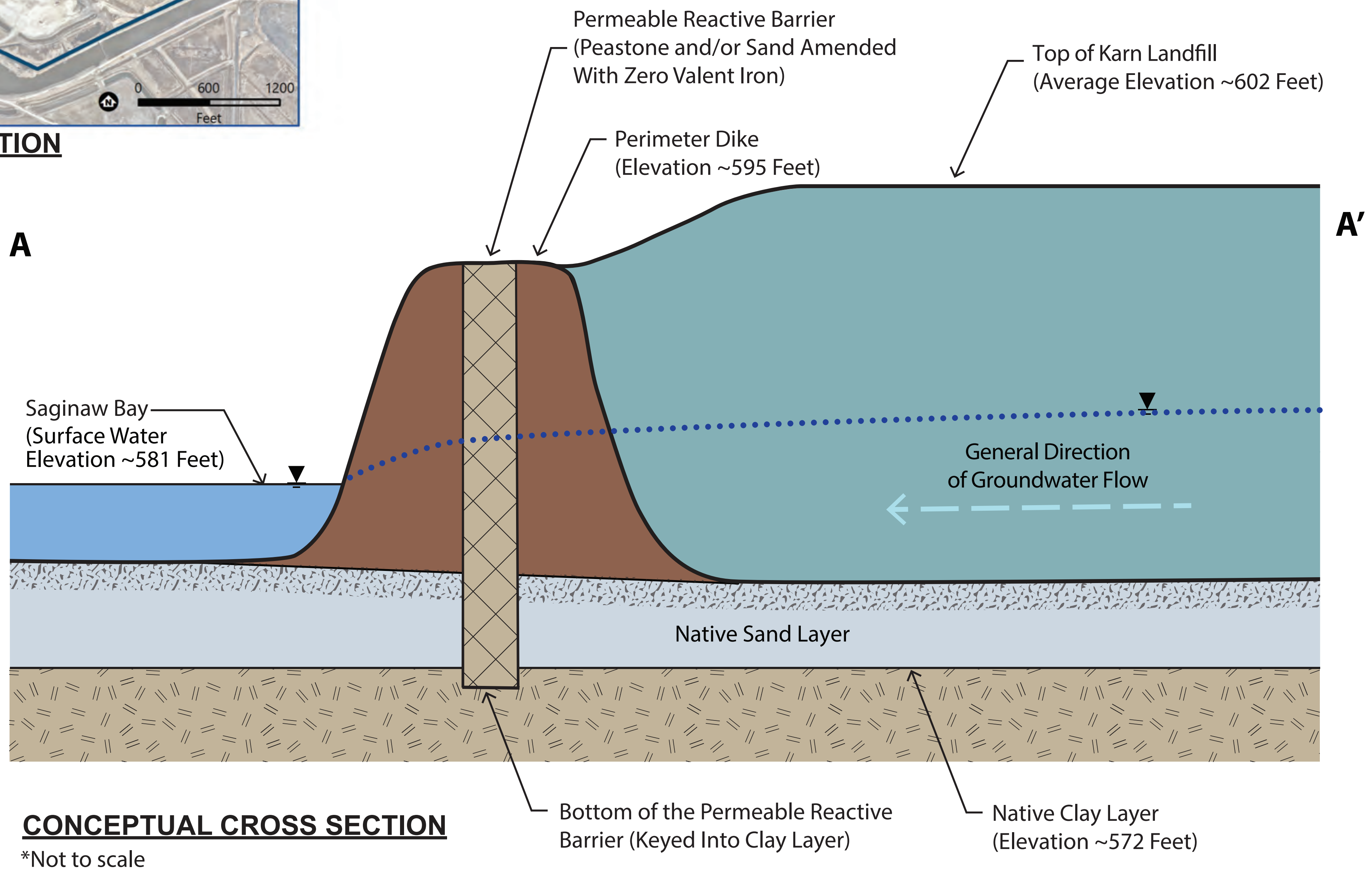


PLAN VIEW EXTENT OF REMEDIAL OPTION



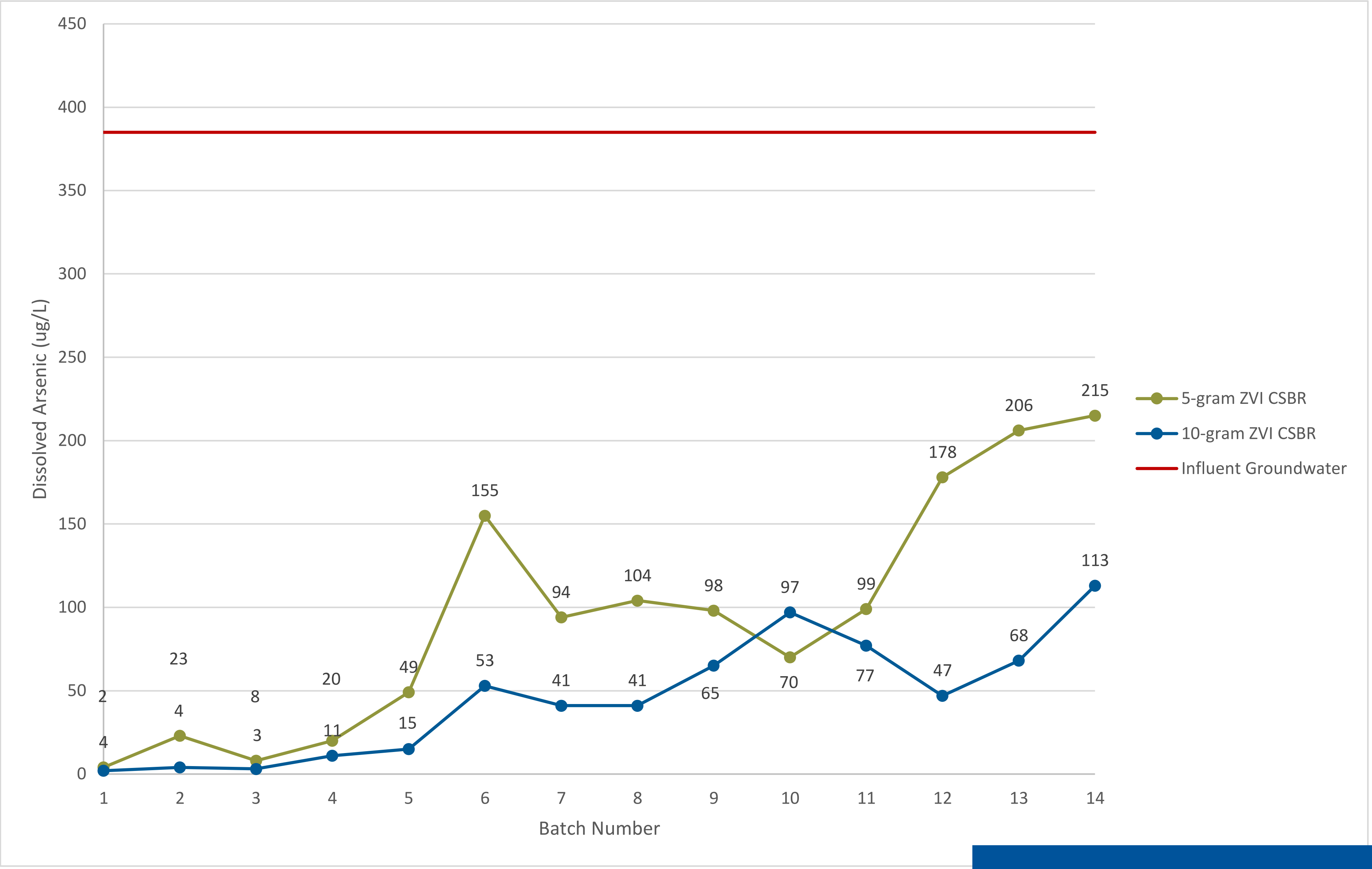
CONCEPTUAL CROSS SECTION

*Not to scale

PERMEABLE REACTIVE BARRIER OPTION OVERVIEW
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 10

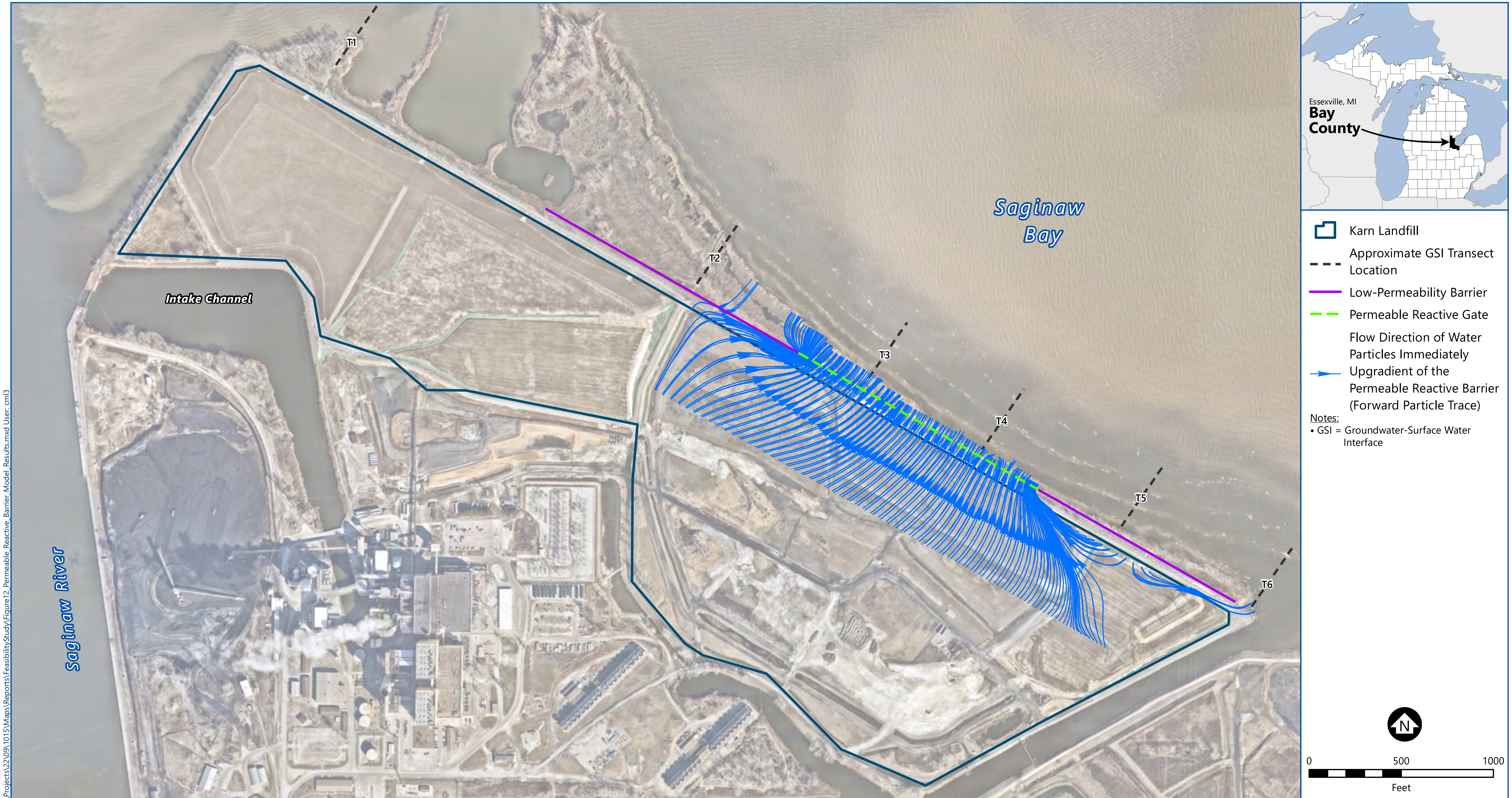
P:\Ann Arbor\22 MI\09\22091015 DE Karn Corrective Action\WorkFiles\Feasibility Study\Figures\Adobe Illustrator Files\PRB_CrossSection.ai



DISSOLVED ARSENIC ANALYTICAL RESULTS COLLECTED FROM THE 5-GRAM AND 10-GRAM ZVI CSBR BATCHES

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 11



Aerial Image: Nearmap 3/23/2018

PERMEABLE REACTIVE BARRIER MODEL RESULTS

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE 12

Appendices

Appendix A

Groundwater Modeling Report

resourceful. naturally.
engineering and environmental consultants
BARR

Technical Memorandum

To: JR Register, Consumers Energy Company
From: Katrina Marini and Katy Lindstrom, PE
Subject: D.E. Karn Groundwater Modeling
Date: February 25, 2021
Project: 22091015.01
c: Caleb Batts and Bradley Runkel, Consumers Energy Company; Tom Boom, Barr Engineering Co.

Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Michigan.

Kathleen Lindstrom
Kathleen Lindstrom
PE license #: 6201061370

02/25/2021
Date

KATHLEEN LINDSTROM
ENGINEER
No. 6201061370

A1 Introduction

The Consumers Energy Company (Consumers) D.E. Karn Electrical Power Generating Facility (generating facility) is located at 2742 N. Weadock Highway in Essexville, Michigan. Power generation at this location is currently achieved by two coal-fired boilers (Karn Units 1&2) and two gas/oil-fired units (Karn Units 3&4). The generating facility is located east of the Saginaw River on the south end of the Saginaw Bay (Figure A-1). The site comprises the generating facility; a closed 171-acre, Type III, low-hazard industrial landfill (Karn Landfill); the clean-closed Karn Bottom Ash Pond; and the Karn Lined Impoundment (Figure A-2). Together, these components make up what is herein referred to as the site. Installation of the final cover was completed over the Karn Landfill in 2019 and Consumers received approval of final closure certification from the Michigan Department of Environment, Great Lakes, and Energy on June 23, 2020 (reference (1)). The approval also stated that the Karn Landfill has entered into the required 30-year post-closure care period. The Karn Lined Impoundment is the only structure at the site which currently receives CCR materials in the form of hydraulically sluiced bottom ash and various process waters. The Karn Lined Impoundment is periodically dredged and removed CCR materials are allowed to dewater before being impounded at the nearby Weadock Solid Waste Disposal Area (Weadock Landfill).

A feasibility study has been prepared to evaluate corrective action options for arsenic-impacted groundwater potentially resulting from the Karn Landfill at the site. A groundwater flow model was developed to represent groundwater flow directions near the landfill in support of the feasibility study. This report describes the process of model development and calibration, along with data used to support decisions made during the modeling process.

A2 Model Development

The site was previously represented in groundwater flow models by others in 2011 and 2016 (reference (2); Attachment B of Appendix F of reference (3)). Hydrologic conditions have changed at the site since 2016 due to the clean-closure of the Karn Bottom Ash Pond and Karn Landfill; therefore, the groundwater flow model was updated to simulate hydrologic conditions in June 2010, March 2016, and October 2019. The following sections provide details on groundwater flow model development. Additionally, a geologic model was developed in Earth Volumetric Studio (EVS) software (reference (4)), and the geologic model provided an up-to-date and comprehensive understanding of site geology for use in an updated groundwater flow model. The model was developed in UTM North American Datum of 1983, Zone 17 North, and North American Vertical Datum of 1988 (NAVD 88).

A2.1 Model Software Selection

MODFLOW 6 (v. 6.1.1; reference (5), reference (6)) was selected for simulation of three-dimensional, steady-state groundwater flow. MODFLOW was developed by the U.S. Geological Survey and is widely used and accepted, and MODFLOW 6 is the most recent core version of MODFLOW published by the U.S. Geological Survey. MODFLOW 6 provided functionality to represent the discontinuous hydrogeologic units (e.g., the intermediate silt/clay layer described in Section A2.2) not available in previous versions of MODFLOW.

The graphical user interface Groundwater Vistas (v. 7; reference (7)) was used to support the development of the MODFLOW model, although some elements of the model calibration were developed outside of Groundwater Vistas.

A2.2 Model Domain, Grid, and Layers

The primary geologic units under the Karn Landfill are ash and other fill materials and sand, silt, and clay. The fill/native sand unit is the primary conduit of impacted groundwater flow. Native sands are present as two units separated by an intermediate silt/clay layer on the west side of the landfill, but the lower native sand pinches out to zero thickness toward the east, in the corrective action area. The upper sand ranges in thickness from approximately 33 feet on the west side of the landfill to less than 10 feet on the east side. A continuous, native, hard silty clay unit, deposited as glacial till, exists beneath the sand and intermediate silt/clay units. The top of this unit is relatively flat throughout the eastern portion of the site, at an elevation of approximately 575 feet, but slopes downward to the west under the river to an elevation of 515 feet and extends to bedrock at an elevation of approximately 500 to 520 feet. Site hydrostratigraphy is described in more detail in the Conceptual Site Model (CSM; Appendix A of this Feasibility Study). The hydrostratigraphic units represented in the groundwater flow model are the CCR and other surficial fill materials, upper native sand, intermediate silt/clay, and lower native sand. The glacial till underlying the site was represented as a no-flow boundary at the bottom of the model.

Groundwater model domains are commonly defined based on surface water divides and major surface water features, which provide the basis for numerical boundary conditions. The site is bordered by the

Saginaw River on the west, by Saginaw Bay to the north and northeast, and by the Weadock Landfill to the south. The south end of the Weadock Landfill was assigned as the southern edge of the model domain due to the lack of nearby surface water divides or features, as well as the distance from the area of interest (i.e., to avoid “boundary effects” on model estimates in the area of interest).

Consistent with previous models, the model grid was rotated 32 degrees counterclockwise to align the primary groundwater flow direction with the orientation of grid columns (Figure A-3). The horizontal grid spacing is uniform 25 feet by 25 feet over the model domain.

Model layers were assigned using the geologic model of the site. The closed Karn Bottom Ash Pond and other fill material at the site, including CCR material, were represented in model layers 1 and 2. The upper native sand unit, intermediate silt/clay layer, and lower native sand unit were represented as model layers 3, 4, and 5, respectively. The MODFLOW 6 option for representation of pinched out layers was utilized (reference (5)), so that only model cells representing areas with more than 0.1 meters of a given material allowed three-dimensional flow. For example, at locations in which the intermediate silt/clay is absent, MODFLOW represented vertical flow directly between the upper native sand unit (model layer 3) and lower native sand unit (model layer 5). The distribution of each modeled unit is shown on Figure A-4a through Figure A-4d.

A2.3 Boundary Conditions

A2.3.1 Recharge

Recharge to the aquifer system was simulated using the Recharge Package (reference (5)). Ten recharge zones were defined to represent areas in which recharge might be expected to differ due to land use or surficial material type z (Figure A-5). The Karn Landfill was separated into multiple recharge zones to allow simulation of the progressive closure of landfill cells between the simulated periods, June 2010, March 2016, and October 2019. Closed landfill cells and surface water bodies were assigned 0 inches/year of recharge. Recharge rates for non-zero recharge zones were adjusted during model calibration.

A2.3.2 Surface Water Features

Large surface waterbodies (Saginaw Bay and the Saginaw River) were represented with specified-head boundary condition cells using the Constant Head Package (reference (5)). The Saginaw Bay was represented with uniform head. The Saginaw River was represented with higher water levels at the south end of the model domain (upstream) with water levels assigned based on DEM data (reference (8)). The extent of specified-head cells in the model is shown on Figure A-6a through Figure A-6e.

The following smaller surface waterbodies were represented using the River Package (reference (5)): the intake channel, the discharge channel, the Karn Bottom Ash Pond, and an unlined drainage ditch. The River Package uses head-dependent boundary conditions where flow into/out of the modeled aquifer is proportional to the difference in head between the boundary condition and the modeled aquifer and a conductance factor. The intake channel was represented with uniform head, and the discharge channel was represented with higher water levels at the western end (upstream), based on DEM data (reference (8)). The closed Karn Bottom Ash Pond was only included in simulations of conditions prior to 2019 at an elevation of 593.4 feet based on 2016 DEM data (reference (8)). The unlined drainage ditch along the southwestern side of the Karn Landfill was represented with a slightly different geometry prior to 2019 than in 2019 based on aerial imagery. The alignment of the unlined drainage ditch changed during closure of landfill cells D2, D3, and F in 2019. The modeled water levels in the unlined drainage ditch were based on DEM data (reference (8)). River cells were placed in a model layer based on the intersection of the water elevation with the model layers. Where river cells were placed in deeper model layers, model cells at the same location in shallower layers were made inactive (i.e., set as a "no flow" boundary condition). The extent of river cells in the model is shown on Figure A-6a through Figure A-6d.

Riverbed conductance was treated as an adjustable parameter during model calibration. In MODFLOW, the conductance of a river cell is defined by the following equation:

$$C = \frac{K*L*W}{T} \qquad \text{(Equation A-1)}$$

where:

C is conductance of river bed material (L^2/T),
K is vertical hydraulic conductivity of river bed material (L/T),
L is length of river reach intersecting model cell (L),
W is width of the river bed in contact with model cell (L), and
T is thickness of river bed material (L)

Groundwater flow into and out of the model domain through the relatively thick unconsolidated deposits adjacent to the Saginaw River in the southwestern portion of the model was represented with the General Head Package (reference (5)). Head values were assigned to the general-head cells based on water levels modeled by others (Attachment B of Appendix F of reference (3)). Due to the distance of the boundary condition cells from calibration targets, the conductance of the general-head boundaries was not included in the calibration. The extents of general-head boundaries in the model are shown on Figure A-6b through Figure A-6e.

A2.3.3 Landfill Features

The slurry wall installed around much of the Weadock Landfill was represented with the Horizontal Flow Barrier Package (reference (9)). The slurry wall was represented as 1 foot thick with a hydraulic conductivity of $8.5\text{x}10^{-5}$ feet/day. Design data for the slurry wall indicates the slurry wall hydraulic conductivity was designed with a maximum hydraulic conductivity of $2.8\text{x}10^{-4}$ feet/day (reference (10)), but could be as low as $2.8\text{x}10^{-6}$ feet/day (reference (11)). The modeled location of the Weadock Landfill slurry wall was based on design report drawings, and is shown on Figure A-6b and Figure A-6c.

The existing groundwater extraction system was installed at the Karn Landfill in 2016 and consists of 6 wells screened across the upper sand unit (Figure A-6c). The extraction wells were represented with the

Well Package (reference (5)). Simulated pumping rates for the extraction wells are discussed in Section A4.1.

A2.4 Hydraulic Conductivity Distribution

A single zone of uniform hydraulic conductivity was assigned to each of the model layers, except layer 2. Multiple zones were assigned in layer 2 to represent potential differences in the hydraulic properties of fill across the model domain. The fill was divided into three zones: CCR in the Karn and Weadock Landfill cells, clayey fill in the perimeter and interior dikes in the Karn landfill, and sandy fill in the remainder of model domain with fill present (Figure A-7). Locations of interior dikes were estimated from aerial imagery and landfill cell closure drawings.

A3 Model Calibration

Calibration was completed using a combination of manual methods and the automated calibration code PEST (version 16, reference (12)). Through systematic adjustment of model inputs (termed “parameters” in the subsequent discussion) within a user-specified range, PEST attempts to minimize the difference between observed and modeled values (residuals). Parameters that were adjusted during the calibration and observations that were matched are discussed below along with other constraints that were applied.

A residual is defined as the difference between an observation (i.e., a measured value) and corresponding model value (reference (13)); therefore, a positive residual indicates that the modeled value is less than the measured value (i.e., the model is under-predicting the value), and a negative residual indicates that the model is over-predicting the value of a given observation. When using PEST, the difference between observed and modeled values is quantified as the sum of squared weighted residuals and is termed the objective function. Therefore, the goal of the calibration was to minimize the objective function.

A3.1 Calibration Datasets

The three model time periods (each run as a separate steady-state simulation) were simultaneously calibrated to groundwater level measurements from their respective times. In June 2010, all landfill cells and the Karn Bottom Ash Pond were in use. By March 2016, landfill cells A West 1, B, and C1 had been closed with final cover. By October 2019, the remaining landfill cells were closed with final cover. CCR materials in the Karn Bottom Ash Pond had also been dredged out and the area backfilled with clay. In addition to changes at the landfill, the Saginaw Bay water levels rose between June 2010 and October 2019 (Table C-1).

Table C-1 Simulated hydrologic conditions

Time Period	Saginaw Bay Water Elevation (feet)	Closed Karn Landfill Cells	Bottom Ash Pond Status
June 2010	578.00	--	Active
March 2016	579.75	A West 1, B, C1	Active
October 2019	581.80	All	Closed

Water level measurements from the Weadock Landfill were assigned lower weights than water level measurements from the Karn Landfill due to the limited number of boring logs from the Weadock Landfill used to interpolate geologic unit contacts, and thus higher uncertainty in the accuracy of the modeled groundwater near the Weadock Landfill. All water level measurements from the Weadock Landfill used in the calibration were from 2016. Some 2019 water level measurements from the extraction system area were also assigned lower weights, because of the density of data in that area and the variability in water levels between wells in the same or adjacent model cells. Extraction wells were also assigned lower weights, because well inefficiencies cause water levels in pumping wells to be lower than in the surrounding aquifer.

The groundwater extraction system was installed in 2016 but has not operated consistently. The extraction wells were not operating in October 2019 during the site-wide monitoring event. However, water level data collected with LevelTROLLs® in November 2019 showed that five of the wells operated nearly continuously for about 10 days (November 5-15th). Water levels on November 8, 2019 at wells without drawdown from the extraction system were similar to the water levels measured in October; therefore, the LevelTROLL® data from November 8th was used to replace manual measurements from October at all 21 wells with LevelTROLL® data. The extraction wells do not have individual flow meters, so the actual pumping rate at each well on November 8, 2019 is unknown. Pumping rates were estimated for the extraction wells based on maximum specific capacity testing by TRC in June 2019, estimates of typical system pumping totals based on professional judgement, and observed drawdown on November 8, 2019 (Table C-2). The maximum specific capacity testing suggests a higher system total pumping rate than is consistent with system totalizer readings from May and June 2020; therefore, the specific capacity values were scaled down so that the estimated system total pumping rate would be 10 gallons per minute (gpm).

Table C-2 Estimated extraction well pumping rates

Well	Maximum Specific Capacity (gallons per minute [gpm] per foot of drawdown)	Approximate Observed Drawdown[1] (feet)	Estimated Pumping Rate (gpm)
EW-1	1.50	> 5.0[2]	3.0
EW-2	0.75	0.0	0.0
EW-3	0.96	4.0	1.5
EW-4	1.24	2.5	1.2
EW-5	1.75	4.5	3.2
EW-6	0.15[3]	3.5	1.1

(1) Based on LevelTROLL® data in November 2019
(2) The water level in EW-1 dropped below the elevation of the LevelTROLL® and the total amount of drawdown in unknown for this reason.
(3) TRC noted that an issue with the EW-6 pump limited the pumping rate to 0.15 gpm during the specific capacity test.

A3.2 Prior Information and Regularization Information

Automated calibration using PEST may be guided with user-supplied information related to model parameter values, known as “prior information” and “regularization information.” Prior information and regularization information do not impose hard constraints on the parameter values; rather, PEST will attempt to match the preferred parameter values to the extent practicable, and a contribution will be added to the objective function if the values deviate from the preferred values. Prior information generally consists of independent estimates based on measurements of parameter values made within the model domain, such as slug tests conducted at the site. In contrast, regularization information represents constraints on relationships between parameters values. Hydraulic conductivity data are available for the Karn and Weadock Landfill areas from slug tests and lab permeability tests. Prior information was used to constrain model parameters representing geologic units for which site data are available, with the geometric mean of site data used as the preferred value (Table C-3). Regularization information was used to prevent the vertical hydraulic conductivity of sandy fill from calibrating to a lower value than the vertical hydraulic conductivity of clayey fill.

Table C-3 Site hydraulic conductivity data available for use as prior information during model calibration

Tested Direction	Tested Material or Unit	Number of Tested Locations	Hydraulic Conductivity Estimates (feet/day)			Parameter Name
			Minimum	Geometric Mean	Maximum	
Horizontal	ash	9	0.0695	0.945	28.3	Kx10
	ash/native deposits	11	0.0271	2.57	46.9	Kx11
	sand and silty sand	29	0.0116	4.56	52.7	Kx1
Vertical	dike (clay)	10	8.16E-03	0.139	0.442	Kz12
	organic silt	2	0.0454	0.164	0.595	Kz2

A3.3 Calibration Parameters

Model inputs adjusted during model calibration (parameters) were horizontal hydraulic conductivity, vertical anisotropy, recharge, and river conductance. Model parameters were allowed to vary within specified bounds, which were based on site-specific data, literature values, and professional judgment. Vertical anisotropy was used as a model input rather than vertical hydraulic conductivity to prevent unrealistic relationships between horizontal and vertical hydraulic conductivity for a given unit. Recharge estimates for the model domain from state-wide data were 6 to 10 inches per year (in/yr) (reference (14)); however, lower rates were allowed during calibration to accommodate the relatively low hydraulic conductivities estimated from site data. River conductance bounds were assigned differently for the river zones representing the intake and discharge channel, the unlined drainage ditch, and the ponds and ditches at Weadock to account for the degree of overlap between these surface water features and the intersected model cells. Parameter bounds and calibrated values are listed in Table C-4.

Table C-4 Parameter Values and Calibration Bounds

Parameter Type	Parameter Description	Parameter ID	Units	Minimum Allowed	Maximum Allowed	Calibrated Value
Horizontal Hydraulic Conductivity	Upper Sand	kx1	feet/day	3.28E-02	3.28E+02	1.11E+01
	Intermediate Silt/Clay	kx2	feet/day	3.28E-04	3.28E+00	1.86E+00
	Lower Sand	kx3	feet/day	3.28E-02	3.28E+02	7.58E+00
	Ash	kx10	feet/day	3.28E-04	3.28E+02	1.11E+00
	Sandy Fill	kx11	feet/day	3.28E-02	3.28E+02	2.28E+00
	Clayey Fill	kx12	feet/day	3.28E-05	3.28E+00	1.34E+00
Vertical Anisotropy	Upper Sand	kz1	unitless	1.00E-02	5.00E-01	2.10E-01
	Intermediate Silt/Clay	kz2	unitless	1.00E-02	5.00E-01	9.04E-02
	Lower Sand	kz3	unitless	1.00E-02	5.00E-01	9.15E-02
	Ash	kz10	unitless	1.00E-02	5.00E-01	4.99E-02
	Sandy Fill	kz11	unitless	1.00E-02	5.00E-01	9.91E-02
	Clayey Fill	kz12	unitless	1.00E-03	5.00E-01	1.02E-01
Recharge	Impermeable or Surface Water	r1	in/year	NA	NA	0.00E+00
	Non-landfill Areas, 2010	r2_10	in/year	1.00E+00	1.00E+01	1.00E+00
	Karn Cell A West 1, 2010	r3_10	in/year	1.00E+00	1.00E+01	1.00E+01
	Karn Cell A West 2, 2010	r4_10	in/year	1.00E+00	1.00E+01	8.42E+00
	Karn Cell A East, 2010	r5_10	in/year	1.00E+00	1.00E+01	1.00E+00
	Karn Cells D1 and D2, 2010	r6_10	in/year	1.00E+00	1.00E+01	1.00E+00
	Karn Cells B and C1, 2010	r7_10	in/year	1.00E+00	1.00E+01	1.00E+01
	Karn Cells C2 and E, 2010	r8_10	in/year	1.00E+00	1.00E+01	8.08E+00
	Karn Cells D2, D3, and F, 2010	r9_10	in/year	1.00E+00	1.00E+01	7.25E+00
	Weadock Landfill, 2010	r10_10	in/year	1.00E+00	1.00E+01	9.16E-01
	Non-landfill Areas, 2016	r2_16	in/year	1.00E+00	1.00E+01	1.00E+00
	Karn Cell A West 2, 2016	r4_16	in/year	1.00E+00	1.00E+01	1.00E+00
	Karn Cell A East, 2016	r5_16	in/year	1.00E+00	1.00E+01	3.94E+00
	Karn Cells D1 and D2, 2016	r6_16	in/year	1.00E+00	1.00E+01	4.64E+00
	Karn Cells C2 and E, 2016	r8_16	in/year	1.00E+00	1.00E+01	1.00E+01
	Karn Cells D2, D3, and F, 2016	r9_16	in/year	1.00E+00	1.00E+01	1.00E+01
	Weadock Landfill, 2016	r10_16	in/year	1.00E+00	1.00E+01	1.00E+00
	Non-landfill Areas, 2019	r2_19	in/year	1.00E+00	1.00E+01	1.01E+00
	Weadock Landfill, 2019	r10_19	in/year	1.00E+00	1.00E+01	1.00E+00
	Closed Bottom Ash Pond, 2019	r11_19	in/year	1.00E-01	1.00E+01	9.98E-01
River Conductance	Intake Channel	rv1	ft^2/day	2.05E+00	2.15E+05	2.43E+04
	Discharge Channel	rv2	ft^2/day	2.05E+00	2.15E+05	2.00E+04
	Former Bottom Ash Pond, 2010-2016	rv3	ft^2/day	2.05E+00	6.15E+04	1.79E+02
	Unlined Ditch, 2010-2016	rv4	ft^2/day	5.38E-01	1.61E+04	2.60E+01
	Unlined Ditch, 2019	rv5	ft^2/day	5.38E-01	1.61E+04	2.60E+01
	Other ponds and ditches	rv6	ft^2/day	2.05E+00	6.15E+04	4.00E+02
	Other ponds and ditches	rv7	ft^2/day	2.05E+00	6.15E+04	4.00E+02

A3.4 Calibration Results

A scatter plot of simulated versus observed steady-state heads is shown on Figure A-8. In general, an acceptable match to the head observations was achieved, though simulated heads are biased high (i.e., heads are overpredicted) at the upper end of the range of modeled heads, and a few locations were poorly matched. Modeled head contours from the upper sand unit and heads residuals from all layers are shown on Figure A-9, Figure A-10, and Figure A-11 for 2010, 2016, and 2019 conditions, respectively. Simulated heads near the Karn Bottom Ash Pond are biased high (overpredicted) in 2010 and 2016, where the groundwater gradients are higher. Simulated heads are biased high to the northwest and low to the southeast in 2019. These areas may have been matched better with adjustments to recharge zone boundaries or use of additional recharge zones. Simulated heads near the extraction system are biased low in 2019, which may be caused by overestimation of the extraction well pumping rates. The average of residuals from all three modeled periods was -0.04 feet, and 88% of the head targets had residuals within 10% of the range of observed water levels (<1.3 feet). All calibration targets and residuals are listed in Table C-5.

All parameters with prior information applied have calibrated values within the range of site-specific hydraulic conductivity estimates. The calibrated horizontal hydraulic conductivity of the upper sand unit was farthest from the geometric mean of site-specific estimates, at about double the geometric mean. The match between site hydraulic conductivity estimates used as prior information and calibrated hydraulic conductivity parameter values is acceptable.

Table C-5 Calibration Targets, Weights, and Residuals

Well	Target ID	Target Group	Target Weight	Units	Measured Value	Modeled Value	Residual
82-MW-11	82mw11_2010	head2010	1.0000	feet	580.26	579.49	0.77
MW-1	mw1_2010	head2010	1.0000	feet	578.68	578.20	0.48
MW-3	mw3_2010	head2010	1.0000	feet	578.51	578.11	0.40
MW-5	mw5_2010	head2010	1.0000	feet	578.97	578.36	0.61
MW-7	mw7_2010	head2010	1.0000	feet	581.65	582.49	-0.84
MW-9	mw9_2010	head2010	1.0000	feet	578.29	580.02	-1.73
MW-11	mw11_2010	head2010	1.0000	feet	579.48	580.10	-0.62
MW-13	mw13_2010	head2010	1.0000	feet	579.36	579.44	-0.08
MW-15	mw15_2010	head2010	1.0000	feet	578.69	578.13	0.57
MW-17	mw17_2010	head2010	1.0000	feet	587.75	590.26	-2.51
MW-18	mw18_2010	head2010	1.0000	feet	590.12	591.78	-1.66
MW-22	mw22_2010	head2010	1.0000	feet	585.03	585.33	-0.30
MW-23	mw23_2010	head2010	1.0000	feet	585.60	584.96	0.64
OW-2	ow2_2010	head2010	1.0000	feet	585.45	585.96	-0.51
OW-6	ow6_2010	head2010	1.0000	feet	586.44	587.85	-1.41
OW-7	ow7_2010	head2010	1.0000	feet	585.46	584.96	0.49
OW-8	ow8_2010	head2010	1.0000	feet	583.05	583.69	-0.64
OW-9	ow9_2010	head2010	1.0000	feet	581.64	583.14	-1.50
OW-10	ow10_2010	head2010	1.0000	feet	585.86	590.48	-4.62
OW-11	ow11_2010	head2010	1.0000	feet	589.32	591.28	-1.96
OW-12	ow12_2010	head2010	1.0000	feet	588.05	592.97	-4.92
OW-13	ow13_2010	head2010	1.0000	feet	585.07	590.06	-5.00
OW-14	ow14_2010	head2010	1.0000	feet	590.44	592.42	-1.98
OW-15	ow15_2010	head2010	1.0000	feet	585.26	584.56	0.70
PZ-2010-201	pz201_2010	head2010	1.0000	feet	582.26	582.21	0.05

Well	Target ID	Target Group	Target Weight	Units	Measured Value	Modeled Value	Residual
VWP-1	vwp1_2010	head2010	1.0000	feet	585.58	579.76	5.82
VWP-6	vwp6_2010	head2010	1.0000	feet	586.76	583.17	3.58
VWP-7	vwp7_2010	head2010	1.0000	feet	587.02	586.90	0.12
VWP-9	vwp9_2010	head2010	1.0000	feet	588.22	586.96	1.26
VWP-13	vwp13_2010	head2010	1.0000	feet	580.97	580.88	0.09
82-MW-10	82mw10_2016	head2016	1.0000	feet	581.19	590.97	-9.78
82-MW-11	82mw11_2016	head2016	1.0000	feet	580.64	581.05	-0.41
82-MW-12	82mw12_2016	head2016	0.7071	feet	580.64	581.81	-1.17
82-MW-13	82mw13_2016	head2016	0.7071	feet	580.76	586.56	-5.80
82-MW-14	82mw14_2016	head2016	0.7071	feet	580.76	579.79	0.97
82-MW-15	82mw15_2016	head2016	0.7071	feet	579.76	579.80	-0.03
82-MW-16	82mw16_2016	head2016	0.7071	feet	579.76	580.27	-0.51
82-MW-17	82mw17_2016	head2016	0.0000	feet	587.90	581.72	6.18
82-MW-18	82mw18_2016	head2016	0.0000	feet	589.92	580.77	9.15
MW-1	mw1_2016	head2016	1.0000	feet	579.83	579.80	0.03
MW-3	mw3_2016	head2016	0.7071	feet	579.86	579.77	0.09
MW-4	mw4_2016	head2016	0.7071	feet	579.76	579.77	-0.01
MW-5	mw5_2016	head2016	1.0000	feet	579.75	579.82	-0.07
MW-7	mw7_2016	head2016	1.0000	feet	580.33	582.73	-2.40
MW-9	mw9_2016	head2016	1.0000	feet	580.33	581.43	-1.10
MW-11	mw11_2016	head2016	1.0000	feet	582.42	580.98	1.44
MW-13	mw13_2016	head2016	1.0000	feet	582.42	581.04	1.38
MW-15	mw15_2016	head2016	1.0000	feet	581.19	579.86	1.33
MW-19	mw19_2016	head2016	1.0000	feet	581.73	581.20	0.53
MW-20	mw20_2016	head2016	1.0000	feet	578.96	579.85	-0.89
MW-21	mw21_2016	head2016	1.0000	feet	585.44	581.26	4.18
MW-22	mw22_2016	head2016	1.0000	feet	586.84	584.74	2.10
MW-23	mw23_2016	head2016	1.0000	feet	588.62	586.16	2.46
OW-1	ow1_2016	head2016	1.0000	feet	579.31	579.89	-0.58
OW-2	ow2_2016	head2016	1.0000	feet	587.40	585.09	2.31
OW-3	ow3_2016	head2016	1.0000	feet	583.34	582.09	1.25
OW-4	ow4_2016	head2016	1.0000	feet	581.12	581.67	-0.55
OW-5	ow5_2016	head2016	1.0000	feet	579.96	580.03	-0.07
OW-6	ow6_2016	head2016	1.0000	feet	591.26	591.01	0.25
OW-7	ow7_2016	head2016	1.0000	feet	588.88	586.20	2.68
OW-8	ow8_2016	head2016	1.0000	feet	583.69	585.37	-1.68
OW-9	ow9_2016	head2016	1.0000	feet	582.36	584.73	-2.37
OW-10	ow10_2016	head2016	1.0000	feet	586.23	590.97	-4.74
OW-11	ow11_2016	head2016	1.0000	feet	591.29	589.89	1.40
OW-12	ow12_2016	head2016	1.0000	feet	587.85	592.99	-5.14
OW-13	ow13_2016	head2016	1.0000	feet	585.11	590.51	-5.40
OW-14	ow14_2016	head2016	1.0000	feet	588.19	592.69	-4.50
OW-15	ow15_2016	head2016	1.0000	feet	584.96	585.66	-0.70
EW-1	ew1_2019	head2019	0.3162	feet	582.11	577.70	4.41
EW-2	ew2_2019	head2019	0.3162	feet	582.12	581.49	0.63
EW-3	ew3_2019	head2019	0.3162	feet	577.91	579.70	-1.79
EW-4	ew4_2019	head2019	0.3162	feet	581.97	579.72	2.25

Well	Target ID	Target Group	Target Weight	Units	Measured Value	Modeled Value	Residual
EW-5	ew5_2019	head2019	0.3162	feet	578.59	576.34	2.25
EW-6	ew6_2019	head2019	0.3162	feet	580.05	580.11	-0.06
DEK-15002	k15002_2019	head2019	1.0000	feet	584.62	584.46	0.16
DEK-15003	k15003_2019	head2019	1.0000	feet	586.02	585.50	0.52
DEK-15004	k15004_2019	head2019	1.0000	feet	581.90	583.28	-1.38
DEK-15005	k15005_2019	head2019	1.0000	feet	582.09	582.38	-0.29
DEK-15006	k15006_2019	head2019	1.0000	feet	582.09	582.25	-0.16
DEK-18001	k18001_2019	head2019	1.0000	feet	585.31	585.64	-0.33
MW-1	mw1_2019	head2019	1.0000	feet	581.76	581.84	-0.08
MW-3	mw3_2019	head2019	0.7071	feet	581.71	581.81	-0.10
MW-4	mw4_2019	head2019	0.7071	feet	581.78	581.81	-0.03
MW-5	mw5_2019	head2019	0.7071	feet	581.79	581.84	-0.05
MW-6	mw6_2019	head2019	0.7071	feet	581.98	581.84	0.14
MW-8	mw8_2019	head2019	1.0000	feet	582.14	582.60	-0.46
MW-10	mw10_2019	head2019	0.7071	feet	582.02	579.98	2.04
MW-12	mw12_2019	head2019	0.7071	feet	581.91	580.85	1.06
MW-14	mw14_2019	head2019	0.7071	feet	582.01	581.25	0.76
MW-16	mw16_2019	head2019	0.7071	feet	581.85	581.82	0.03
MW-17	mw17_2019	head2019	1.0000	feet	585.64	586.32	-0.68
MW-18	mw18_2019	head2019	1.0000	feet	582.34	583.67	-1.33
MW-19	mw19_2019	head2019	1.0000	feet	582.03	582.89	-0.85
MW-20	mw20_2019	head2019	1.0000	feet	580.52	581.86	-1.34
MW-21	mw21_2019	head2019	1.0000	feet	582.12	582.16	-0.04
MW-22	mw22_2019	head2019	1.0000	feet	583.21	583.19	0.01
MW-23	mw23_2019	head2019	1.0000	feet	585.10	581.53	3.57
OW-1	ow1_2019	head2019	1.0000	feet	580.75	581.90	-1.15
OW-2	ow2_2019	head2019	1.0000	feet	583.33	583.28	0.05
OW-3	ow3_2019	head2019	0.7071	feet	581.60	579.83	1.77
OW-4	ow4_2019	head2019	0.7071	feet	582.06	581.15	0.92
OW-5	ow5_2019	head2019	0.7071	feet	582.27	581.85	0.42
OW-6	ow6_2019	head2019	1.0000	feet	584.54	582.92	1.62
OW-7	ow7_2019	head2019	1.0000	feet	584.82	581.53	3.29
OW-8	ow8_2019	head2019	1.0000	feet	583.55	584.61	-1.06
OW-9	ow9_2019	head2019	1.0000	feet	583.38	584.33	-0.95
OW-10	ow10_2019	head2019	1.0000	feet	585.33	586.22	-0.89
OW-11	ow11_2019	head2019	1.0000	feet	586.20	585.34	0.87
OW-12	ow12_2019	head2019	1.0000	feet	585.90	584.95	0.95
OW-13	ow13_2019	head2019	1.0000	feet	584.76	584.73	0.03
OW-15	ow15_2019	head2019	1.0000	feet	584.63	584.73	-0.10
PZ-2	pz2_2019	head2019	0.7071	feet	582.25	581.54	0.71
PZ-3	pz3_2019	head2019	0.7071	feet	582.15	581.03	1.12
PZ-4	pz4_2019	head2019	0.7071	feet	582.09	581.50	0.59
PZ-5	pz5_2019	head2019	0.7071	feet	581.91	581.41	0.50
PZ-6	pz6_2019	head2019	0.7071	feet	582.01	581.19	0.83
PZ-7	pz7_2019	head2019	0.7071	feet	581.69	580.31	1.38
PZ-8	pz8_2019	head2019	0.7071	feet	581.98	580.94	1.04
PZ-9	pz9_2019	head2019	0.7071	feet	581.89	580.97	0.93
PZ-10	pz10_2019	head2019	0.7071	feet	582.35	581.48	0.87

Well	Target ID	Target Group	Target Weight	Units	Measured Value	Modeled Value	Residual
PZ-11	pz11_2019	head2019	0.7071	feet	582.18	581.80	0.38
PZ-12	pz12_2019	head2019	0.7071	feet	581.82	580.98	0.84
PZ-13	pz13_2019	head2019	0.7071	feet	582.09	581.74	0.35
PZ-14	pz14_2019	head2019	0.7071	feet	581.91	581.45	0.46
PZ-15	pz15_2019	head2019	0.7071	feet	582.84	581.64	1.20
EW-1	ew1_flux	wellflux	2.0000	gpm	3.01	3.01	0.00
EW-2	ew2_flux	wellflux	2.0000	gpm	0.00	0.00	0.00
EW-3	ew3_flux	wellflux	2.0000	gpm	1.54	1.54	0.00
EW-4	ew4_flux	wellflux	2.0000	gpm	1.24	1.24	0.00
EW-5	ew5_flux	wellflux	2.0000	gpm	3.15	3.14	-0.02
EW-6	ew6_flux	wellflux	2.0000	gpm	1.06	1.06	0.00

A4 Predictive Simulations

The calibrated groundwater flow model was used to evaluate effectiveness of potential corrective action options. Three options were considered: groundwater extraction with treatment prior to discharge, air sparging, and a permeable reactive barrier. Air sparging would not alter groundwater flow directions at the site; therefore, predictive simulations were not completed for that option. Groundwater conditions from the 2019 calibration period were used for the predictive scenarios of groundwater extraction or a permeable reactive barrier. The effectiveness of groundwater capture in the predictive scenarios was evaluated using particle tracking in MODPATH (v. 7.2.01; reference (15); reference (16)). MODPATH uses effective porosity as an input for calculation of groundwater velocity; effective porosity was assumed to be 0.2 for all units.

A4.1 Groundwater Extraction

Groundwater extraction predictive scenarios included simulation of:

- a groundwater extraction system with six wells,
- a groundwater extraction system with seven wells,
- a groundwater extraction system with eight wells and a low-permeability barrier wall, and
- a horizontal well and a low-permeability barrier wall.

The existing groundwater extraction wells were assumed to be abandoned and replaced for all predictive scenarios with vertical wells. As a conservative assumption, modeled drawdown was limited to near the top of the upper sand unit so that the greater drawdown within the extraction wells (due to well inefficiencies) would remain above the replacement well screens. To do this, a flow-reduction option within MODFLOW 6 was used to reduce pumping rates if modeled groundwater elevations dropped too low within the upper sand unit (reference (6)).

A4.1.1 Groundwater Extraction with Six Wells

The long-term capture potential of six extraction wells was evaluated. The total system modeled pumping rate was 14.3 gpm using the flow-reduction option described above, and the particle tracking results are shown on Figure A-12. Most of the groundwater upgradient of the corrective action area is estimated to be captured; however, some groundwater northwest of the proposed groundwater extraction system would not be captured, as indicated by particle traces from the Karn Landfill travelling to Saginaw Bay. Simulated drawdown at the extraction wells was approximately 2 feet to 3 feet, and minimum simulated drawdown between the extraction wells was approximately 1.25 feet. Drawdown induced by long-term operation of the extraction system would need to be comparable to the simulated drawdown (i.e., a minimum of 1.25 feet of drawdown between wells) to achieve capture similar to what was shown with the model. This option is insufficient to meet the corrective action objectives but was completed to better understand capture by the existing extraction system.

A4.1.2 Groundwater Extraction with Seven Wells

To evaluate capture for the entire corrective action area and to better match anticipated drawdown based on observations from the existing extraction system, one well was added northwest of the six replacement extraction wells and the total pumping rate was decreased relative to the six-well scenario. In this scenario, the total system modeled pumping rate was 6.8 gpm, and groundwater upgradient of the corrective action area was captured (Figure A-13). Simulated drawdown at the extraction wells ranged from 1.4 feet to 3.0 feet. Minimum simulated drawdown between extraction wells varied from 0.9 feet in the northwest to 0.5 feet at the southeast end of the extraction system. Some of the water pumped by the proposed extraction wells would originate in Saginaw Bay.

A4.1.3 Groundwater Extraction with Seven Wells and a Low-Permeability Barrier

A low-permeability barrier was added between the seven proposed extraction wells and Saginaw Bay using the Horizontal Flow Barrier Package (reference (6)). This predictive scenario was used to estimate the contribution of Saginaw Bay to the extraction wells and potential reductions to pumping rates to achieve complete capture if that source of clean water could be removed. The low-permeability barrier was assumed to be 1 foot thick and have a horizontal hydraulic conductivity of 2.8×10^{-4} feet/day. The total system modeled pumping rate was 2.7 gpm, a reduction of 4.1 gpm from the scenario without a low-permeability barrier. Groundwater upgradient of the proposed groundwater extraction system was captured (Figure A-14).

A4.1.4 Groundwater Extraction with a Horizontal Well and a Low-Permeability Barrier

A horizontal well was included in the predictive scenarios because the relative thinness of the upper sand unit poses design challenges for vertical wells. A low-permeability barrier 3,775 feet long was included between the horizontal well and Saginaw Bay to limit the extraction of water from Saginaw Bay and minimize the pumping rate required to induce enough drawdown to achieve capture of groundwater upgradient of the corrective action area. The low-permeability barrier was assumed to be 1 foot thick and have a horizontal hydraulic conductivity of 2.8×10^{-4} feet/day. The horizontal well was represented with the

Drain Package (reference (6)) and was assumed to be 6 inches in diameter and 1,550 feet long (Figure A-15). The well was represented as surrounded by 6 inches of gravel pack with hydraulic conductivity of 560 feet/day. The elevation of the well was assigned as 577.4 feet, which is about 1 to 5 feet below the top of the upper sand unit. The modeled pumping rate from the horizontal well was 3.9 gpm and all but the northwestern extent of groundwater upgradient of the proposed horizontal well was captured.

A4.2 Permeable Reactive Barrier

Two permeable reactive barriers were simulated assuming funnel-and-gate setups (i.e., combinations of permeable and low-permeability barrier sections): 1) a 1,500-ft permeable reactive barrier between two approximately 750-ft low-permeability barriers and 2) a 1,500-ft permeable reactive barrier between two longer low-permeability barriers. In the latter predictive scenario, the northwestern low-permeability barrier was 1,575 feet long and the southeastern low-permeability barrier was 1,225 feet long (the discharge channel prevents use of a longer wall in that direction). A permeable reactive barrier without one or more low-permeability barriers would not alter groundwater flow directions at the site, so this option was not evaluated with the groundwater flow model.

The existing extraction system was not included in the predictive scenarios for the permeable reactive barrier. The low-permeability barriers were represented as keyed into the glacial till underlying the site; therefore, the low-permeability barriers penetrated the intermediate silt/clay and lower sand, where present. Consistent with groundwater extraction predictive scenarios, the low-permeability barriers were assumed to be 1 foot thick with hydraulic conductivity of $2.8\text{x}10^{-4}$ feet/day.

A4.2.1 Permeable Reactive Barrier with Half-length Low-Permeability Barriers

A 1,500-foot permeable reactive barrier bounded on either side by low-permeability barriers approximately 750 feet long was represented in the groundwater flow model using the Horizontal Flow Barrier Package (reference (6)). The permeable reactive barrier was assumed to have similar hydraulic properties to the upper sand unit, and was not directly represented in the model. Particle traces from MODPATH indicate groundwater upgradient of the low-permeability barriers would be diverted through the permeable reactive barrier along approximately half of the length of the low-permeability barriers (Figure A-16). The remaining groundwater was simulated as flowing around the outside of the barriers, through the upper sand unit to Saginaw Bay. However, the low-permeability cutoff walls could increase groundwater elevations upgradient of the low-permeability cutoff walls and cause daylighting of groundwater along sections of the cutoff walls. Review of particle travel times suggests that groundwater diverted through the permeable reactive barrier near the ends of the low-permeability barriers would travel approximately twice as fast as groundwater starting directly upgradient of the permeable reactive barrier.

A4.2.2 Permeable Reactive Barrier with Extended Low-Permeability Barriers

The proposed low-permeability barriers were extended for a total length of 2,800 feet to evaluate whether low-permeability barriers would consistently divert approximately half of the groundwater upgradient of the low-permeability barriers through the proposed central permeable reactive barrier. Particle traces from MODPATH indicate increasing the lengths of the low-permeability barriers does not sufficiently divert groundwater to the permeable portion of the barrier (Figure A-17). The primary benefit of longer low-permeability barriers is the increased travel time from the middle of the landfill to Saginaw Bay, which could act to increase attenuation prior to discharge to Saginaw Bay. The low-permeability cutoff walls could increase groundwater elevations upgradient of the cutoff walls and cause daylighting of groundwater along sections of the cutoff walls.

A4.3 Discussion of Predictive Scenarios

Optimization of the existing groundwater extraction system, and the addition of a barrier wall to increase capture, was one of the corrective action options recommended to be carried forward from the options assessment (Appendix B of this Feasibility Study). Additional assessments of groundwater levels and groundwater modeling simulations performed since that time indicate the existing six groundwater extraction wells will not allow for sufficient groundwater drawdown and capture needed to achieve remedial objectives. Additionally, groundwater modeling results for an extraction system option with a low-permeability barrier wall in place showed that a barrier wall would reduce the flow rate needed to achieve capture, but it was not a significant enough reduction to balance the costs of a low-permeability barrier wall. Likewise, the outcomes were similar with a horizontal well compared to seven vertical wells, and the groundwater extraction option with seven new wells was selected for inclusion in the feasibility study.

The fully permeable PRB was not simulated using the groundwater model because implementation of that design is not expected to alter groundwater flow at the site, but a simulation was performed to assess the feasibility of a funnel-and-gate PRB. Groundwater model results from the funnel-and-gate PRB indicate the following potential drawbacks of a funnel-and-gate PRB:

- the low-permeability cutoff walls would potentially need to extend beyond the corrective action area to provide complete treatment of impacted groundwater in the corrective action area due to groundwater flow around the impermeable cutoff walls;
- the low-permeability cutoff walls could increase groundwater elevations upgradient of the PRB and cause daylighting of groundwater along sections of the PRB; and
- groundwater flow could be accelerated at the interfaces of the impermeable cutoff walls and reactive gate, which would reduce the residence time of the groundwater in the reactive media and potentially accelerate aging of portions of the permeable reactive gates.

Based on these modeling results and the increased travel time of groundwater diverted around the extended cutoff walls, an extended barrier funnel-and-gate design was selected for inclusion in the feasibility study.

A4.4 Sensitivity Analysis

Predictive scenarios were simulated with the calibrated groundwater flow model used 2019 data for baseline conditions, which included a relatively high water level for Saginaw Bay (581.80 feet, see Table C-1). Therefore, additional simulations with a range of potential future Saginaw Bay levels were completed in a limited sensitivity analysis. The Saginaw Bay water level was increased to 585.0 feet, which is the 100-year flood water level, and the shorelines of Saginaw Bay and Saginaw River were adjusted based on topography using DEM data (reference (8)). The Saginaw Bay water level was also decreased to 576.0 feet, which is the minimum observed water level (measured in 2013), and the shorelines of Saginaw Bay and Saginaw River were adjusted using a combination of aerial imagery and DEM data, because readily available topographic data do not extend to 576 feet along the Saginaw Bay shoreline. The primary difference in Saginaw Bay shoreline was in the Windy Point area, northwest of the corrective action area.

Groundwater model results for the groundwater extraction option with seven wells with the higher assumed Saginaw Bay level are shown on Figure A-18. A total pumping rate of approximately 18 gpm was estimated to fully capture groundwater upgradient of the corrective action area. Simulated drawdown varied from 2.2 feet to 5.4 feet. Groundwater model results for the groundwater extraction option with seven wells with the lower assumed Saginaw Bay level are shown on Figure A-19. A total pumping rate of approximately 2 gpm was simulated, resulting in estimated drawdown ranging from 0.3 feet to 2.6 feet. Capture of groundwater upgradient of the corrective action area was estimated to be incomplete, and the water table could drop below the bottom of the upper sand unit (making the upper sand unit dry) in some areas near the southeast corner of the Karn Landfill even without operation of the groundwater extraction system. These results indicate that the pumping rates for the groundwater extraction system would need to be adjusted with increasing or decreasing trends in Saginaw Bay water level.

Groundwater model results for the fully permeable PRB option with the higher assumed Saginaw Bay level are shown on Figure A-20. The simulated groundwater flow directions did not change with an increase in modeled Saginaw Bay water level. Groundwater model results for the fully permeable PRB option with the lower assumed Saginaw Bay level are shown on Figure A-21. The modeled water table dropped below the bottom of the upper sand unit (making the upper sand unit dry) in a portion of the southeastern corner of the Karn Landfill, where the top of the till surface is relatively high. Modeled groundwater flow was diverted away from the dry area, resulting in some flow toward the discharge channel, rather than to Saginaw Bay.

A5 Summary

The following corrective options evaluated with the groundwater flow model were selected for inclusion in the feasibility study:

- groundwater extraction with seven wells
- a permeable reactive barrier with extended low-permeability barriers

Both predictive scenarios simulated capture of groundwater upgradient of the corrective action, whether with extraction wells or a permeable reactive barrier. Sensitivity analysis of the model predictions to Saginaw Bay water levels indicated that very low water levels could result in the upper sand unit drying out in some areas, which would impair corrective action by diverting some groundwater flow toward the south of the corrective system in both corrective options. If a groundwater extraction system is implemented, groundwater extraction rates would need to be adjusted for long-term increases or decreases in Saginaw Bay water levels. If a fully permeable PRB option is implemented, the PRB design would need consider placement of the wall such that groundwater is treated under low water level conditions in Saginaw Bay.

A6 References

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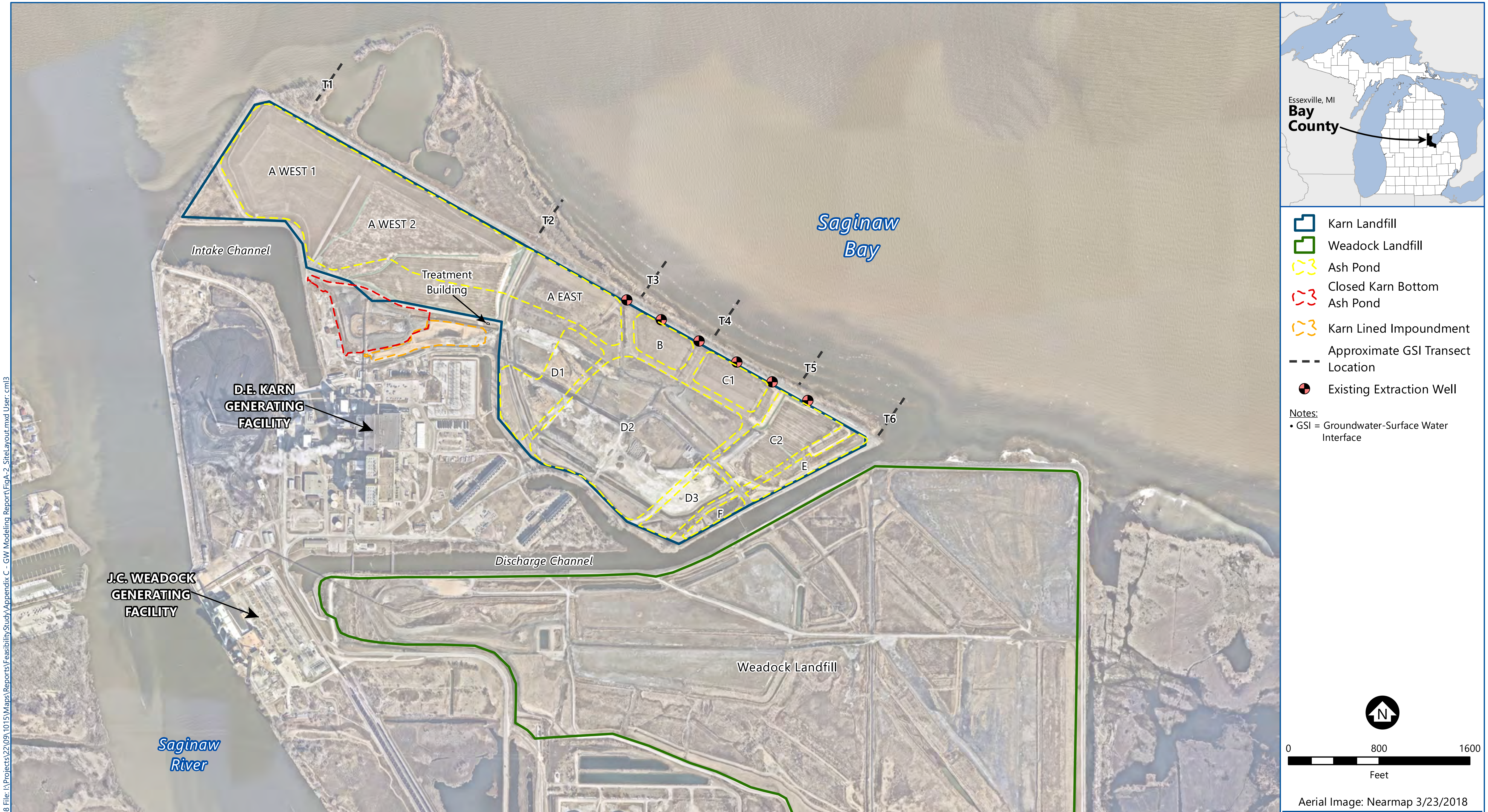
Figures

Background: 2013 National Geographic Society

SITE LOCATION
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-1

Barr Footer: ArcGIS 10.7.1, 2021-02-23 13:08 File: I:\Projects\22\09\1015\Maps\Reports\FeasibilityStudy\Appendix C - GW Modeling Report\FigA-1_Site_Location.mxd User: cml3



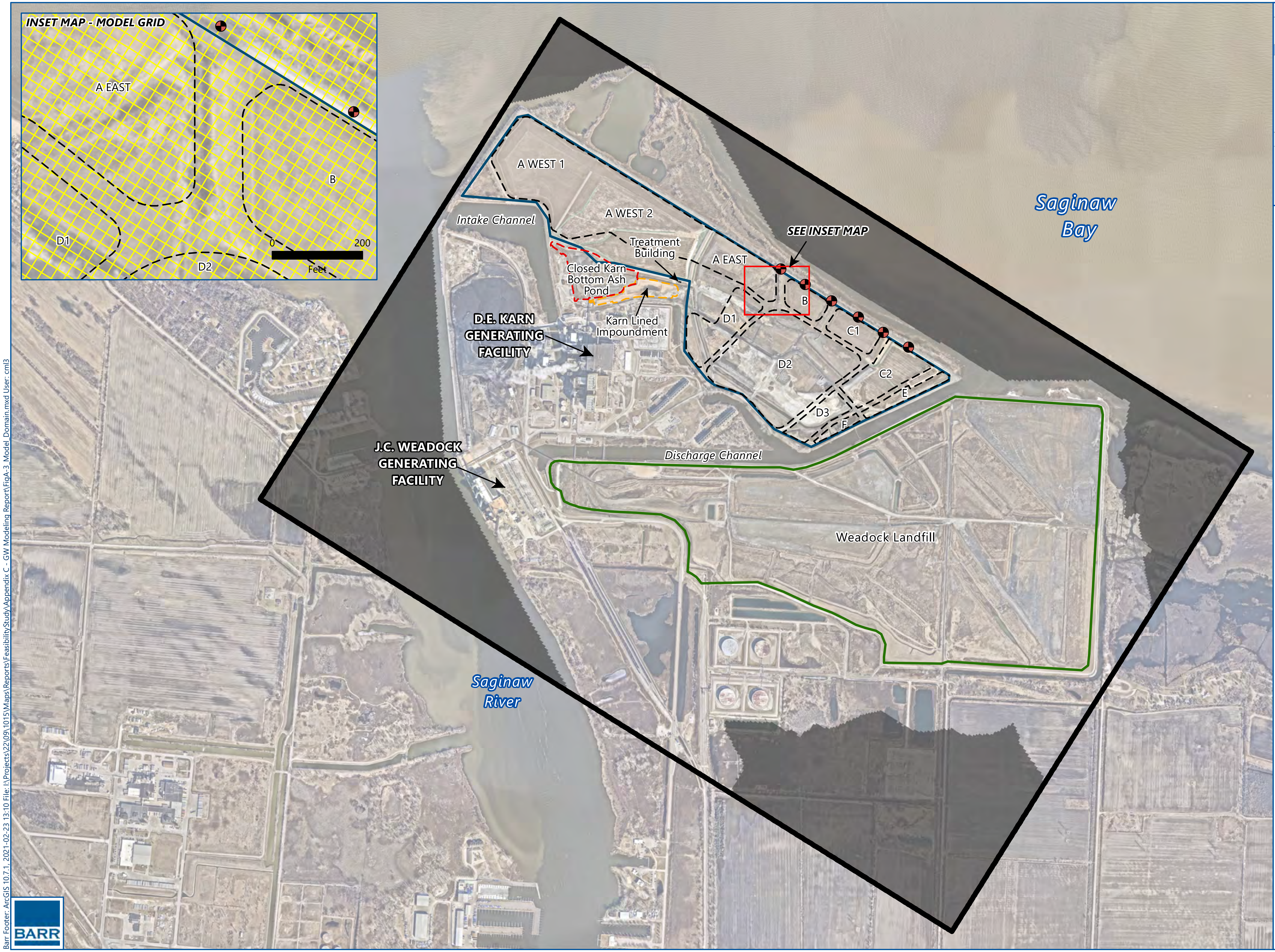
Notes:
- GSI = Groundwater-Surface Water Interface

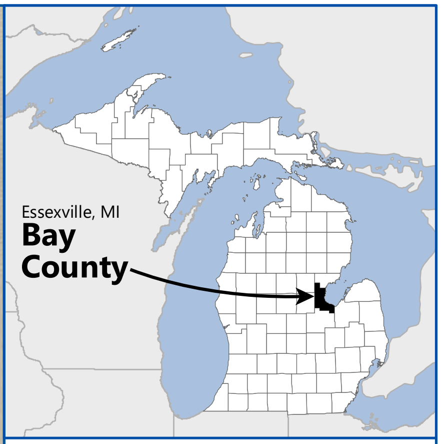
Aerial Image: Nearmap 3/23/2018

SITE LAYOUT
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-2

BARR





🟦 Karn Landfill

🟩 Weadock Landfill

⬚ Ash Pond

⬚ Closed Karn Bottom Ash Pond

⬚ Karn Lined Impoundment

● Extraction Well

▬ Model Domain

▨ No-Flow Model Cell

☐ Model Grid *(Inset Only)*

Notes:

- Additional no-flow cells are present in layers 1-3 above boundary condition cells representing the intake and discharge channels.

N

0 1100 2200

Feet

Aerial Image: Nearmap 3/23/2018

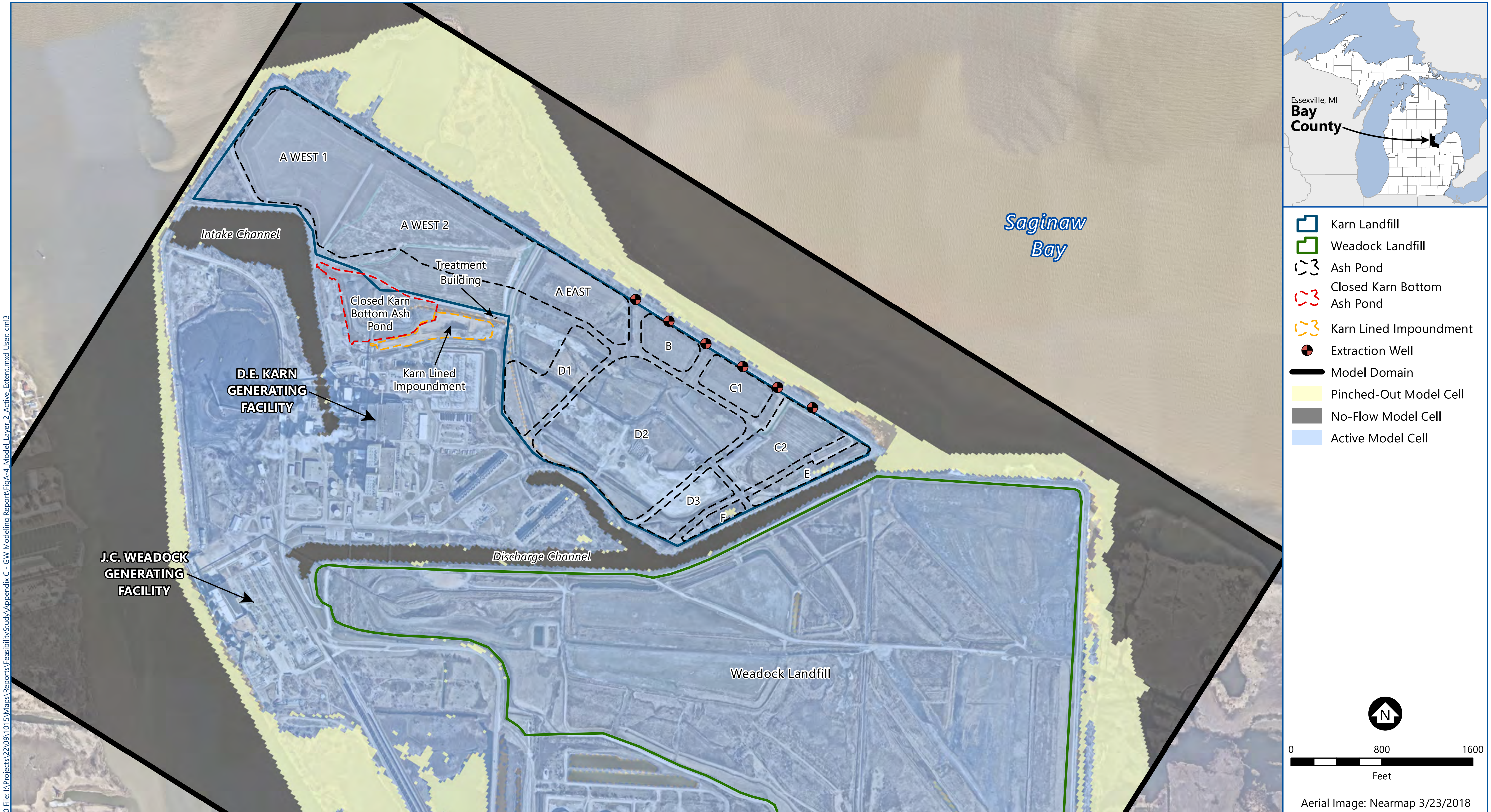
MODEL DOMAIN

D.E. Karn Generating Facility

Consumers Energy Company

Essexville, MI

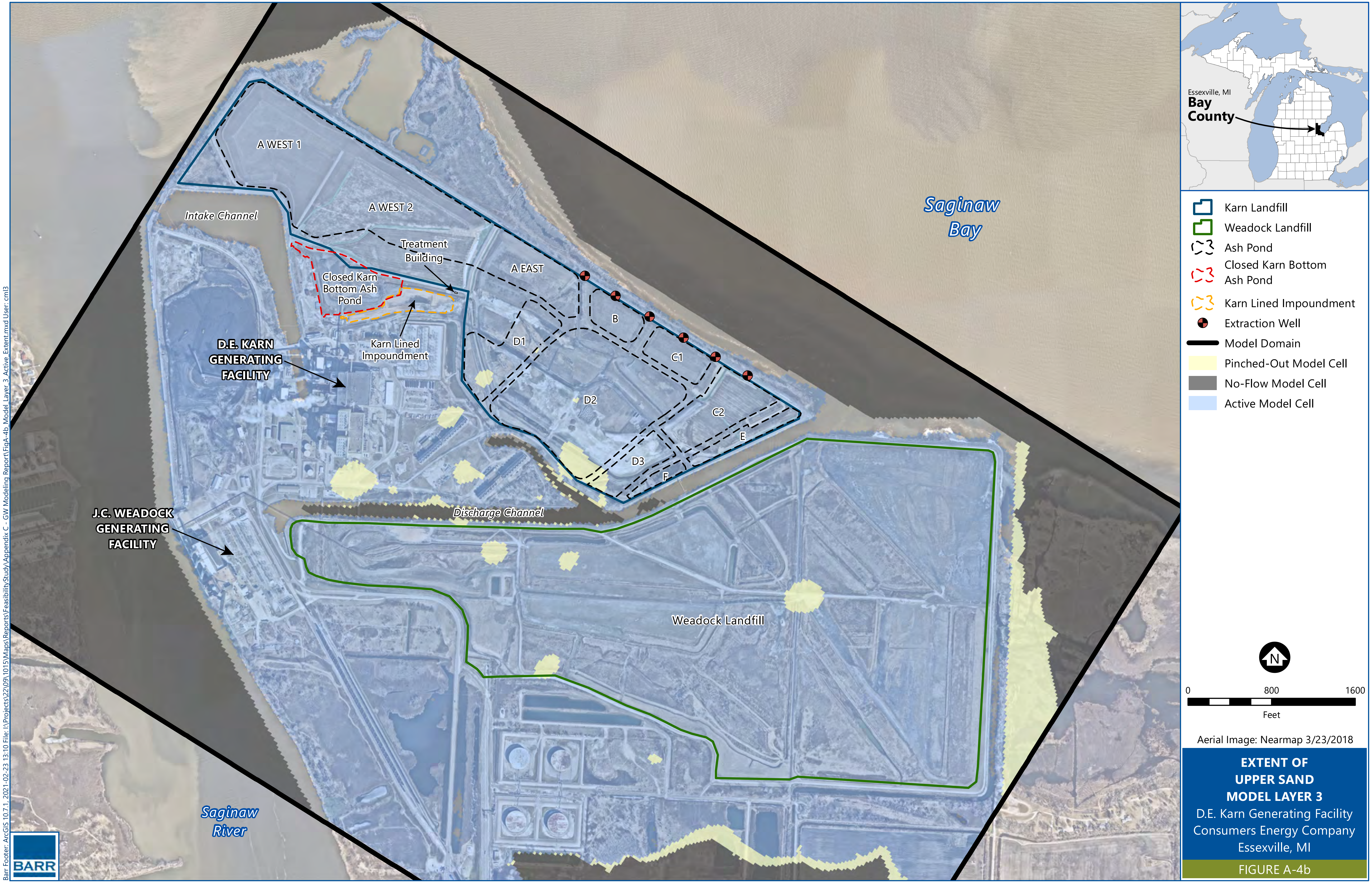
FIGURE A-3



Aerial Image: Nearmap 3/23/2018

EXTENT OF
ASH AND FILL
MODEL LAYER 1 AND 2
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-4a

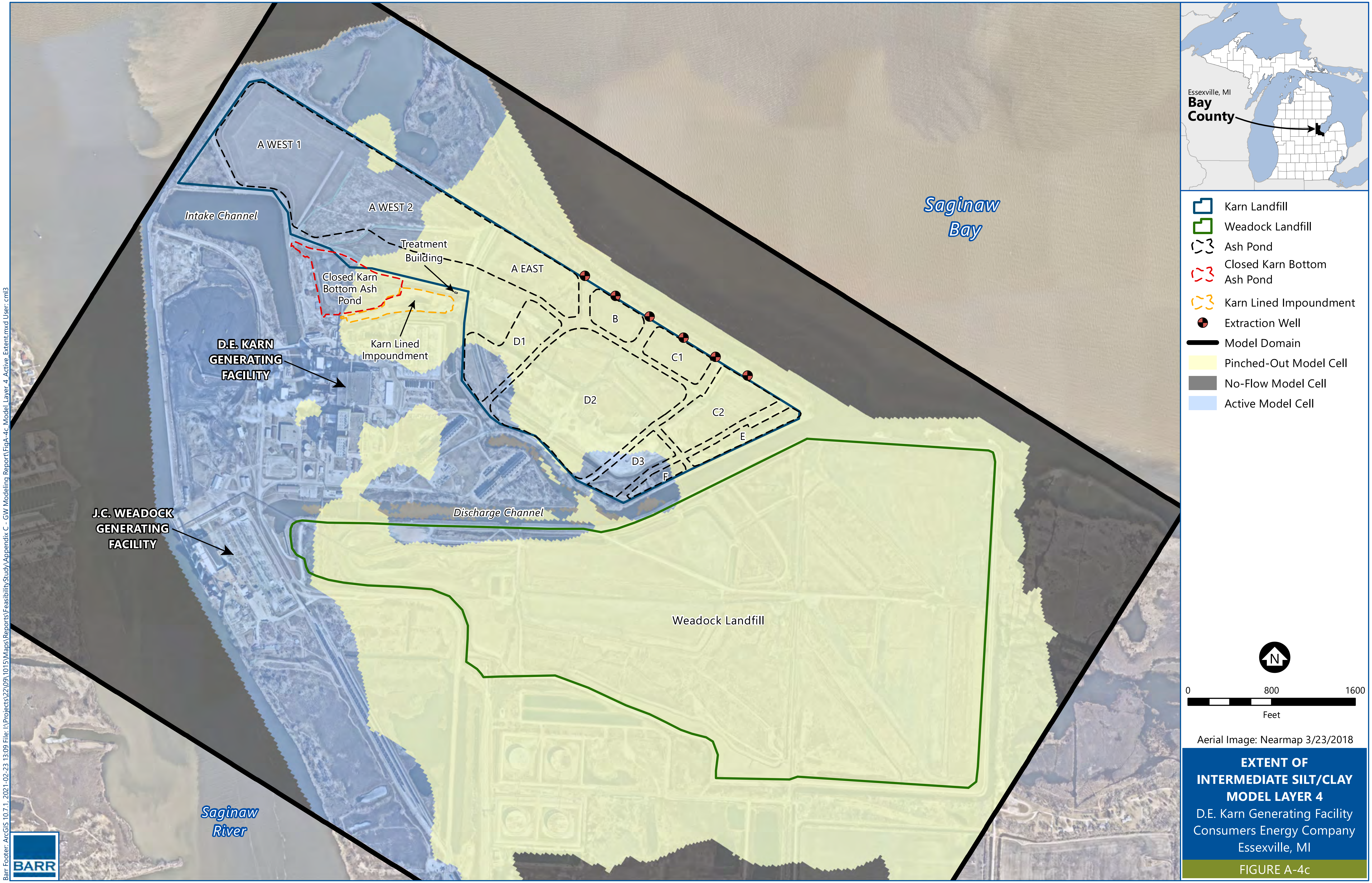


Aerial Image: Nearmap 3/23/2018

EXTENT OF UPPER SAND MODEL LAYER 3

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-4b

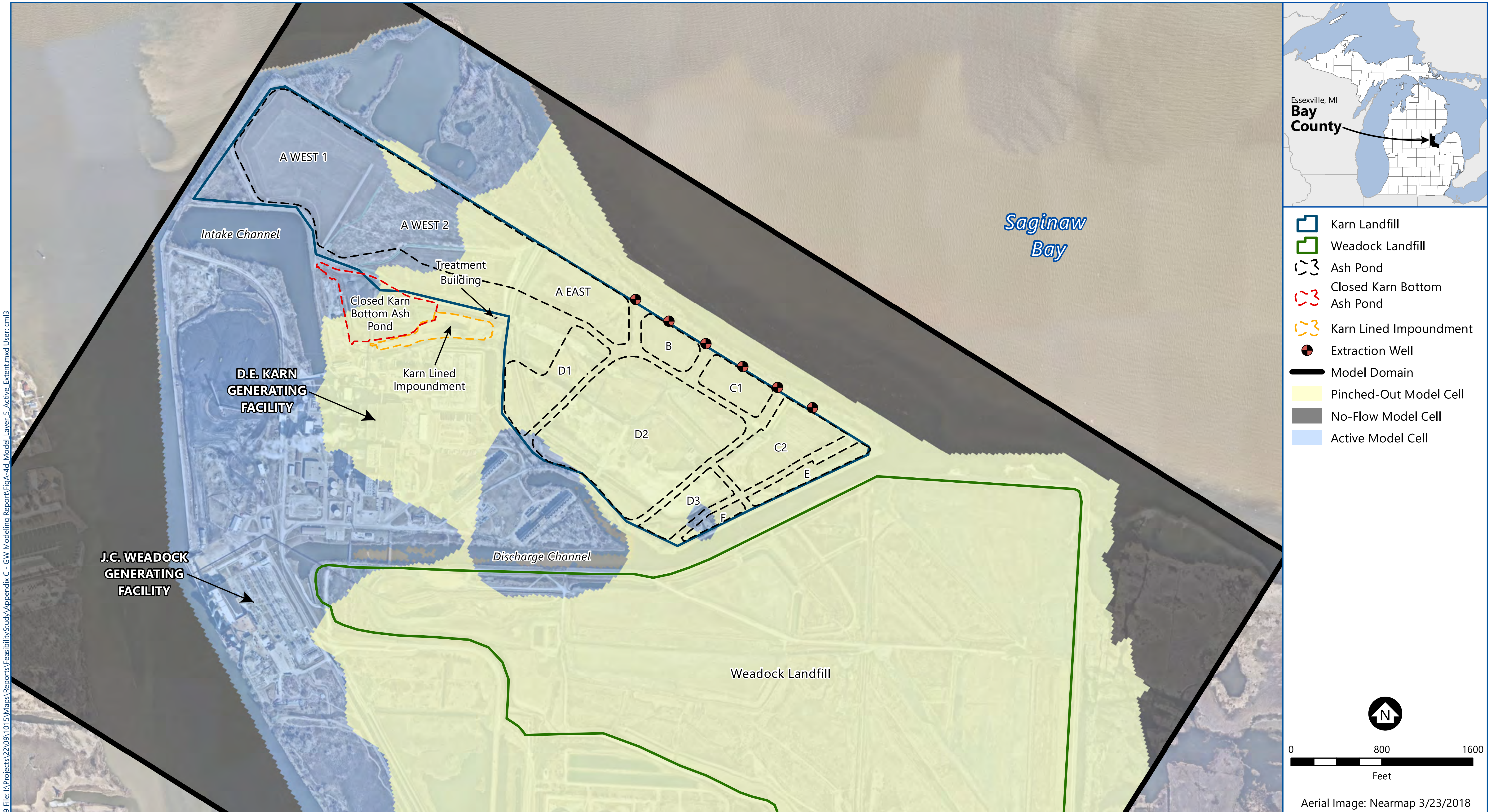


Aerial Image: Nearmap 3/23/2018

EXTENT OF INTERMEDIATE SILT/CLAY MODEL LAYER 4

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-4c

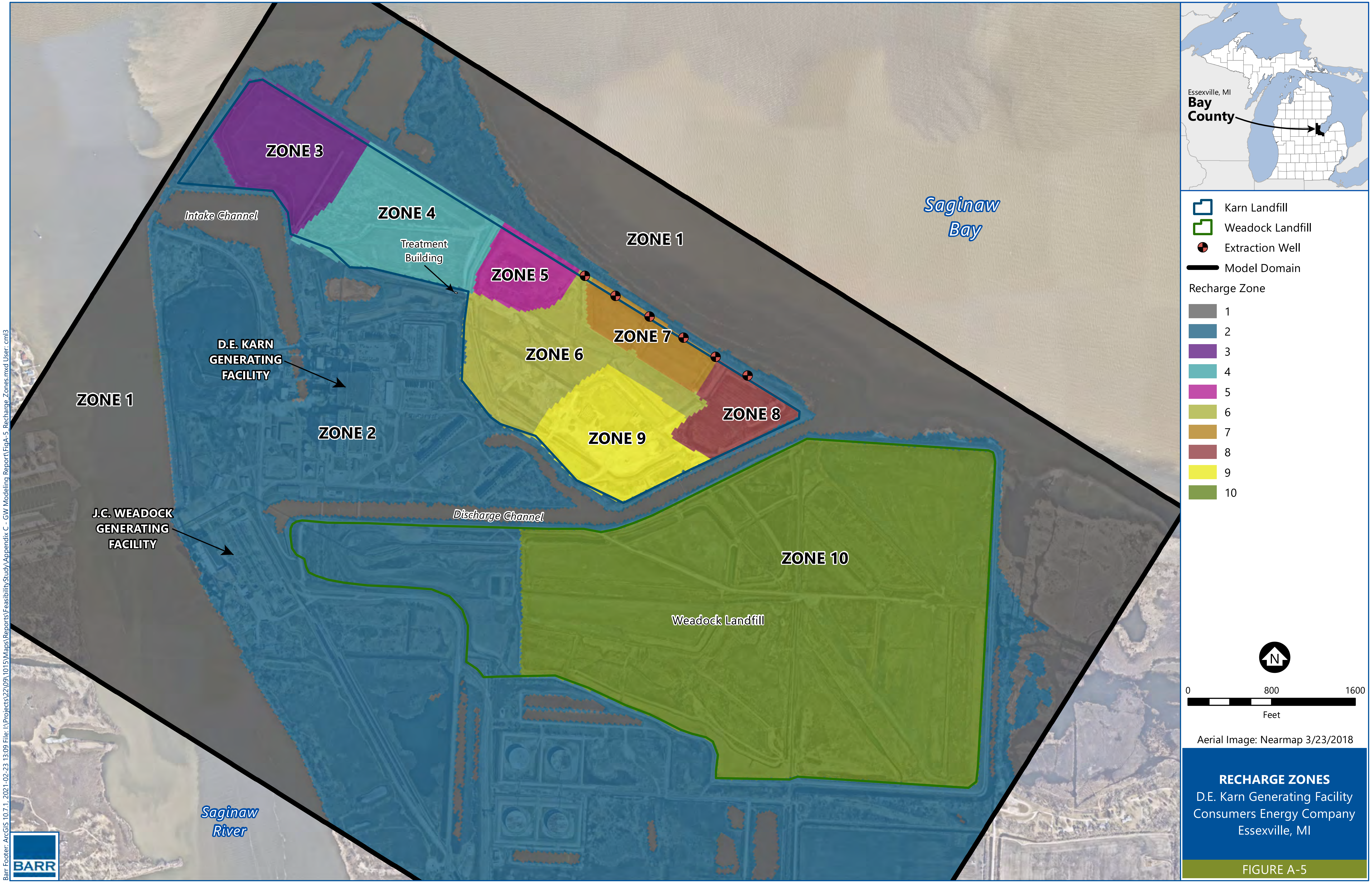


Aerial Image: Nearmap 3/23/2018

EXTENT OF LOWER SAND MODEL LAYER 5

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-4d



Aerial Image: Nearmap 3/23/2018

RECHARGE ZONES
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-5

Aerial Image: Nearmap 3/23/2018

BOUNDARY CONDITIONS MODEL LAYER 1

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-6a

Aerial Image: Nearmap 3/23/2018

BOUNDARY CONDITIONS MODEL LAYER 2

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-6b

Aerial Image: Nearmap 3/23/2018

BOUNDARY CONDITIONS MODEL LAYER 3

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-6c

Aerial Image: Nearmap 3/23/2018

BOUNDARY CONDITIONS
MODEL LAYER 4
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-6d

- Karn Landfill
- Weadock Landfill
- Ash Pond
- Closed Karn Bottom Ash Pond
- Karn Lined Impoundment
- ● Extraction Well
- Model Domain

Layer 5 Boundary Conditions

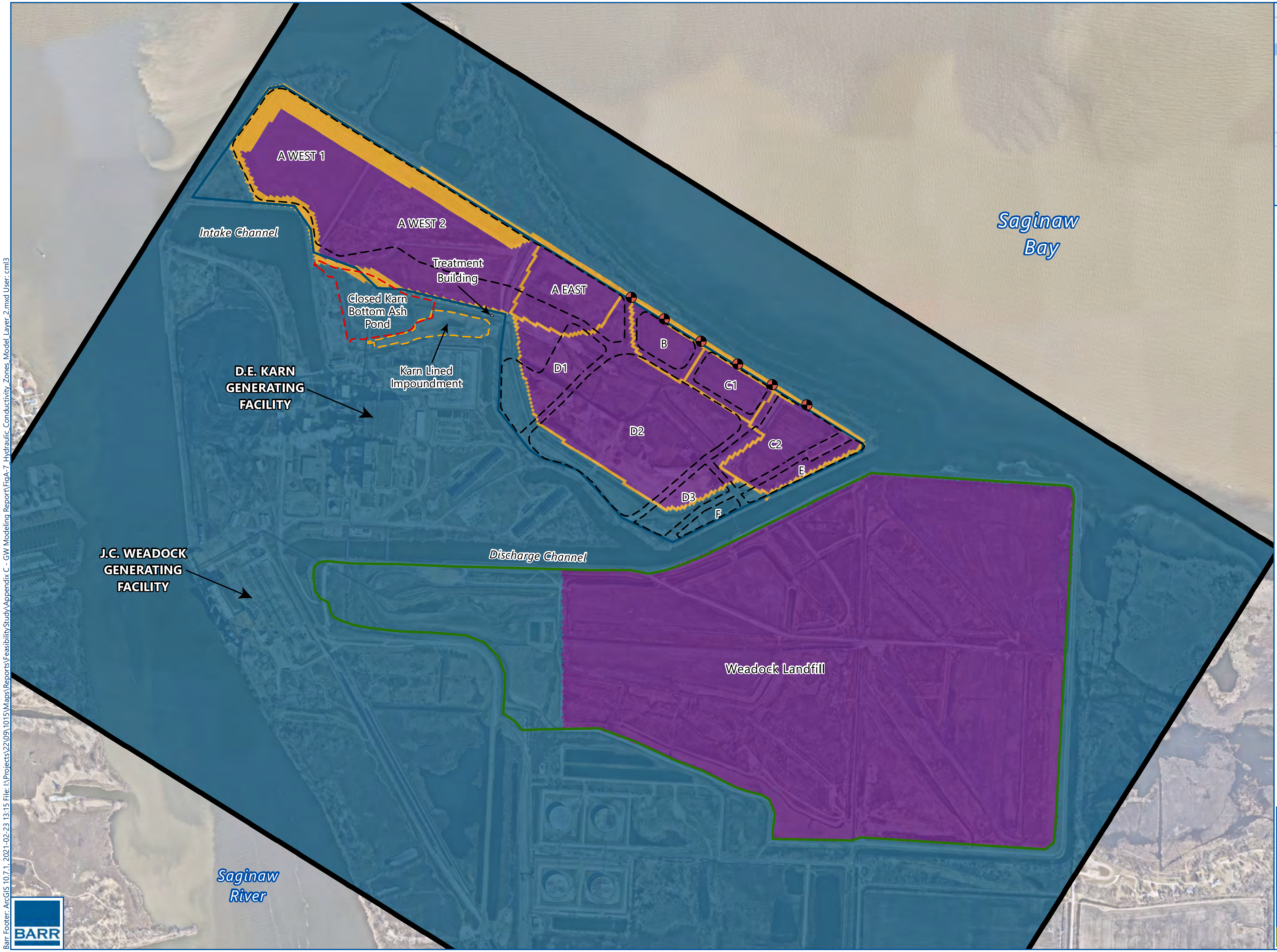
- ■ No Flow
- 🟩 River
- 🟦 Constant Head
- ■ General Head

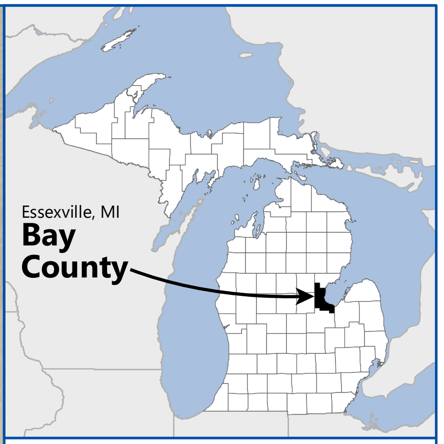
Aerial Image: Nearmap 3/23/2018

BOUNDARY CONDITIONS MODEL LAYER 5

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-6e





- Karn Landfill
- Weadock Landfill
- Ash Pond
- Closed Karn Bottom Ash Pond
- Karn Lined Impoundment
- ● Extraction Well
- Model Domain

Hydraulic Conductivity Zones

🟪	10
🟦	11
🟧	12

N

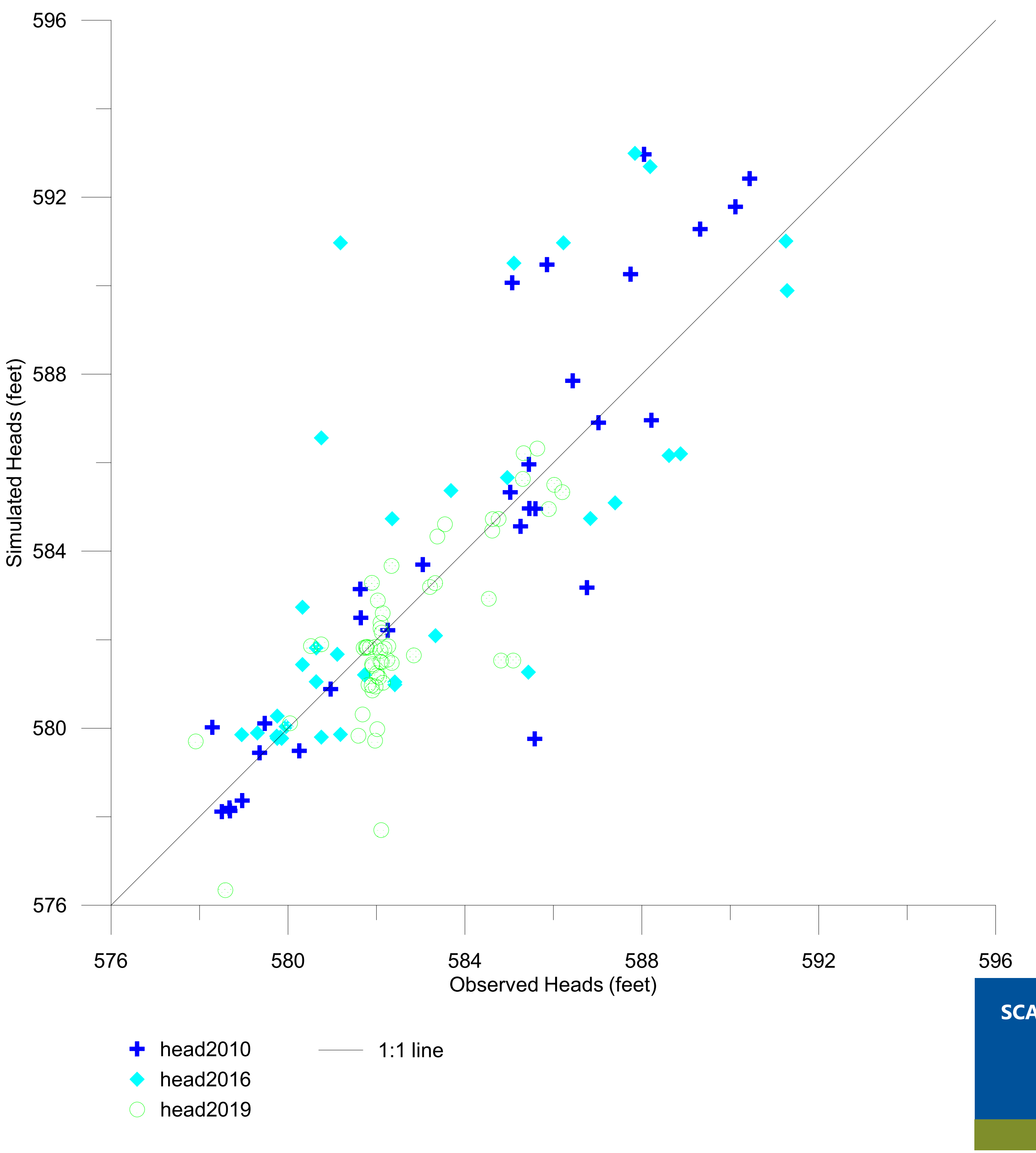
0 800 1600
Feet

Aerial Image: Nearmap 3/23/2018

HYRAULIC CONDUCTIVITY ZONES IN MODEL LAYER 2

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-7



SCATTER PLOT OF HEADS RESIDUALS

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

Figure A-8

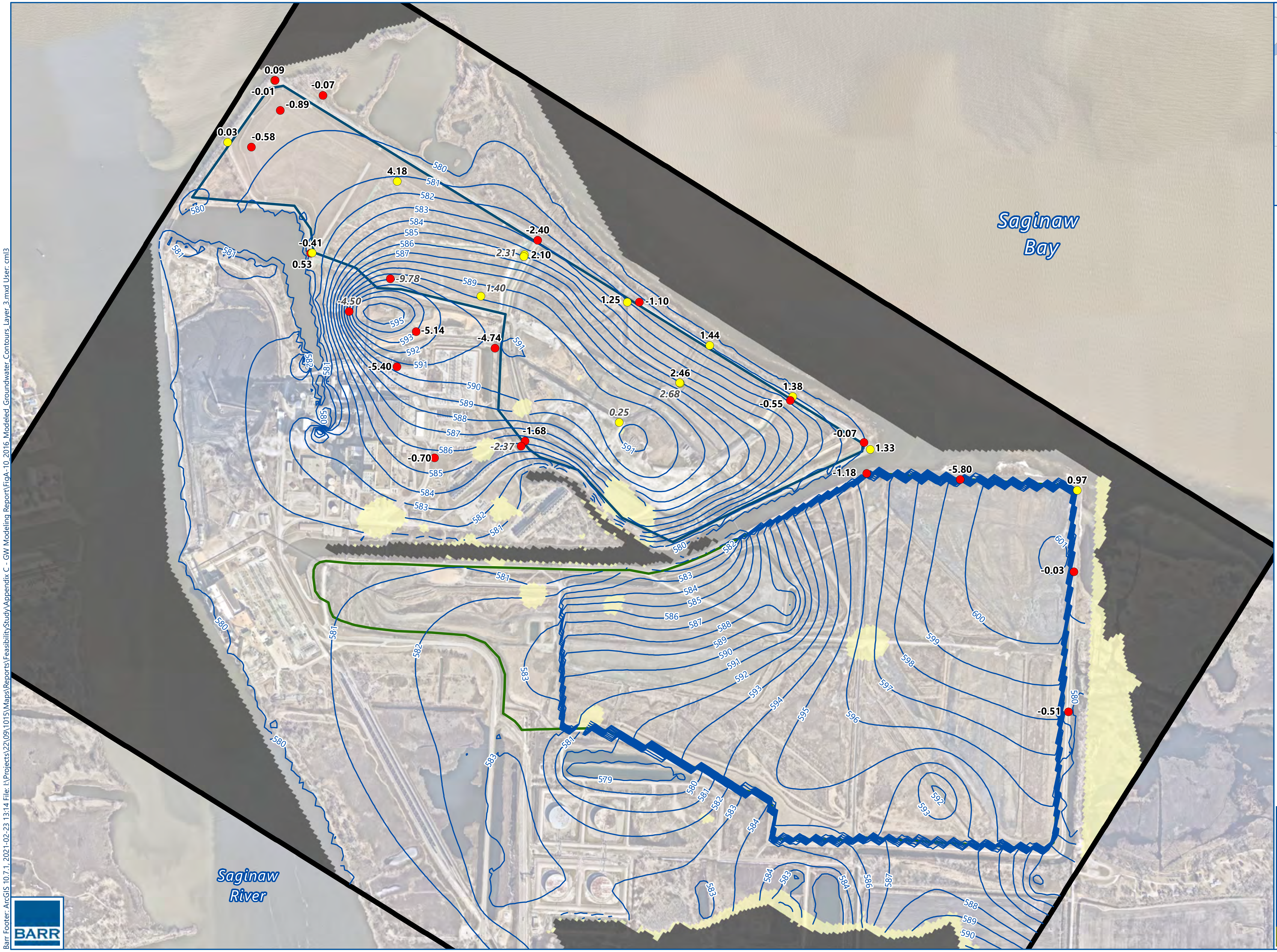
\\barr.com\projects\Ann Arbor\22 MI\09\22091015 DE Karn Corrective Action\WorkFiles\Feasibility Study\Appendices\Appendix A - GW Modeling Report\Figures\Fig08_Scatterplot of heads residuals.grf

Aerial Image: Nearmap 3/23/2018

2010 MODELED GROUNDWATER CONTOURS
LAYER 3
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-9

BARR



- Karn Landfill
- Weadock Landfill
- Model Domain
- Pinched-Out Model Cell
- No-Flow Model Cell
- Modeled Groundwater Elevation (feet)

Head Target Residuals (feet)

- ● Overpredicted Target
- ● Underpredicted Target
- **0.01** Residual (ft) for Layer 3
- *0.08* Residual (ft) for Layers 1, 2, 4, and 5

N

0 800 1600
Feet

Aerial Image: Nearmap 3/23/2018

2016 MODELED GROUNDWATER CONTOURS LAYER 3

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-10

- ▢ Karn Landfill
- ▢ Weadock Landfill
- ━ Model Domain
- ▨ Pinched-Out Model Cell
- ▨ No-Flow Model Cell
- ～ Modeled Groundwater Elevation (feet)

Head Target Residuals

- ● Overpredicted Target
- ● Underpredicted Target
- **0.01** Residual (ft) for Layer 3
- *0.08* Residual (ft) for Layers 1, 2, 4, and 5

N

0 800 1600
Feet

Aerial Image: Nearmap 3/23/2018

2019 MODELED GROUNDWATER CONTOURS LAYER 3
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-11

Notes:
- Existing extraction wells will be abandoned and replaced with EW-1R through EW-6R.
- GSI = Groundwater-Surface Water Interface

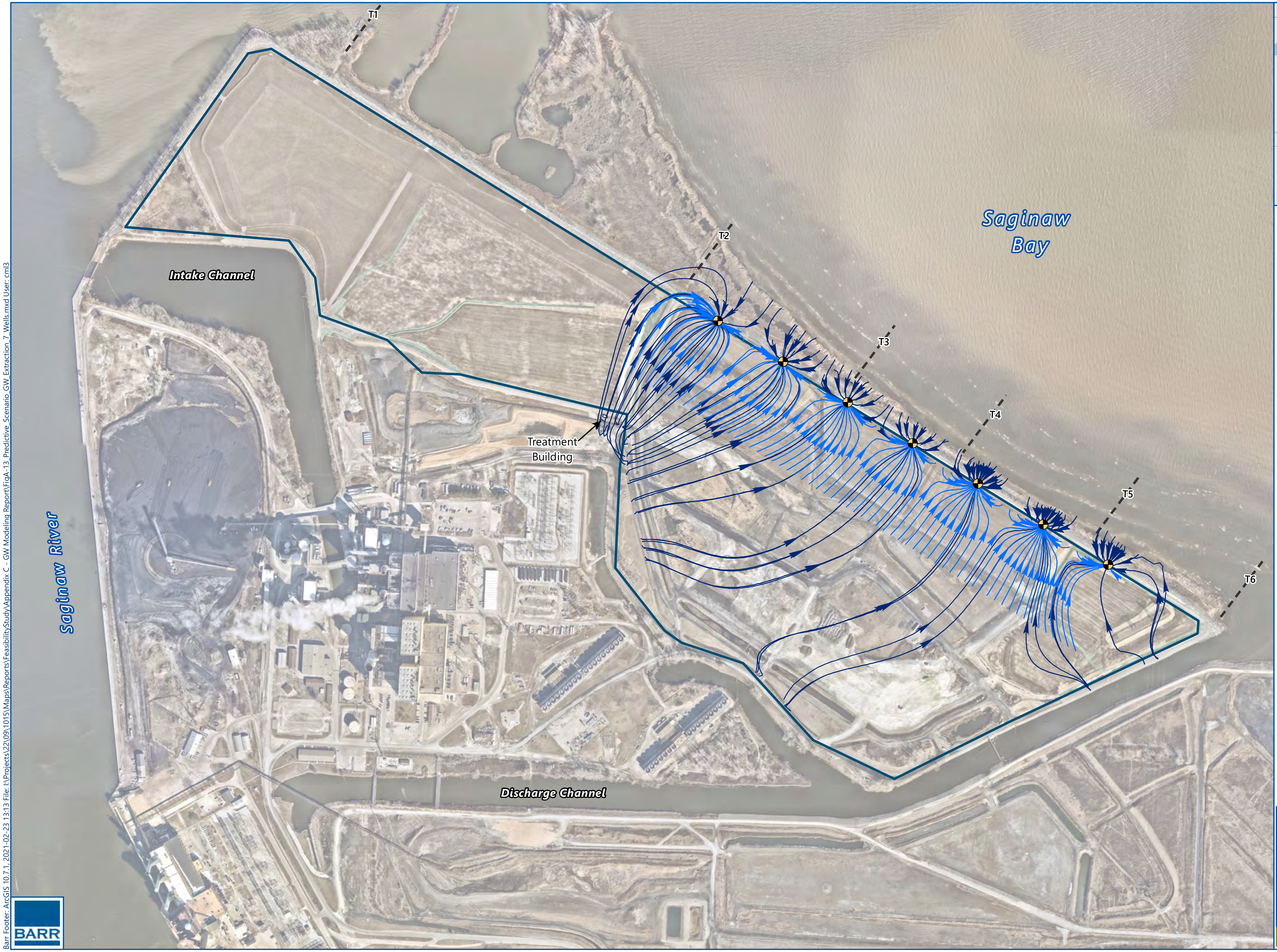
Aerial Image: Nearmap 3/23/2018

PREDICTIVE SCENARIO-GROUNDWATER EXTRACTION OPTION WITH 6 WELLS

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-12

BARR



- ▭ Karn Landfill
- ● Proposed Extraction Well
- - - Approximate GSI Transect Location
- → Flow Direction of Water Particles Immediately Upgradient of the Proposed Groundwater Extraction System (Forward Particle Trace)
- ← Flow Direction of Water Captured by Extraction System (Backward Particle Trace)

Notes:
- Existing extraction wells will be abandoned and replaced with EW-1R through EW-6R.
- GSI = Groundwater-Surface Water Interface

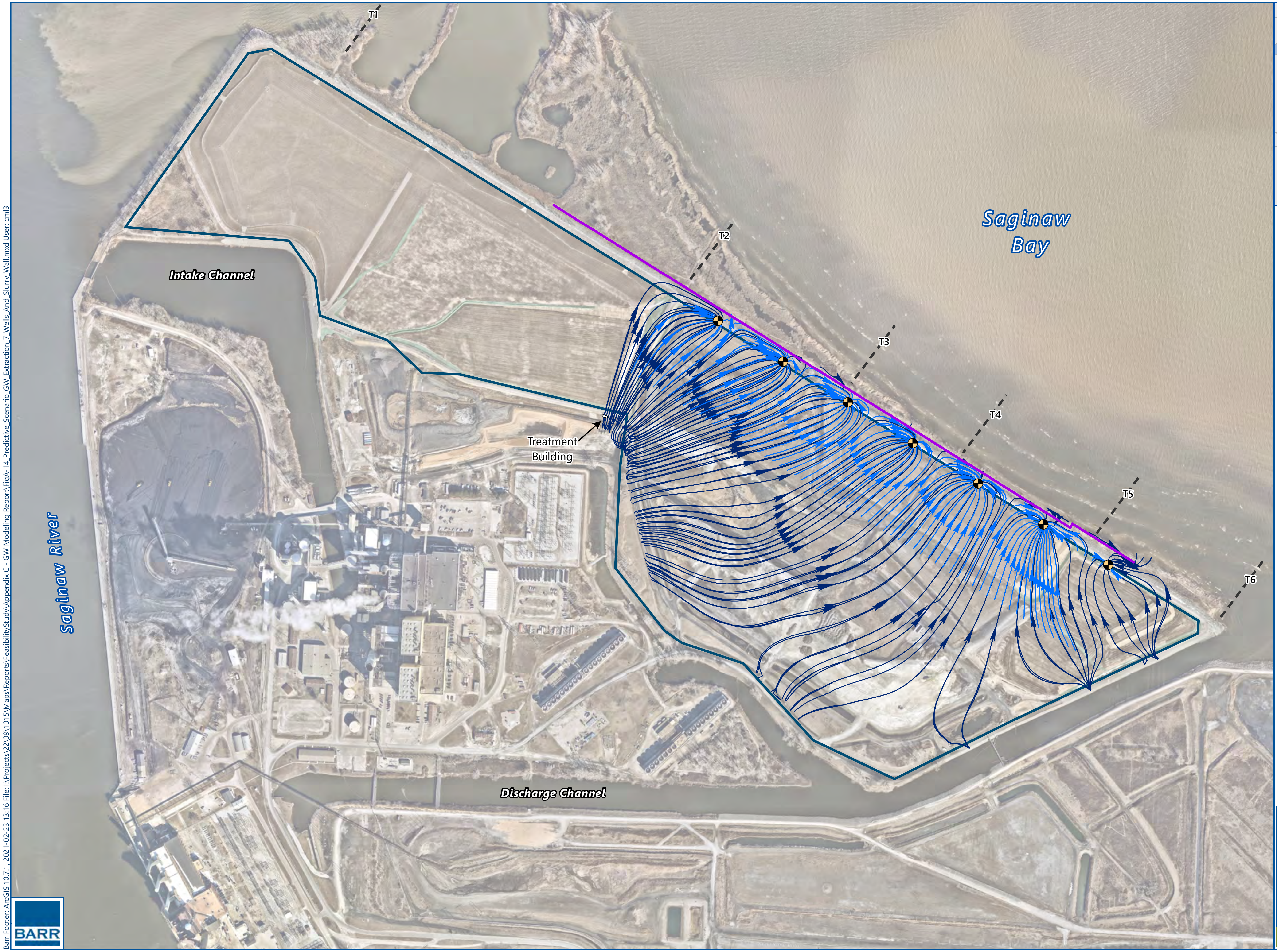
N

0 500 1000
Feet

Aerial Image: Nearmap 3/23/2018

**PREDICTIVE SCENARIO-
GROUNDWATER
EXTRACTION OPTION
WITH 7 NEW WELLS**
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-13



- Karn Landfill
- Proposed Extraction Well
- Approximate GSI Transect Location
- Barrier Wall
- Flow Direction of Water Particles Immediately Upgradient of the Proposed Groundwater Extraction System (Forward Particle Trace)
- Flow Direction of Water Captured by Extraction System (Backward Particle Trace)

Notes:
- Existing extraction wells will be abandoned and replaced with EW-1R through EW-6R.
- GSI = Groundwater-Surface Water Interface

N

0 500 1000
Feet

Aerial Image: Nearmap 3/23/2018

PREDICTIVE SCENARIO-GROUNDWATER EXTRACTION OPTION WITH 7 NEW WELLS AND BARRIER WALL

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-14

▢	Karn Landfill
◐	Proposed Extraction Well
- - -	Approximate GSI Transect Location
—	Barrier Wall
→	Flow Direction of Water Particles Immediately Upgradient of the Proposed Groundwater Extraction System (Forward Particle Trace)
▭	Horizontal Well

Notes:
- Existing extraction wells will be abandoned and replaced with EW-1R through EW-6R.
- GSI = Groundwater-Surface Water Interface

N

0 500 1000
Feet

Aerial Image: Nearmap 3/23/2018

PREDICTIVE SCENARIO- GROUNDWATER EXTRACTION OPTION WITH A HORIZONTAL WELL AND BARRIER WALL

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-15

▭ Karn Landfill

- - - Approximate GSI Transect Location

— Low-Permeability Barrier

- - - Permeable Reactive Gate

→ Flow Direction of Water Particles Immediately Upgradient of the Permeable Reactive Barrier (Forward Particle Trace)

Notes:
- GSI = Groundwater-Surface Water Interface

N

0 500 1000
Feet

Aerial Image: Nearmap 3/23/2018

PREDICTIVE SCENARIO-PRB OPTION WITH 1500-FT PRB AND TWO 750-FT BARRIER WALLS

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-16

- Karn Landfill
- Approximate GSI Transect Location
- Low-Permeability Barrier
- Permeable Reactive Gate
- Flow Direction of Water Particles Immediately Upgradient of the Permeable Reactive Barrier (Forward Particle Trace)

Notes:
- GSI = Groundwater-Surface Water Interface

N

0 500 1000
Feet

Aerial Image: Nearmap 3/23/2018

PREDICTIVE SCENARIO- PRB OPTION WITH 1500-FT PRB AND EXTENDED BARRIER WALLS

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-17

Karn Landfill

● Proposed Extraction Well

Approximate GSI Transect Location

Flow Direction of Water Particles Immediately Upgradient of the Permeable Reactive Barrier (Forward Particle Trace)

Flow Direction of Water Captured by Extraction System (Backward Particle Trace)

Saginaw Bay Extent

Notes:
- GSI = Groundwater-Surface Water Interface
- Saginaw Bay is modeled at 585 ft, which is 100-year storm level.

Aerial Image: Nearmap 3/23/2018

UNCERTAINTY PREDICTIVE SCENARIO- GROUNDWATER EXTRACTION WITH 7 NEW WELLS AND HIGH SAGINAW BAY

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-18

Notes:
- GSI = Groundwater-Surface Water Interface
- Saginaw Bay is modeled at 576 ft, which is recent minimum lake level and consistent with minimum water level used in slope stability modeling.

Aerial Image: Nearmap 3/23/2018

UNCERTAINTY PREDICTIVE SCENARIO- GROUNDWATER EXTRACTION WITH 7 NEW WELLS AND LOW SAGINAW BAY

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-19

- Karn Landfill
- Approximate GSI Transect Location
- Permeable Reactive Gate
- Flow Direction of Water Particles Immediately Upgradient of the Permeable Reactive Barrier (Forward Particle Trace)
- Saginaw Bay Extent

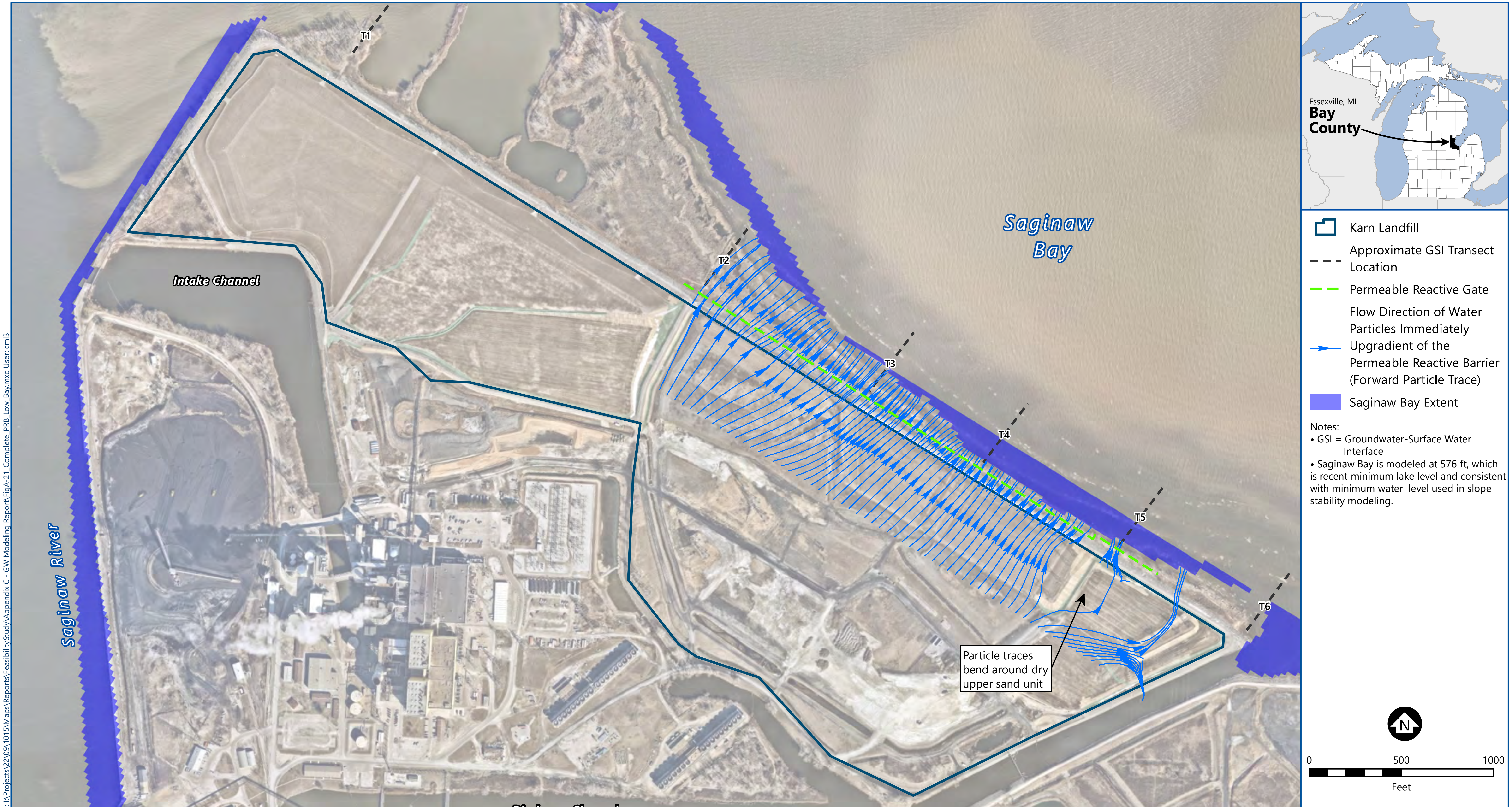
Notes:
- GSI = Groundwater-Surface Water Interface
- Saginaw Bay is modeled at 585 ft, which is 100-year storm level.

Aerial Image: Nearmap 3/23/2018

UNCERTAINTY PREDICTIVE SCENARIO - PRB OPTION WITH COMPLETE PRB AND HIGH SAGINAW BAY

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-20



Notes:
- GSI = Groundwater-Surface Water Interface
- Saginaw Bay is modeled at 576 ft, which is recent minimum lake level and consistent with minimum water level used in slope stability modeling.

Aerial Image: Nearmap 3/23/2018

UNCERTAINTY PREDICTIVE SCENARIO - PRB OPTION WITH COMPLETE PRB AND LOW SAGINAW BAY

D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE A-21

Appendix B

Geotechnical Modeling Report

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engineering and environmental consultants
BARR

Technical Memorandum

To: JR Register, Consumers Energy Company
From: Matthew Walker, Bethany Kelly (PE)
Subject: Geotechnical Stability of D.E. Karn Dike for Remedial Concepts
Date: March 2, 2020
Project: 22091015.01
c: Caleb Batts and Bradley Runkel, Consumers Energy Company; Katy Lindstrom and Tom Boom, Barr Engineering Co.

Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the state of Michigan.

Bethany Kelly

Bethany Kelly
PE license #: 6201057709

03/02/2021
Date

BETHANY KELLY
ENGINEER
No.
6201057709

B1 Introduction

Barr Engineering Co. (Barr) has prepared this technical memorandum to evaluate geotechnical stability of the northeast perimeter dike at Consumers' D.E. Karn Generating Facility (facility) coal ash landfill (Karn Landfill). Geotechnical stability was evaluated for existing conditions and surcharge loading expected for corrective action options for groundwater improvement, which require trenching.

Several geotechnical investigations have been performed on the ash ponds and surrounding dikes, and a summary of previous geotechnical investigations is included in the Conceptual Site Model (Appendix A of the Feasibility Study). Data generated from previous investigations, namely the 2009 AECOM soil-bentonite wall feasibility study (reference (1)), the 2010 NTH stability report (reference (2)), and the 2014 Golder report (reference (3)), provided the geotechnical data and supported development of most geotechnical parameters for the evaluation.

The perimeter dike of interest was initially constructed as a breakwater dike in Saginaw Bay, which was later filled with ash, reclaiming a portion of Saginaw Bay in the process, as described in the 2014 Golder Geotechnical Report (reference (3)). The same report documents the division of the ash disposal area with a series of interior dikes between 1965 and 1977. Throughout the life of the ash disposal facility, the perimeter dikes needed to be raised and the Golder report (reference (3)) documents this as inboard upstream construction from approximately elevation 587 feet to 595 feet.

Two sections through the perimeter dike of interest were evaluated for long-term and construction loading in SLOPE/W, a two-dimensional slope stability modeling software by Seequent Limited (reference (4)). Stratigraphic information was initially input from the geologic model developed in Earth Volumetric Studio (EVS) software (described in the "Geology" section of the CSM [Appendix A of the Feasibility Study]). Two cross sections were selected (Figure 1 below), one at Transect 4 [T4 on Figure 2 of the Feasibility Study] and one through Pond A East, generally coinciding with Section I-I' in the Golder report (reference (3)) . As described further in Section B2 on model stratigraphy and inputs, the initial EVS-generated stratigraphy for both sections was refined with geotechnical-specific information based on data from AECOM (reference (1)) and Golder (reference (3)). The two cross sections were selected as potential critical sections for slope stability because Transect 4 has the steepest slope into Lake Huron with almost no beach at normal lake levels (as visible below), while Pond A East was built to the greatest height above Saginaw Bay, with about 25 feet of elevation change from toe to crest.

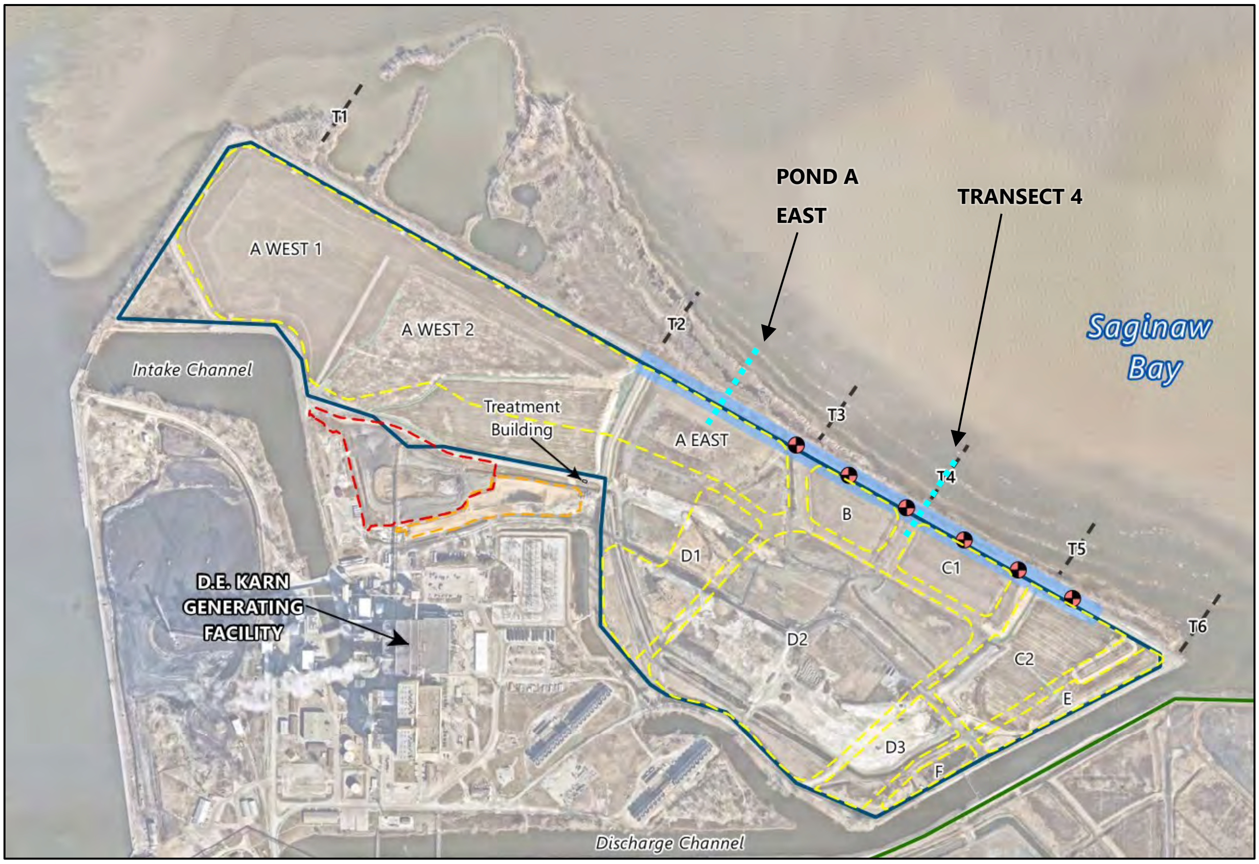


Figure 1 Geotechnical cross sections at Pond A East and Transect 4 (T4) (annotated excerpt of Figure 2 of the Feasibility Study)

Loading at the two sections consisted of 1) existing conditions, and 2) construction loading with two discrete surcharge loads on either side of the proposed trench to represent tracks of either a specialty one-pass trencher or a conventional long-arm excavator. Additional details on the hydraulic and surcharge loading are provided in Sections B3.1 and B3.2, respectively.

The slope stability factor of safety for the two sections, computed as the resisting force along a trial slip surface divided by the shear force along the same slip surface, was evaluated for each condition. With the construction loading, the resulting factors of safety for both the long-term (drained) and construction loading (undrained) cases were acceptable. Factor of safety values were found to be greater than 2.0 for all examined cases, exceeding design minimums of 1.5 (long-term) and 1.3 (construction). The modeling scenarios and results are presented in Section B4, with conclusions presented in Section B5 and potential next steps provided in Section B6.

B2 Geotechnical Site Stratigraphy

The following sections describe the stratigraphy for the two selected cross sections. The following section discusses the consistency and input parameters for the various materials.

B2.1 Transect 4

For Transect 4, no previous geotechnical sections had been evaluated in the immediate vicinity, so stratigraphy was newly developed from the EVS model for the site (described in Appendix A of the Feasibility Study]) and from nearby cone penetration testing (CPT) soundings and borings, completed as part of the 2009 and 2010 AECOM investigations. Because the EVS model was insufficiently detailed in geotechnical subdivisions of the site deposits, the CPT and geotechnical borings helped resolve intra-layer stratigraphic breaks based on penetration resistance and soil behavior correlations. These mainly consisted of differentiating fill into compacted ash, sluiced ash, and compacted dike fill. Sand was divided into loose sand and medium dense sand. Clay underlying the sand was assumed to extend to the bedrock surface as hard clay, based on borings from the Golder report (reference (3)).

A native silt layer was added to the model between the sand and clay layers to account for soft fine-grained soil encountered in the 2010 CPT investigation (reference (1)). The presence of the silt layer at Transect 4 was supported by CPT investigation in the area. Nearby borings may have missed the silt layer due to a combination of the sampling interval (i.e., noncontinuous) and the use of thin-wall sampling in this zone (i.e., not all thin-wall samples were logged during extrusion or laboratory tested).

It was assumed the inboard ponds at this location, Pond B and Pond C1, consist of sluiced ash (ash deposited during normal operation) overlain by dry/compacted ash deposited dry as part of pond closure. Because limited boring data were available on the pond in the sections of interest, the stratigraphic break between the two ash units was assumed to occur at the top of dike elevation. This is a conservative assumption, because it is unlikely that ash would have been deposited up to a zero-freeboard condition.

B2.2 Pond A East

A previous geotechnical model was developed for the critical section through Pond A East, as part of Golder's report (reference (3)), referred to as Section I-I'. Broad stratigraphic breaks from the site EVS model (Appendix A of the Feasibility Study; reference (3)) were consistent. Most of the stratigraphy for Pond A East was taken from the Golder stratigraphy (reference (3)). Minor edits were made based on different interpretations of the nearby CPT and borings (reference (1)), including removal of the ash layer beneath the dike that was included in the previous Golder report (reference (3)).

B3 Material Parameters and Model Inputs

Material parameters from Table 6.3 of the Golder report (reference (3)) were reviewed by Barr, while reviewing the available geotechnical investigation data; they were generally considered appropriate and predominantly carried forward. Changes were made to select material parameters by Barr based on the following:

- When compared to the Golder report (reference (3)), the drained strength of dike fill was increased to a friction angle of 35 degrees. This was done in reflection of the generally high blow counts in standard penetration testing and that the fill was generally too dense to push CPT, such that predrill holes were used to advance the CPT through the dike fill. This also matches the interpretation of NTH (2010).

- Similarly, the silt drained strength was increased to 28 degrees to reflect similar behavior of the silt-sized sluiced ash. Laboratory testing in NTH (2010) suggested higher strengths, with triaxial testing at a friction angle of 33 degrees. Golder (reference (3)) draws its lower friction angle from the NTH (2010) design value. The NTH (2010) design value is based on interpreting all CPT data as drained, although Golder (reference (3)) itself interprets CPT data in the silt as undrained.

- At both sections, the previous CPT investigation by NTH indicated that soft clay may exist beneath a stiff clay crust, but the soundings did not extend deep enough to confirm the layer's existence. In nearby soundings, tip stress generally decreased with depth after the cone passed below the initial stiff clay crust. Sensitivity analysis was performed in SLOPE/W to understand the effect of a soft clay layer, if present. These analyses indicated that stability was still satisfactory if strengths were conservatively lowered to soft clay beneath a stiff clay crust.

A summary of the material parameters used for geotechnical modeling is included in Table B.1.

Table B.1 Material parameters for geotechnical slope stability modeling

Material Type	Bulk Unit Weight (pcf)	ESSA(3)		USSA(4)	Source
		Drained Internal Friction Angle (°)	Effective Cohesion (psf)	Undrained Shear Strength (psf)	
Compacted or Dry Ash	105	35	0	--(1)	Golder (2014)
Sluiced or Wet Ash	100	28	0	600	Golder (2014)
Compacted Dike Fill	135	35	0	2,000	NTH (2010)
Loose Sand	125	32	0	--(1)	Golder (2014)
Medium Dense Sand	130	35	0	--(1)	Golder (2014)
Native Silt	107	28	0	$0.22\sigma'_v$(2)	Drained: reinterpreted from NTH (2010) Undrained: Golder (2014)
Stiff Clay	140	30	0	4,000	Golder (2014)
Soft Clay	140	30	0	700	Golder (2014)
Trenched Wall	100	--	--	100	conservative low value

(1) For short-term or end-of-construction conditions, drained strengths were used either due to the relative permeability of the material (sands) or because drained strengths are conservative at low confining stress (dry and compacted ash)

(2) SHANSEP (stress history and normalized soil engineering properties) method used for undrained strength in native silt, with a minimum undrained strength of 400 psf

(3) Effective stress stability analysis

(4) Undrained strength stability analysis

B3.1 Hydraulic Conditions

The SLOPE/W models of Transect 4 and Pond A East use a manually-input phreatic surface for hydraulic conditions.

- The upstream boundary for each section is sourced from the Barr groundwater model for the site (Appendix C of the Feasibility Study).
- For the downstream condition, the water level is controlled by the level of Lake Huron. Recent NOAA Lake Huron low-lake levels (576 feet [reference (5)]) were used for the downstream condition at Transect 4, where a low-water condition is critical due to the lack of water buttressing the toe of the slope in the water.
- At Pond A East, the water level at the downstream toe was set at the beach elevation (581 feet) rather than the recent low lake level (576 feet), because dropping the water lower than the beach would result in less conservative conditions (higher effective stress at the toe).

Some sensitivity modeling was performed to evaluate a high lake level in Lake Huron at Transect 4, as well. This consisted of running construction loading models with water level at elevation 581 feet, near current levels as of September 2020. This analysis indicated similarly satisfactory stability as the low-water condition.

B3.2 Construction Loading

Barr consulted one-pass trenching contractors to better understand loading from typical equipment used for similar projects. A one-pass trencher with a pair of tracks oriented along the dike alignment with a surcharge load of 2,300 psf (per linear foot of the model) assumed for the construction process. This was modeled as a pair of surcharge loads with 8-foot offsets from the dike edges recommended by the contractor. The hypothetical trencher was assumed to be 12 feet wide (from the outside of each track) and was modeled with two sets of 38-inch-wide tracks.

B4 Model Scenarios and Results

SLOPE/W was used to model several scenarios for each section.

- Models with drained strength parameters were used to represent long-term conditions and situations where excess pore pressures dissipate during construction loading. Models with drained parameters are referred to as effective stress stability analyses (ESSA) in the output attachments, Attachment B.1 and Attachment B.2.
- Models with undrained strength parameters were used for construction loading or other short-term loading scenarios when excess pore pressures cannot dissipate. Models with undrained parameters are referred to as undrained strength stability analyses (USSA) in the output attachments.

- Slip surfaces were analyzed using Spencer's method (reference (4)) and searched with entry-exit ranges with a 3-foot minimum slip surface depth.
- Separate scenarios were run to simulate circular failure surfaces and block failures. Block failures are important for situations where relatively weak material overlies stronger or stiffer strata. For example, a shear surface could develop along a block between sluiced ash and native sands below; in this case, the stiff, lower strata is set to impenetrable (or bedrock) in the model, forcing the circular slip surface to truncate along that layer.

Results of the analyses are shown in Table B.2 and Table B.3 for Transect 4 and Pond A East, respectively. Results in Tables D.2 and D.3 reflect modeling simulations performed with the lake at the critical lake level for each cross section because those results reflect a conservative factor of safety at each cross section. Output sections from SLOPE/W are included for Transect 4 and Pond A East in Attachment B.1 and Attachment B.2, respectively.

Table B.2 Modeling results from Transect 4

Scenario	Target Factor of Safety	Modeled Factor of Safety
Existing Conditions (ESSA)	1.5	2.30
Existing Conditions (USSA)	1.5	2.90
Existing Conditions (USSA) – Block Slip Surface on Sand	1.5	4.74
Existing Conditions (USSA) – Block Slip Surface on Silt	1.5	2.65
Construction Loading (ESSA)	1.3	2.29
Construction Loading (USSA)	1.3	2.04
Construction Loading (USSA) – Block Slip Surface on Sand	1.3	3.37
Construction Loading (USSA) – Block Slip Surface on Silt	1.3	1.99

Table B.3 Modeling results from Pond A East

Scenario	Target Factor of Safety	Modeled Factor of Safety
Existing Conditions (ESSA)	1.5	2.36
Existing Conditions (USSA)	1.5	3.65
Existing Conditions (USSA) – Block Slip Surface on Silt	1.5	2.19
Construction Loading (ESSA)	1.3	2.05
Construction Loading (USSA)	1.3	2.26
Construction Loading (USSA) – Block Slip Surface on Silt	1.3	2.18

B5 Conclusions

Based on available data from prior investigations and laboratory testing, the dikes along the proposed wall alignment are expected to withstand construction activities associated with typical trenching cutoff or permeable wall construction.

1) Slope stability modeling with SLOPE/W indicates that stability is adequate for all examined conditions, consisting of existing and construction loading conditions with ESSA and USSA.

2) Stability was also adequate for sensitivity models that assumed soft clay exists below the site. Model simulations using a high surface water elevation for Lake Huron also did not negatively affect this conclusion. However, if Lake Huron continues to rise above existing all-time-high levels, the dikes in question could be exposed to increased erosion from wave action and slope steepening.

3) At the feasibility stage, no seismic, liquefaction, or seepage (to account for the effect of cutoff or permeable walls) models were created.

B6 Potential Next Steps

In the design phase, additional geotechnical data collection activities and analysis may be warranted, depending on the selected remedial option. Collection of soil samples could help refine the design and constructability of permeable barriers, especially with respect to the permeability of the site materials and potential for fines migration through the barrier or fouling of the reactive media. Additional investigation could help refine the wall depth along its profile, although existing records from prior consultants may be sufficient for these purposes. This information could be paired with seepage and deformation models to generate specifications for contractors installing walls.

Construction monitoring of the perimeter dike may also be warranted to detect deformation of the dike during construction due to localized settlement or liquefaction of the loose sand and silt underlying the dike during the trenching process. This could take the form of surveying survey monuments, global navigation satellite system receivers (GNSS), inclinometers, or automated motorized total stations (AMTS).

If lake levels remain elevated, the dike erosion rate may increase if wave run-up exceeds the elevation of the existing riprap. If high levels continue, periodic inspections of the dike facing the lake should be performed, particularly after large storm events, adverse high winds, and leading up to construction.

B7 References

1. **AECOM.** Subsurface Investigation and Soil-Bentonite Wall Feasibility Study for D.E. Karn Ash Landfill. December 4, 2009.

2. **NTH Consultants, Ltd.** Updated Slope Stability Analysis D.E. Karn Ash Disposal Facility. September 29, 2010.

3. **Golder Associates Inc.** Geotechnical Report for the D.E. Karn Solid Waste Disposal Area. January 15, 2014.

4. **GEO-SLOPE International Ltd.** Stability Modeling with GeoStudio. 2020.

5. **Office of Oceanic and Atmospheric Research (OAR).** Great Lakes Water Levels. *NOAA - Great Lakes Environmental Research Laboratory.* [Online] August 28, 2020. https://www.glerl.noaa.gov/data/wlevels/.

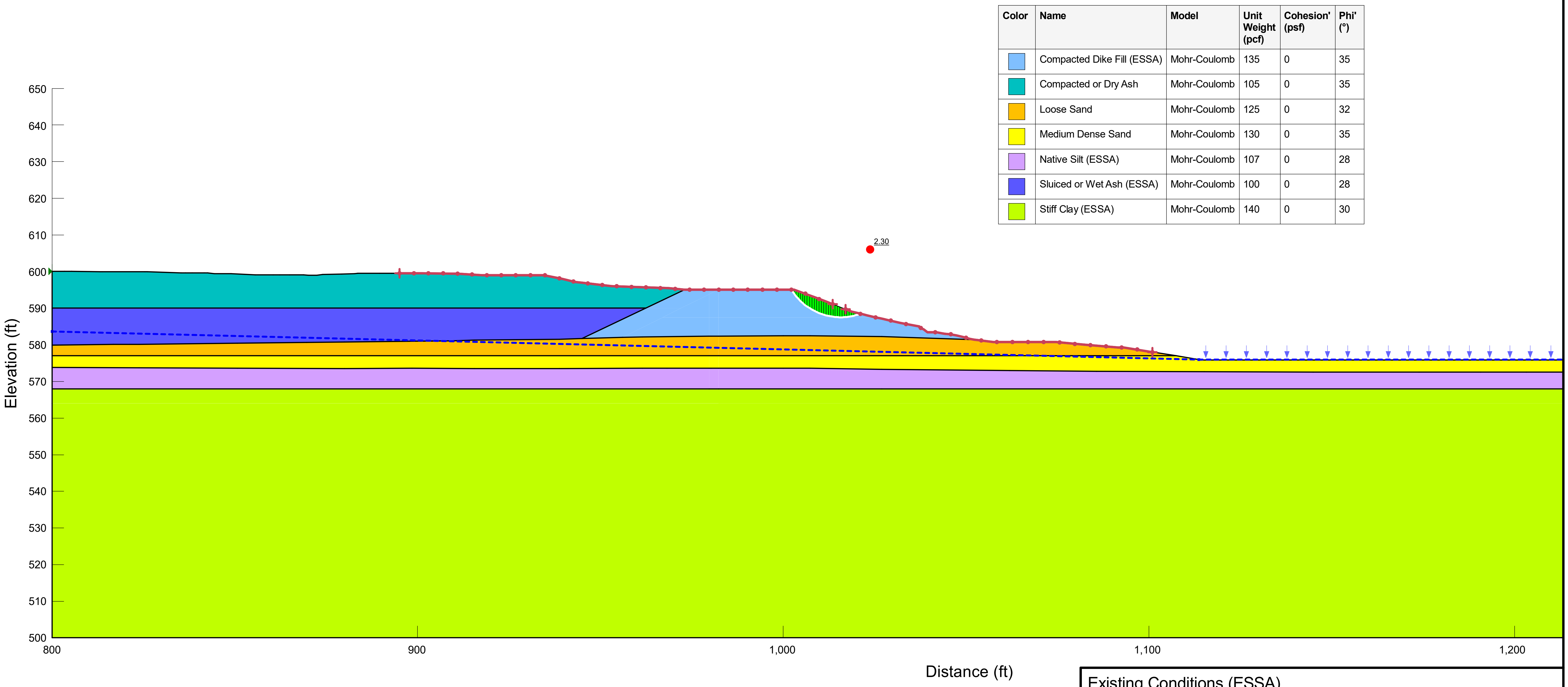
Attachments

Attachment B.1

Transect 4 Results

D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Existing Conditions (ESSA)
Last Solved Date: 09/22/2020
Factor of Safety: 2.30



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Compacted Dike Fill (ESSA)	Mohr-Coulomb	135	0	35
🟦	Compacted or Dry Ash	Mohr-Coulomb	105	0	35
🟧	Loose Sand	Mohr-Coulomb	125	0	32
🟨	Medium Dense Sand	Mohr-Coulomb	130	0	35
🟪	Native Silt (ESSA)	Mohr-Coulomb	107	0	28
🟦	Sluiced or Wet Ash (ESSA)	Mohr-Coulomb	100	0	28
🟩	Stiff Clay (ESSA)	Mohr-Coulomb	140	0	30

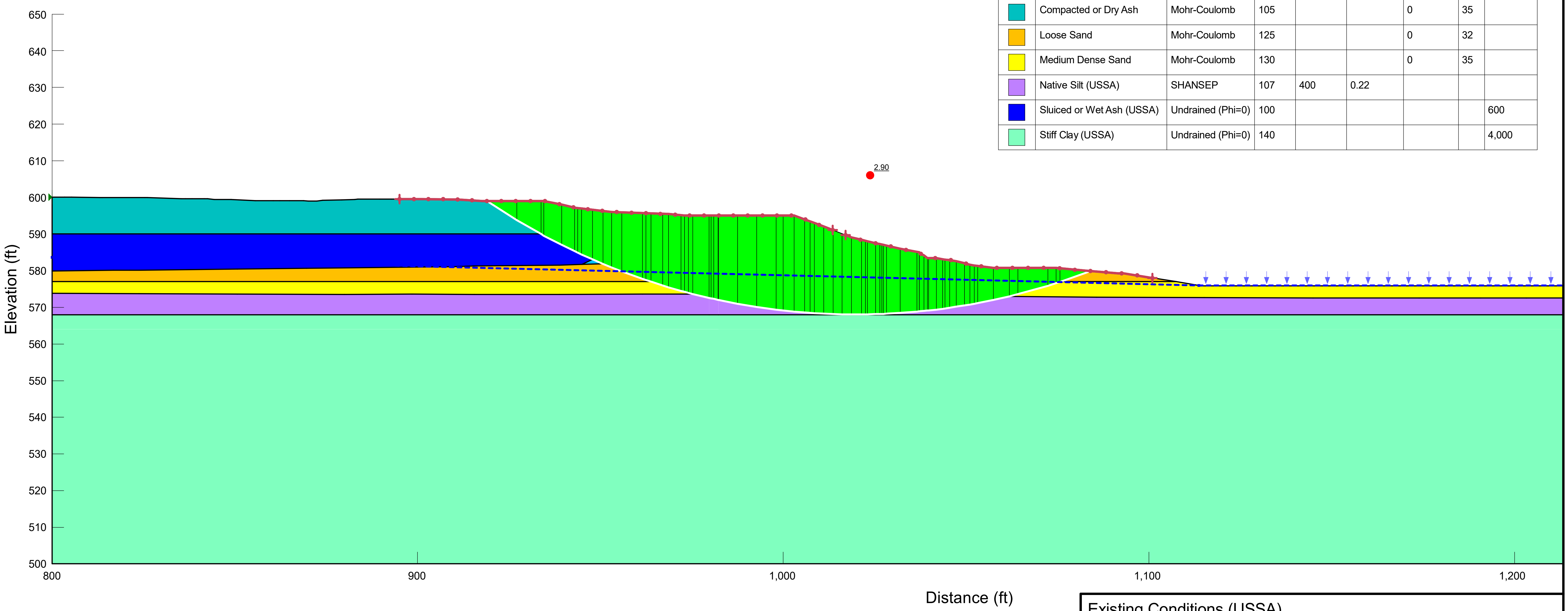
Existing Conditions (ESSA)	
Transect4_09152020_v1.gsz	
09/22/2020	1:325

C:\Users\mdw\Desktop\KarnLocal\

D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Existing Conditions (USSA)
Last Solved Date: 09/22/2020
Factor of Safety: 2.90

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟨	Medium Dense Sand	Mohr-Coulomb	130			0	35	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600
🟩	Stiff Clay (USSA)	Undrained (Phi=0)	140					4,000

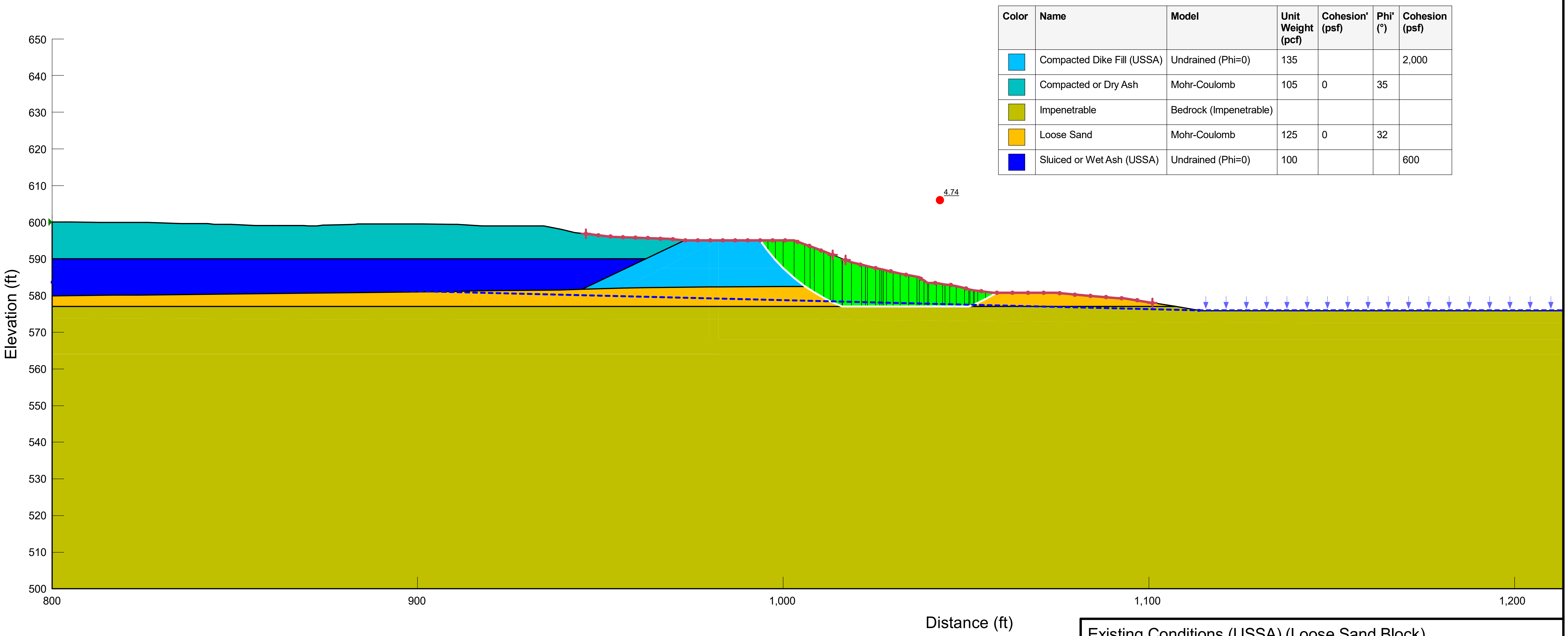


Existing Conditions (USSA)
Transect4_09152020_v1.gsz
09/22/2020 1:325

C:\Users\mdw\Desktop\KarnLocal\

D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Existing Conditions (USSA) (Loose Sand Block)
Last Solved Date: 09/22/2020
Factor of Safety: 4.74



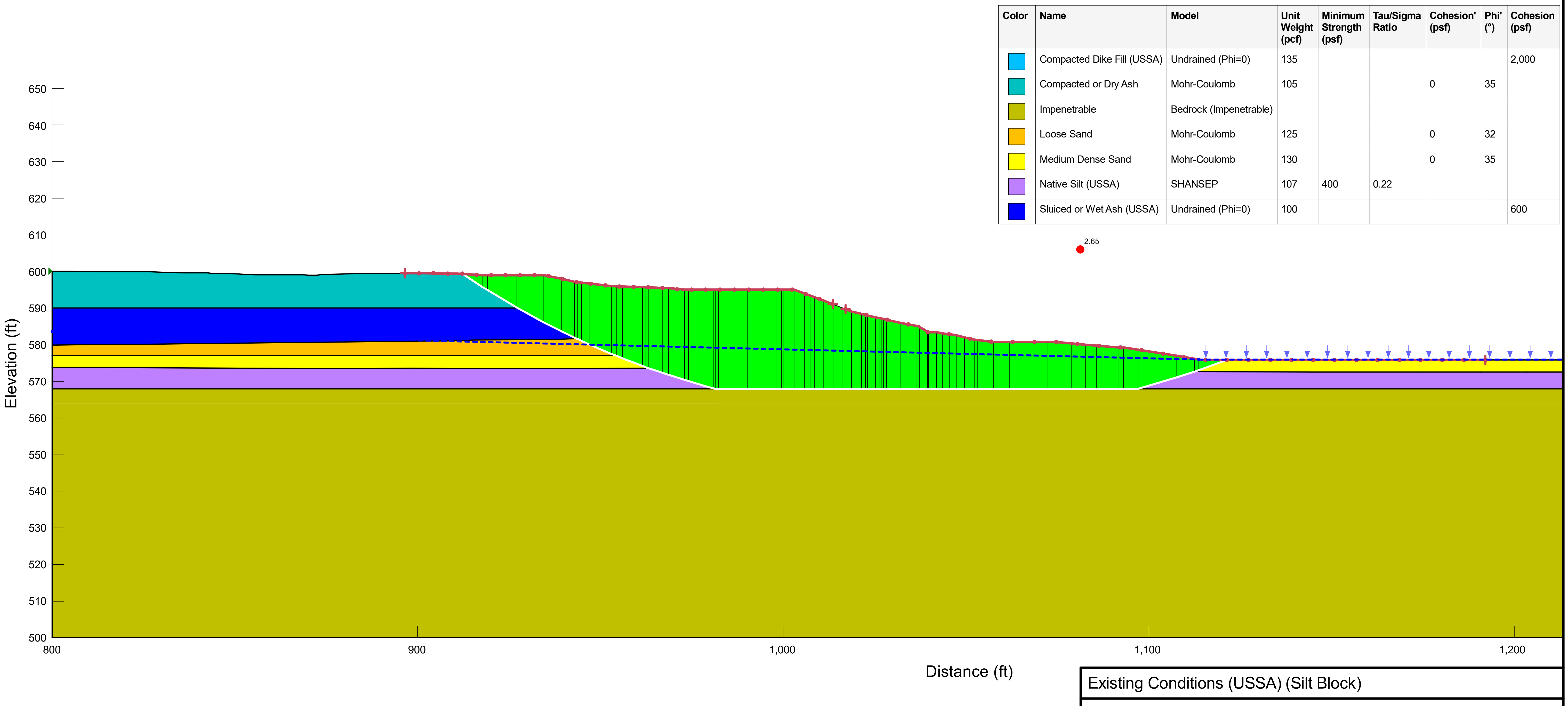
Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135			2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105	0	35	
🟩	Impenetrable	Bedrock (Impenetrable)				
🟨	Loose Sand	Mohr-Coulomb	125	0	32	
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100			600

Existing Conditions (USSA) (Loose Sand Block)
Transect4_09152020_v1.gsz
09/22/2020 1:325

C:\Users\mdw\Desktop\KarnLocal\

D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Existing Conditions (USSA) (Silt Block)
Last Solved Date: 09/22/2020
Factor of Safety: 2.65



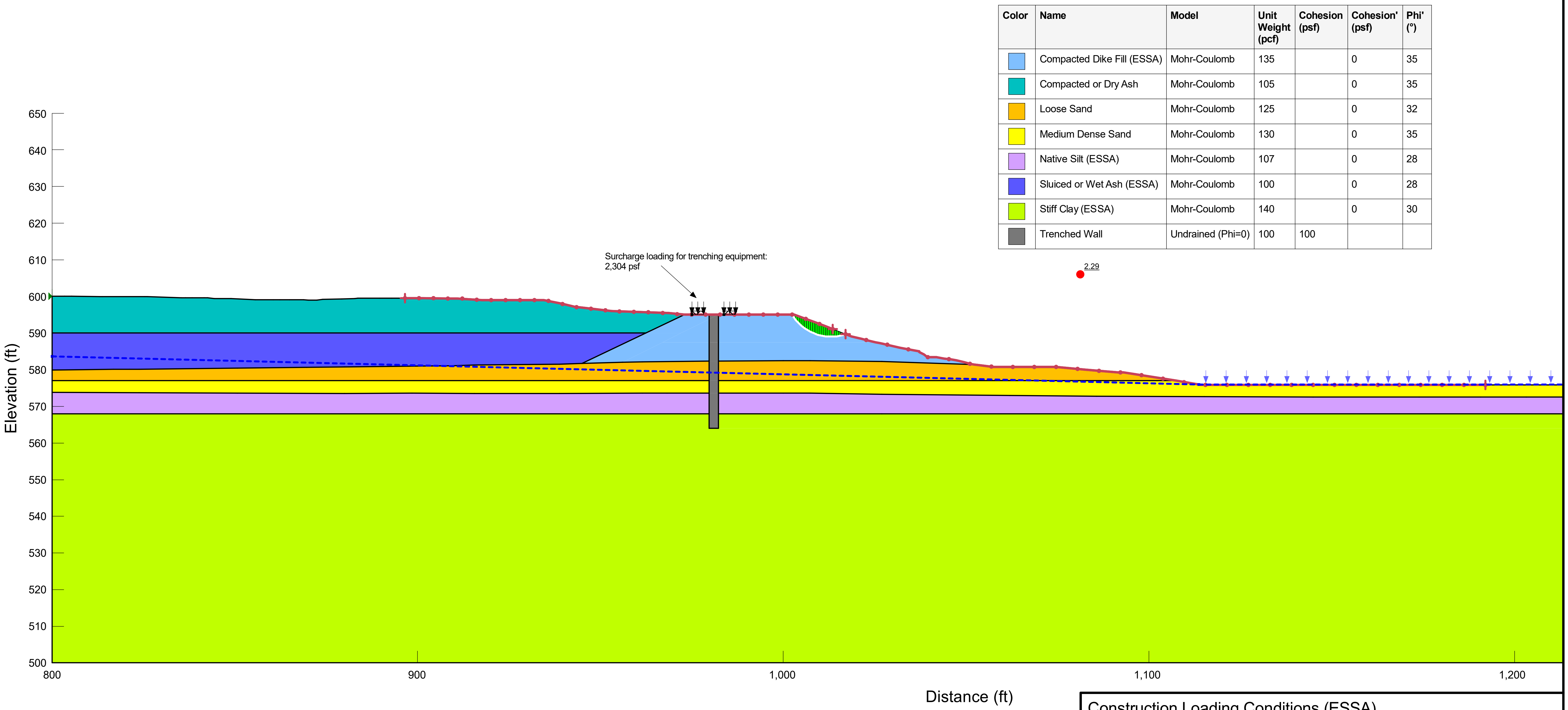
Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟫	Impenetrable	Bedrock (Impenetrable)						
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟨	Medium Dense Sand	Mohr-Coulomb	130			0	35	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600

Existing Conditions (USSA) (Silt Block)
Transect4_09152020_v1.gsz
09/22/2020 1:325

C:\Users\mdw\Desktop\KarnLocal\

D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Construction Loading Conditions (ESSA)
Last Solved Date: 09/22/2020
Factor of Safety: 2.29



Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	Cohesion' (psf)	Phi' (°)
🟦	Compacted Dike Fill (ESSA)	Mohr-Coulomb	135		0	35
🟦	Compacted or Dry Ash	Mohr-Coulomb	105		0	35
🟧	Loose Sand	Mohr-Coulomb	125		0	32
🟨	Medium Dense Sand	Mohr-Coulomb	130		0	35
🟪	Native Silt (ESSA)	Mohr-Coulomb	107		0	28
🟦	Sluiced or Wet Ash (ESSA)	Mohr-Coulomb	100		0	28
🟩	Stiff Clay (ESSA)	Mohr-Coulomb	140		0	30
⬛	Trenched Wall	Undrained (Phi=0)	100	100		

Construction Loading Conditions (ESSA)	
Transect4_09152020_v1.gsz	
09/22/2020	1:325

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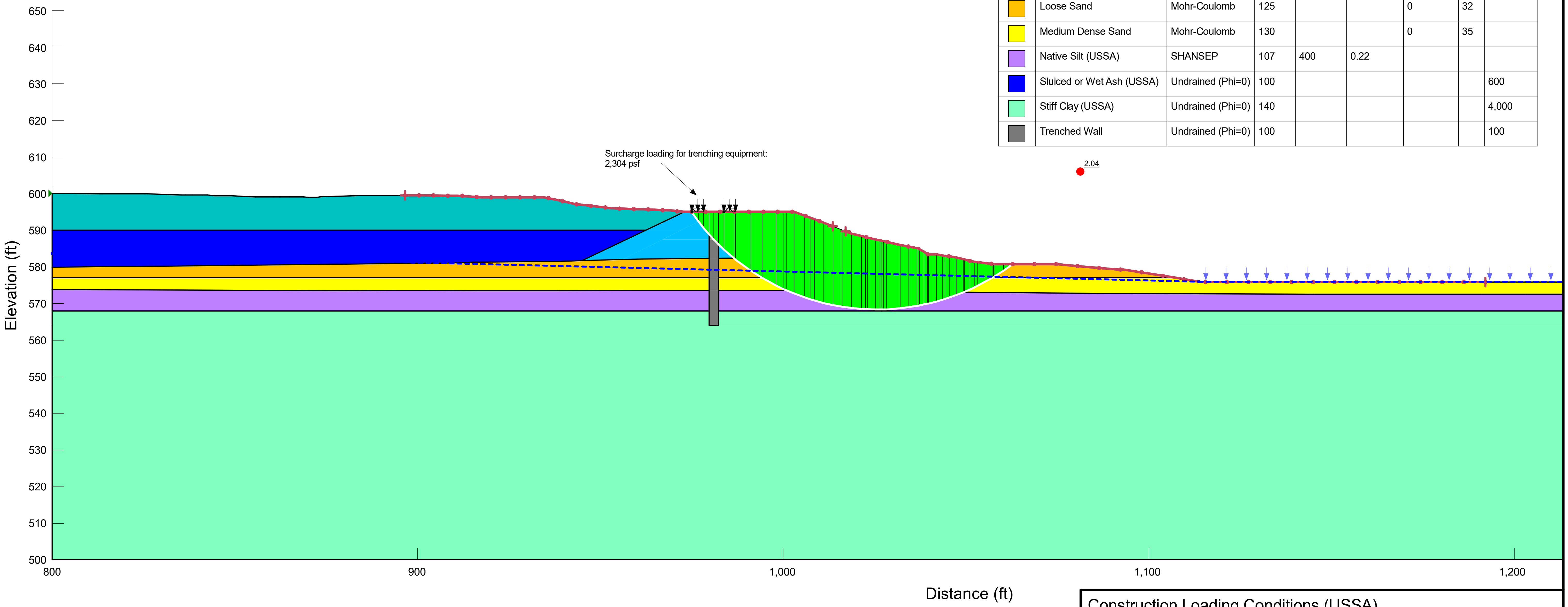
D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Construction Loading Conditions (USSA)
Last Solved Date: 09/22/2020
Factor of Safety: 2.04

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟨	Medium Dense Sand	Mohr-Coulomb	130			0	35	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600
🟩	Stiff Clay (USSA)	Undrained (Phi=0)	140					4,000
⬛	Trenched Wall	Undrained (Phi=0)	100					100


Surcharge loading for trenching equipment:
2,304 psf

Construction Loading Conditions (USSA)
Transect4_09152020_v1.gsz
09/22/2020 1:325

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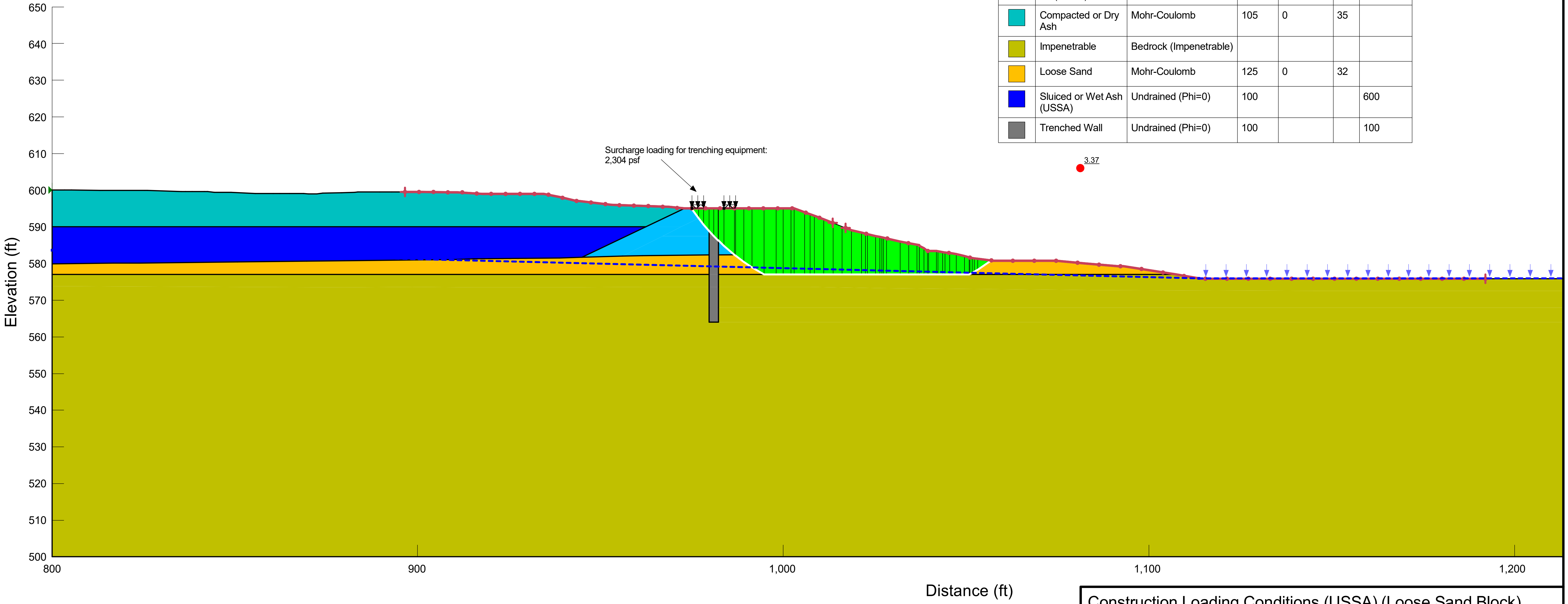
D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Construction Loading Conditions (USSA) (Loose Sand Block)
Last Solved Date: 09/22/2020
Factor of Safety: 3.37

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135			2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105	0	35	
🟨	Impenetrable	Bedrock (Impenetrable)				
🟧	Loose Sand	Mohr-Coulomb	125	0	32	
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100			600
⬛	Trenched Wall	Undrained (Phi=0)	100			100



Construction Loading Conditions (USSA) (Loose Sand Block)

Transect4_09152020_v1.gsz

09/22/2020 1:325

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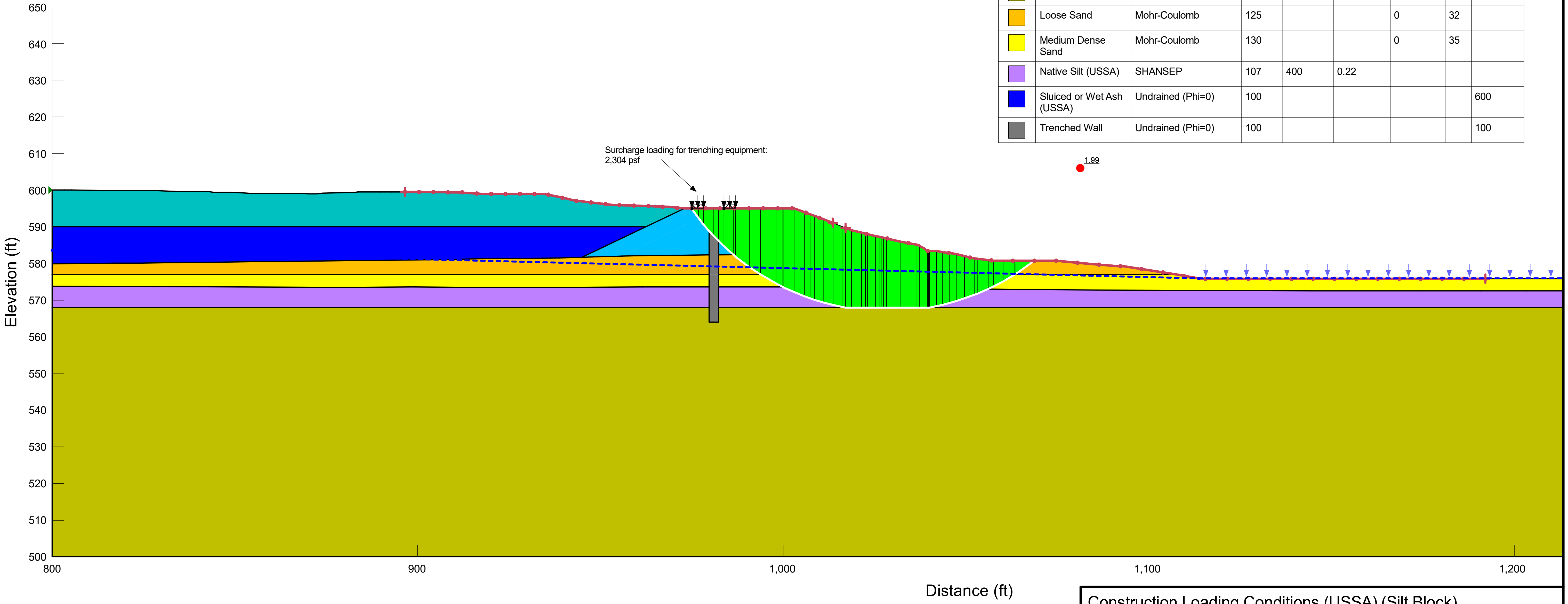
D.E. Karn Landfill
Geotechnical Feasibility
Transect 4

Construction Loading Conditions (USSA) (Silt Block)
Last Solved Date: 09/22/2020
Factor of Safety: 1.99

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟩	Impenetrable	Bedrock (Impenetrable)						
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟨	Medium Dense Sand	Mohr-Coulomb	130			0	35	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600
⬛	Trenched Wall	Undrained (Phi=0)	100					100



Construction Loading Conditions (USSA) (Silt Block)
Transect4_09152020_v1.gsz
09/22/2020 1:325

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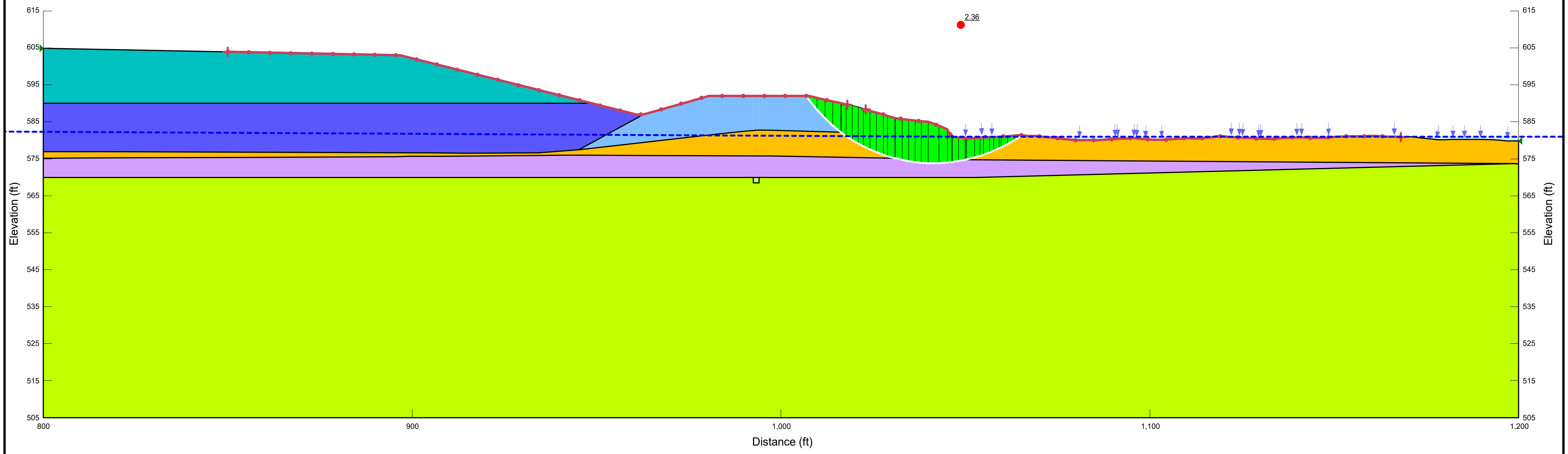
Attachment B.2

Pond A East Results

D.E. Karn Landfill
Geotechnical Feasibility
Pond A East

Existing Conditions (ESSA)
Last Solved Date: 09/22/2020
Factor of Safety: 2.36

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
🟦	Compacted Dike Fill (ESSA)	Mohr-Coulomb	135	0	35
🟦	Compacted or Dry Ash	Mohr-Coulomb	105	0	35
🟧	Loose Sand	Mohr-Coulomb	125	0	32
🟪	Native Silt (ESSA)	Mohr-Coulomb	107	0	28
🟦	Sluiced or Wet Ash (ESSA)	Mohr-Coulomb	100	0	28
🟩	Soft Clay (ESSA)	Mohr-Coulomb	140	0	30
🟩	Stiff Clay (ESSA)	Mohr-Coulomb	140	0	30



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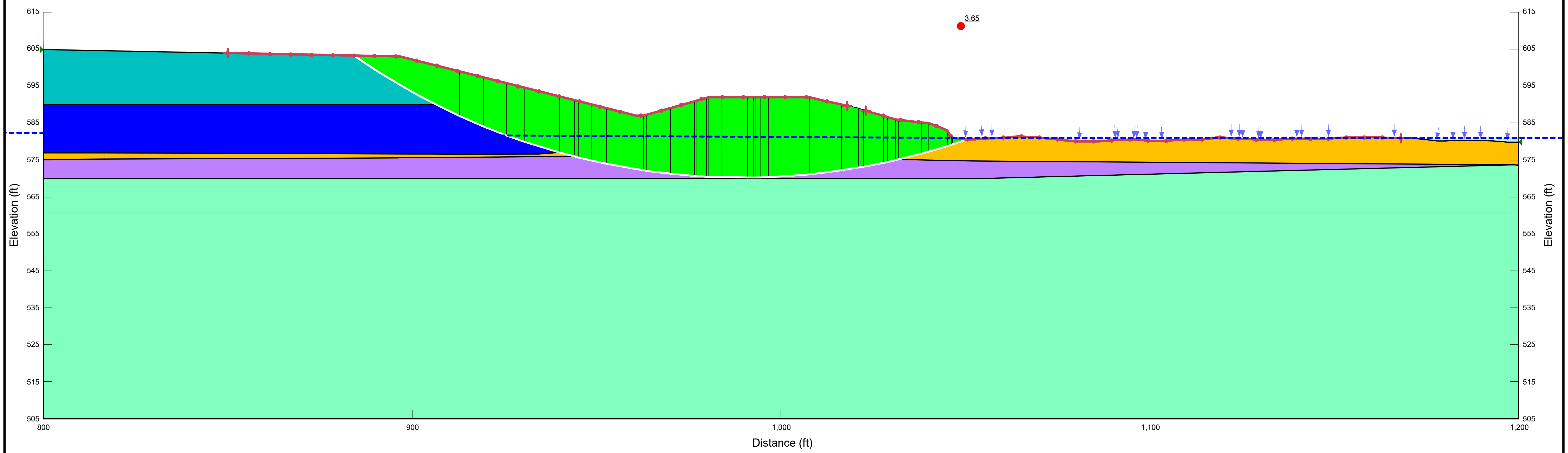
Existing Conditions (ESSA)
PondAEast_09152020_v1.gsz
09/22/2020 1:317

D.E. Karn Landfill
Geotechnical Feasibility
Pond A East

Existing Conditions (USSA)
Last Solved Date: 09/22/2020
Factor of Safety: 3.65

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600
🟩	Stiff Clay (USSA)	Undrained (Phi=0)	140					4,000



Existing Conditions (USSA)
PondAEast_09152020_v1.gsz
09/22/2020 1:317

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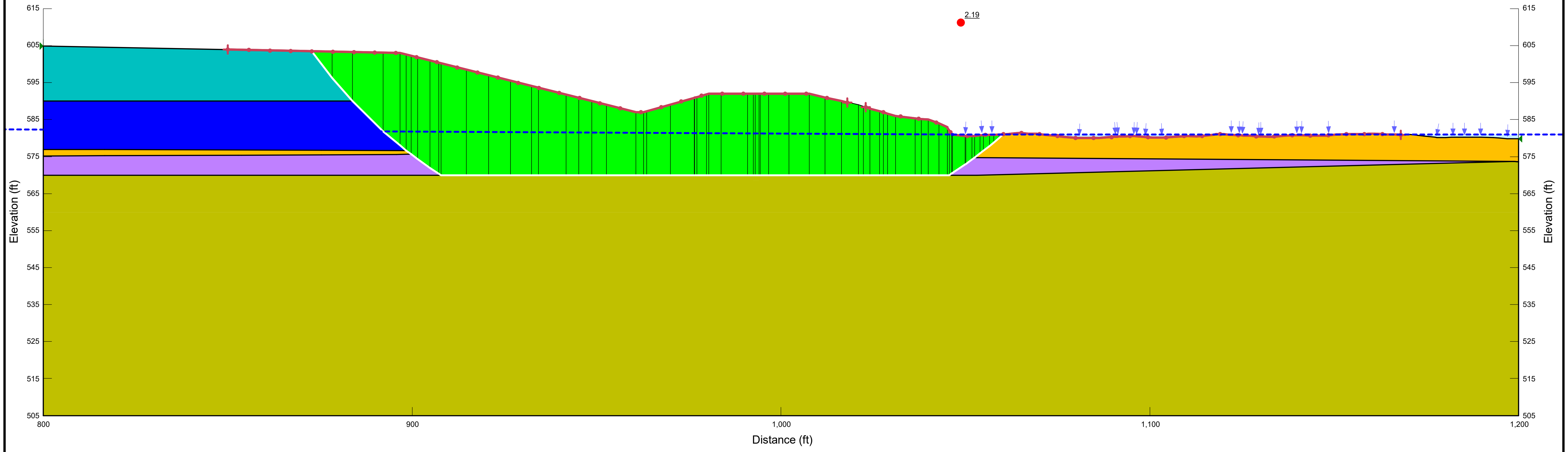
D.E. Karn Landfill
Geotechnical Feasibility
Pond A East

Existing Conditions (USSA) (Silt Block)
Last Solved Date: 09/22/2020
Factor of Safety: 2.19

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟨	Impenetrable	Bedrock (Impenetrable)						
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600



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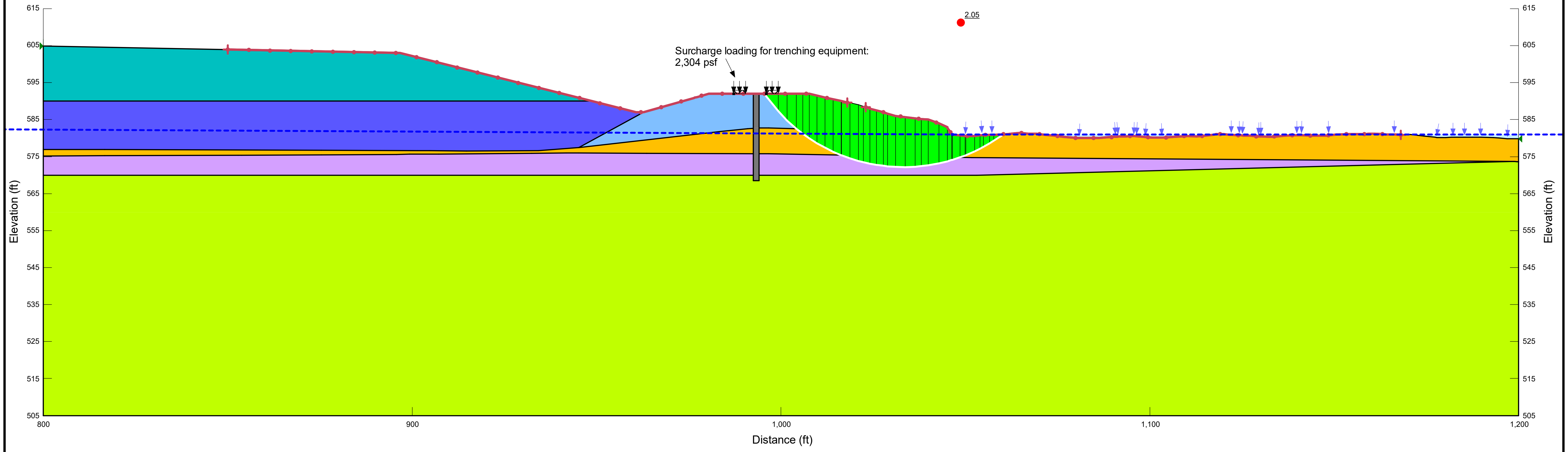
Existing Conditions (USSA) (Silt Block)	
PondAEast_09152020_v1.gsz	
09/22/2020	1:317

D.E. Karn Landfill
Geotechnical Feasibility
Pond A East

Construction Loading (ESSA)
Last Solved Date: 09/22/2020
Factor of Safety: 2.05

Color	Name	Model	Unit Weight (pcf)	Cohesion (psf)	Cohesion' (psf)	Phi' (°)
🟦	Compacted Dike Fill (ESSA)	Mohr-Coulomb	135		0	35
🟩	Compacted or Dry Ash	Mohr-Coulomb	105		0	35
🟧	Loose Sand	Mohr-Coulomb	125		0	32
🟪	Native Silt (ESSA)	Mohr-Coulomb	107		0	28
🟦	Sluiced or Wet Ash (ESSA)	Mohr-Coulomb	100		0	28
🟩	Stiff Clay (ESSA)	Mohr-Coulomb	140		0	30
⬛	Trenched Wall	Undrained (Phi=0)	100	100		



Surcharge loading for trenching equipment:
2,304 psf

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Construction Loading (ESSA)

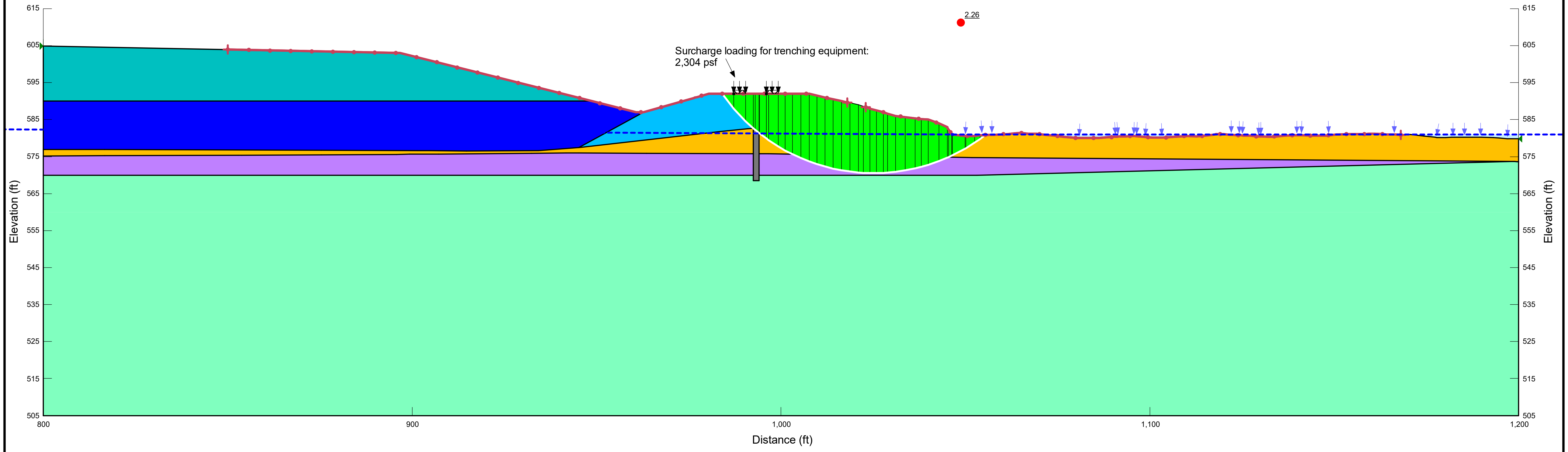
PondAEast_09152020_v1.gsz

09/22/2020 1:317

D.E. Karn Landfill
Geotechnical Feasibility
Pond A East

Constructtion Loading (USSA)
Last Solved Date: 09/22/2020
Factor of Safety: 2.26

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600
🟩	Stiff Clay (USSA)	Undrained (Phi=0)	140					4,000
⬛	Trenched Wall	Undrained (Phi=0)	100					100



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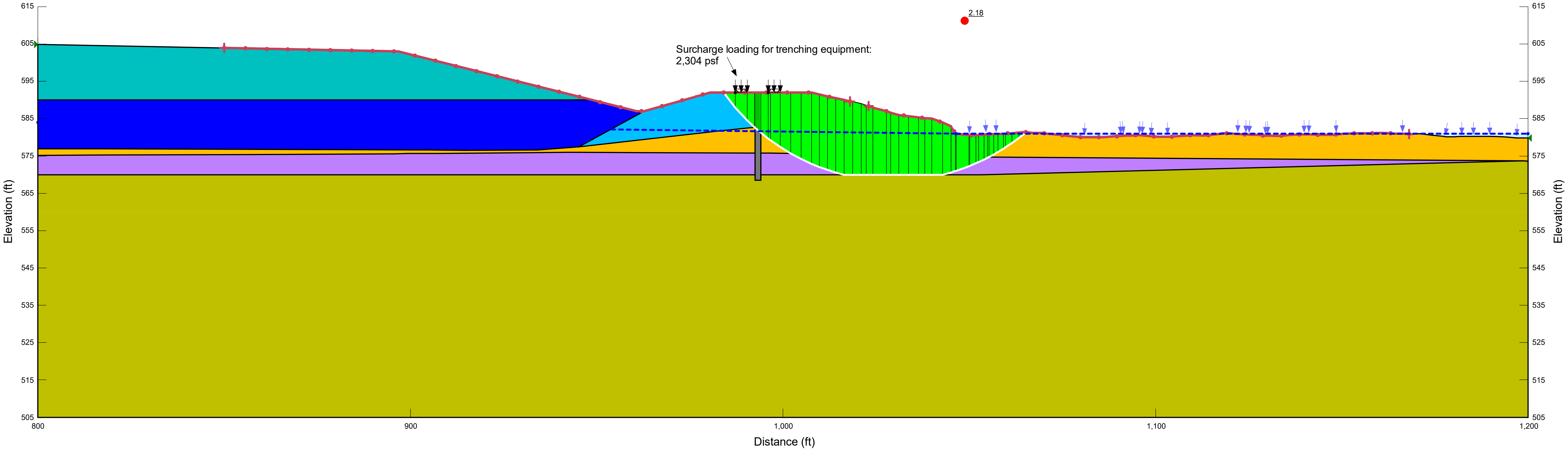
Constructtion Loading (USSA)
PondAEast_09152020_v1.gsz
09/22/2020 1:317

D.E. Karn Landfill
Geotechnical Feasibility
Pond A East

Constructtion Loading (USSA) (Silt Block)
Last Solved Date: 09/22/2020
Factor of Safety: 2.18

Color	Name	Model	Unit Weight (pcf)	Minimum Strength (psf)	Tau/Sigma Ratio	Cohesion' (psf)	Phi' (°)	Cohesion (psf)
🟦	Compacted Dike Fill (USSA)	Undrained (Phi=0)	135					2,000
🟦	Compacted or Dry Ash	Mohr-Coulomb	105			0	35	
🟨	Impenetrable	Bedrock (Impenetrable)						
🟧	Loose Sand	Mohr-Coulomb	125			0	32	
🟪	Native Silt (USSA)	SHANSEP	107	400	0.22			
🟦	Sluiced or Wet Ash (USSA)	Undrained (Phi=0)	100					600
⬛	Trenched Wall	Undrained (Phi=0)	100					100



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Constructtion Loading (USSA) (Silt Block)
PondAEast_09152020_v1.gsz
09/22/2020 1:317

Appendix C

Groundwater Extraction System Data

C-1: Groundwater Extraction System Analytical Data
C-2a: November 2019 Laboratory Groundwater Extraction System Data Report
C-2b: June 2020 Laboratory Groundwater Extraction System Data Report
C-2c: July 2020 Laboratory Groundwater Extraction System Data Report
C-3: Groundwater Extraction System Data QA/QC Review

Appendix C-1

Groundwater Extraction System Analytical Data

Appendix C-1
Groundwater Extraction System Analytical Data
D.E. Karn Generating Facility
Consumers Energy Company

Location		**KARN INFLUENT**	**KARN INFLUENT**	**KARN INFLUENT**	**KARN EFFLUENT**	**KARN EFFLUENT**	**KARN EFFLUENT**
Date		**11/26/2019**	**6/05/2020**	**7/17/2020**	**11/26/2019**	**6/05/2020**	**7/17/2020**
Sample Type		**N**	**N**	**N**	**N**	**N**	**N**
Parameter	Units						
General Parameters							
Alkalinity, total, as CaCO3	mg/l	**494**	--	--	**397**	--	--
Biochemical Oxygen Demand (5-day)	mg/l	< 2.00 UH	--	--	< 2.00 UH	--	--
Carbon, total organic	mg/l	**3.28**	--	--	**3.04**	--	--
Chemical Oxygen Demand	mg/l	**11.1**	--	--	< 10.0 U	--	--
Phosphorus, total, as P	mg/l	**0.355**	--	--	**0.133**	--	--
Solids, total suspended	mg/l	**15.0**	--	--	**9.00**	--	--
Total Metals							
Arsenic	µg/l	**539**	**327**	**187**	**189**	**431**	**199**
Iron	µg/l	**6390**	**2910**	**1550**	**1210**	**14500**	**2920**

LEGEND

Detections are presented in **bold**.

Footnotes

N Sample Type: Normal

H Recommended sample preservation, extraction, or analysis holding time was exceeded.

U The analyte was analyzed for, but was not detected.

Data Footnotes and Qualifiers

Barr Standard Footnotes and Qualifiers

--	Not analyzed/Not available.
N	Sample Type: Normal
H	Recommended sample preservation, extraction or analysis holding time was exceeded.
U	The analyte was analyzed for, but was not detected.

Appendix C-2a

November 2019 Laboratory Groundwater Extraction System Data Report

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ANALYTICAL REPORT

Eurofins TestAmerica, Canton
4101 Shuffel Street NW
North Canton, OH 44720
Tel: (330)497-9396

Laboratory Job ID: 240-123028-1
Client Project/Site: Kern Treatment

For:
Barr Engineering Company
4771 50th St SE
Grand Rapids, Michigan 49512

Attn: Michael Potter

Leslie A Howell

Authorized for release by:
12/13/2019 11:06:40 AM

Leslie Howell, Project Manager I
(330)966-9266
leslie.howell@testamericainc.com

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

Table of Contents

Qualifiers

General Chemistry

Qualifier	Qualifier Description
H	Sample was prepped or analyzed beyond the specified holding time
H3	Sample was received and analyzed past holding time.

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
PQL	Practical Quantitation Limit
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)

Job ID: 240-123028-1

Laboratory: Eurofins TestAmerica, Canton

Narrative

Job Narrative
240-123028-1

Comments
No additional comments.

Receipt
The samples were received on 11/29/2019 9:05 AM; the samples arrived in good condition, properly preserved and, where required, on ice. The temperature of the cooler at receipt was 3.2º C.

Receipt Exceptions

Method SM 5210B: The following sample was received outside of holding time: KARN EFFLUENT (240-123028-2).

Metals
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

General Chemistry
Method SM 5210B: The following samples were received outside of holding time: KARN INFLUENT (240-123028-1) and KARN EFFLUENT (240-123028-2).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Method Summary

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-123028-1

Method	Method Description	Protocol	Laboratory
6020	Metals (ICP/MS)	SW846	TAL CAN
2320B-2011	Alkalinity, Total	SM	TAL CAN
2540 D-2011	Total Suspended Solids (Dried at 103-105°C)	SM	TAL CAN
5210B-2011	BOD, 5-Day	SM	TAL CAN
5220D-2011	Chemical Oxygen Demand	SM	TAL CAN
9060A	Organic Carbon, Total (TOC)	SW846	TAL CAN
SM4500 P E-2011	Phosphorus	SM	TAL CAN
3005A	Preparation, Total Recoverable or Dissolved Metals	SW846	TAL CAN

Protocol References:

SM = "Standard Methods For The Examination Of Water And Wastewater"

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396

Sample Summary

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-123028-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received	Asset ID
240-123028-1	KARN INFLUENT	Water	11/26/19 11:50	11/29/19 09:05	
240-123028-2	KARN EFFLUENT	Water	11/26/19 14:50	11/29/19 09:05	

Detection Summary

Client Sample ID: KARN INFLUENT — Lab Sample ID: 240-123028-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	539		5.00		ug/L	1		6020	Total Recoverable
Iron	6390		200		ug/L	1		6020	Total Recoverable
Alkalinity	494		5.00		mg/L	1		2320B-2011	Total/NA
Total Suspended Solids	15.0		4.00		mg/L	1		2540 D-2011	Total/NA
Chemical Oxygen Demand	11.1		10.0		mg/L	1		5220D-2011	Total/NA
TOC Result 1	3.13		1.00		mg/L	1		9060A	Total/NA
TOC Result 2	3.28		1.00		mg/L	1		9060A	Total/NA
TOC Result 3	3.19		1.00		mg/L	1		9060A	Total/NA
TOC Result 4	3.26		1.00		mg/L	1		9060A	Total/NA
Total Organic Carbon	3.21		1.00		mg/L	1		9060A	Total/NA
Total Phosphorus as P	0.355		0.100		mg/L	1		SM4500 P E-2011	Total/NA

Client Sample ID: KARN EFFLUENT — Lab Sample ID: 240-123028-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	189		5.00		ug/L	1		6020	Total Recoverable
Iron	1210		200		ug/L	1		6020	Total Recoverable
Alkalinity	397		5.00		mg/L	1		2320B-2011	Total/NA
Total Suspended Solids	9.00		4.00		mg/L	1		2540 D-2011	Total/NA
TOC Result 1	2.92		1.00		mg/L	1		9060A	Total/NA
TOC Result 2	3.13		1.00		mg/L	1		9060A	Total/NA
TOC Result 3	3.04		1.00		mg/L	1		9060A	Total/NA
TOC Result 4	3.11		1.00		mg/L	1		9060A	Total/NA
Total Organic Carbon	3.05		1.00		mg/L	1		9060A	Total/NA
Total Phosphorus as P	0.133		0.100		mg/L	1		SM4500 P E-2011	Total/NA

This Detection Summary does not include radiochemical test results.

Client Sample Results

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-123028-1

Client Sample ID: KARN INFLUENT

Lab Sample ID: 240-123028-1

Date Collected: 11/26/19 11:50

Matrix: Water

Date Received: 11/29/19 09:05

Method: 6020 - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**539**		5.00		ug/L		12/02/19 14:00	12/04/19 11:54	1
Iron	**6390**		200		ug/L		12/02/19 14:00	12/04/19 11:54	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	**494**		5.00		mg/L			12/03/19 13:29	1
Total Suspended Solids	**15.0**		4.00		mg/L			11/29/19 13:24	1
Biochemical Oxygen Demand	<2.00	H H3	2.00		mg/L			11/29/19 13:36	1
Chemical Oxygen Demand	**11.1**		10.0		mg/L			12/02/19 12:38	1
TOC Result 1	**3.13**		1.00		mg/L			12/02/19 09:48	1
TOC Result 2	**3.28**		1.00		mg/L			12/02/19 09:48	1
TOC Result 3	**3.19**		1.00		mg/L			12/02/19 09:48	1
TOC Result 4	**3.26**		1.00		mg/L			12/02/19 09:48	1
Total Organic Carbon	**3.21**		1.00		mg/L			12/02/19 09:48	1
Total Phosphorus as P	**0.355**		0.100		mg/L			12/02/19 08:32	1

Client Sample ID: KARN EFFLUENT

Date Collected: 11/26/19 14:50
Date Received: 11/29/19 09:05

Lab Sample ID: 240-123028-2
Matrix: Water

Method: 6020 - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**189**		5.00		ug/L		12/02/19 14:00	12/04/19 12:04	1
Iron	**1210**		200		ug/L		12/02/19 14:00	12/04/19 12:04	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	**397**		5.00		mg/L			12/03/19 13:34	1
Total Suspended Solids	**9.00**		4.00		mg/L			11/29/19 13:24	1
Biochemical Oxygen Demand	<2.00	H H3	2.00		mg/L			11/29/19 13:43	1
Chemical Oxygen Demand	<10.0		10.0		mg/L			12/02/19 12:41	1
TOC Result 1	**2.92**		1.00		mg/L			12/02/19 10:45	1
TOC Result 2	**3.13**		1.00		mg/L			12/02/19 10:45	1
TOC Result 3	**3.04**		1.00		mg/L			12/02/19 10:45	1
TOC Result 4	**3.11**		1.00		mg/L			12/02/19 10:45	1
Total Organic Carbon	**3.05**		1.00		mg/L			12/02/19 10:45	1
Total Phosphorus as P	**0.133**		0.100		mg/L			12/02/19 08:46	1

QC Sample Results

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-123028-1

Method: 6020 - Metals (ICP/MS)

Lab Sample ID: MB 240-413321/1-A
Matrix: Water
Analysis Batch: 413957

Client Sample ID: Method Blank
Prep Type: Total Recoverable
Prep Batch: 413321

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<5.00		5.00		ug/L		12/02/19 14:00	12/04/19 11:50	1
Iron	<200		200		ug/L		12/02/19 14:00	12/04/19 11:50	1

Lab Sample ID: LCS 240-413321/2-A
Matrix: Water
Analysis Batch: 413957

Client Sample ID: Lab Control Sample
Prep Type: Total Recoverable
Prep Batch: 413321

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	1000	1081		ug/L		108	80 - 120
Iron	5000	5163		ug/L		103	80 - 120

Lab Sample ID: 240-123028-1 MS
Matrix: Water
Analysis Batch: 413957

Client Sample ID: KARN INFLUENT
Prep Type: Total Recoverable
Prep Batch: 413321

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	539		1000	1719		ug/L		118	75 - 125
Iron	6390		5000	11550		ug/L		103	75 - 125

Lab Sample ID: 240-123028-1 MSD
Matrix: Water
Analysis Batch: 413957

Client Sample ID: KARN INFLUENT
Prep Type: Total Recoverable
Prep Batch: 413321

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	539		1000	1716		ug/L		118	75 - 125	0	20
Iron	6390		5000	11790		ug/L		108	75 - 125	2	20

Method: 2320B-2011 - Alkalinity, Total

Lab Sample ID: MB 240-413712/30
Matrix: Water
Analysis Batch: 413712

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Alkalinity	<5.00		5.00		mg/L			12/03/19 13:01	1

Lab Sample ID: LCS 240-413712/29
Matrix: Water
Analysis Batch: 413712

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Alkalinity	183	174.5		mg/L		95	86 - 123

QC Sample Results

Method: 2540 D-2011 - Total Suspended Solids (Dried at 103-105°C)

Lab Sample ID: MB 240-413152/1
Matrix: Water
Analysis Batch: 413152

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Suspended Solids	<4.00		4.00		mg/L			11/29/19 13:24	1

Lab Sample ID: LCS 240-413152/2
Matrix: Water
Analysis Batch: 413152

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Suspended Solids			82.3	75.00		mg/L		91	64 - 120		

Method: 5220D-2011 - Chemical Oxygen Demand

Lab Sample ID: MB 240-413340/9
Matrix: Water
Analysis Batch: 413340

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			12/02/19 12:37	1

Lab Sample ID: LCS 240-413340/10
Matrix: Water
Analysis Batch: 413340

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Chemical Oxygen Demand			68.4	61.52		mg/L		90	90 - 110		

Lab Sample ID: 240-123028-1 MS
Matrix: Water
Analysis Batch: 413340

Client Sample ID: KARN INFLUENT
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Chemical Oxygen Demand	11.1		50.0	57.67		mg/L		93	90 - 110		

Lab Sample ID: 240-123028-1 MSD
Matrix: Water
Analysis Batch: 413340

Client Sample ID: KARN INFLUENT
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Chemical Oxygen Demand	11.1		50.0	57.07		mg/L		92	90 - 110	1	20

Method: 9060A - Organic Carbon, Total (TOC)

Lab Sample ID: MB 240-413436/4
Matrix: Water
Analysis Batch: 413436

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
TOC Result 1	<1.00		1.00		mg/L			12/02/19 09:17	1
Total Organic Carbon	<1.00		1.00		mg/L			12/02/19 09:17	1

QC Sample Results

Method: 9060A - Organic Carbon, Total (TOC) (Continued)

Lab Sample ID: LCS 240-413436/6
Matrix: Water
Analysis Batch: 413436

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

			Spike	LCS	LCS				%Rec.		
Analyte			**Added**	**Result**	**Qualifier**	**Unit**	**D**	**%Rec**	**Limits**		
TOC Result 1			27.0	27.55		mg/L		102	80 - 120		
Total Organic Carbon			27.0	27.55		mg/L		102	80 - 120		

Lab Sample ID: LLCS 240-413436/5
Matrix: Water
Analysis Batch: 413436

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

			Spike	LLCS	LLCS				%Rec.		
Analyte			**Added**	**Result**	**Qualifier**	**Unit**	**D**	**%Rec**	**Limits**		
TOC Result 1			6.75	6.723		mg/L		100	88 - 115		
Total Organic Carbon			6.75	6.723		mg/L		100	88 - 115		

Lab Sample ID: 240-123028-1 MS
Matrix: Water
Analysis Batch: 413436

Client Sample ID: KARN INFLUENT
Prep Type: Total/NA

	Sample	Sample	Spike	MS	MS				%Rec.		
Analyte	**Result**	**Qualifier**	**Added**	**Result**	**Qualifier**	**Unit**	**D**	**%Rec**	**Limits**		
TOC Result 1	3.13		25.0	26.45		mg/L		93	65 - 134		
Total Organic Carbon	3.21		25.0	26.45		mg/L		93	65 - 134		

Lab Sample ID: 240-123028-1 MSD
Matrix: Water
Analysis Batch: 413436

Client Sample ID: KARN INFLUENT
Prep Type: Total/NA

	Sample	Sample	Spike	MSD	MSD				%Rec.		RPD
Analyte	**Result**	**Qualifier**	**Added**	**Result**	**Qualifier**	**Unit**	**D**	**%Rec**	**Limits**	**RPD**	**Limit**
TOC Result 1	3.13		25.0	28.42		mg/L		101	65 - 134	7	10
Total Organic Carbon	3.21		25.0	28.42		mg/L		101	65 - 134	7	10

Method: SM4500 P E-2011 - Phosphorus

Lab Sample ID: MB 240-413278/3
Matrix: Water
Analysis Batch: 413278

Client Sample ID: Method Blank
Prep Type: Total/NA

	MB	MB							
Analyte	**Result**	**Qualifier**	**RL**	**MDL**	**Unit**	**D**	**Prepared**	**Analyzed**	**Dil Fac**
Total Phosphorus as P	<0.100		0.100		mg/L			12/02/19 07:50	1

Lab Sample ID: LCS 240-413278/4
Matrix: Water
Analysis Batch: 413278

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

			Spike	LCS	LCS				%Rec.		
Analyte			**Added**	**Result**	**Qualifier**	**Unit**	**D**	**%Rec**	**Limits**		
Total Phosphorus as P			0.405	0.3914		mg/L		97	77 - 120		

Metals

Prep Batch: 413321

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total Recoverable	Water	3005A	
240-123028-2	KARN EFFLUENT	Total Recoverable	Water	3005A	
MB 240-413321/1-A	Method Blank	Total Recoverable	Water	3005A	
LCS 240-413321/2-A	Lab Control Sample	Total Recoverable	Water	3005A	
240-123028-1 MS	KARN INFLUENT	Total Recoverable	Water	3005A	
240-123028-1 MSD	KARN INFLUENT	Total Recoverable	Water	3005A	

Analysis Batch: 413957

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total Recoverable	Water	6020	413321
240-123028-2	KARN EFFLUENT	Total Recoverable	Water	6020	413321
MB 240-413321/1-A	Method Blank	Total Recoverable	Water	6020	413321
LCS 240-413321/2-A	Lab Control Sample	Total Recoverable	Water	6020	413321
240-123028-1 MS	KARN INFLUENT	Total Recoverable	Water	6020	413321
240-123028-1 MSD	KARN INFLUENT	Total Recoverable	Water	6020	413321

General Chemistry

Analysis Batch: 413107

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total/NA	Water	5210B-2011	
240-123028-2	KARN EFFLUENT	Total/NA	Water	5210B-2011	

Analysis Batch: 413152

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total/NA	Water	2540 D-2011	
240-123028-2	KARN EFFLUENT	Total/NA	Water	2540 D-2011	
MB 240-413152/1	Method Blank	Total/NA	Water	2540 D-2011	
LCS 240-413152/2	Lab Control Sample	Total/NA	Water	2540 D-2011	

Analysis Batch: 413278

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total/NA	Water	SM4500 P E-2011	
240-123028-2	KARN EFFLUENT	Total/NA	Water	SM4500 P E-2011	
MB 240-413278/3	Method Blank	Total/NA	Water	SM4500 P E-2011	
LCS 240-413278/4	Lab Control Sample	Total/NA	Water	SM4500 P E-2011	

Analysis Batch: 413340

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total/NA	Water	5220D-2011	
240-123028-2	KARN EFFLUENT	Total/NA	Water	5220D-2011	
MB 240-413340/9	Method Blank	Total/NA	Water	5220D-2011	
LCS 240-413340/10	Lab Control Sample	Total/NA	Water	5220D-2011	
240-123028-1 MS	KARN INFLUENT	Total/NA	Water	5220D-2011	
240-123028-1 MSD	KARN INFLUENT	Total/NA	Water	5220D-2011	

QC Association Summary

General Chemistry

Analysis Batch: 413436

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total/NA	Water	9060A	
240-123028-2	KARN EFFLUENT	Total/NA	Water	9060A	
MB 240-413436/4	Method Blank	Total/NA	Water	9060A	
LCS 240-413436/6	Lab Control Sample	Total/NA	Water	9060A	
LLCS 240-413436/5	Lab Control Sample	Total/NA	Water	9060A	
240-123028-1 MS	KARN INFLUENT	Total/NA	Water	9060A	
240-123028-1 MSD	KARN INFLUENT	Total/NA	Water	9060A	

Analysis Batch: 413712

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-123028-1	KARN INFLUENT	Total/NA	Water	2320B-2011	
240-123028-2	KARN EFFLUENT	Total/NA	Water	2320B-2011	
MB 240-413712/30	Method Blank	Total/NA	Water	2320B-2011	
LCS 240-413712/29	Lab Control Sample	Total/NA	Water	2320B-2011	

Client Sample ID: KARN INFLUENT

Lab Sample ID: 240-123028-1

Date Collected: 11/26/19 11:50
Date Received: 11/29/19 09:05

Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total Recoverable	Prep	3005A			413321	12/02/19 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020		1	413957	12/04/19 11:54	DSH	TAL CAN
Total/NA	Analysis	2320B-2011		1	413712	12/03/19 13:29	JMR	TAL CAN
Total/NA	Analysis	2540 D-2011		1	413152	11/29/19 13:24	JMR	TAL CAN
Total/NA	Analysis	5210B-2011		1	413107	11/29/19 13:36	BLW	TAL CAN
Total/NA	Analysis	5220D-2011		1	413340	12/02/19 12:38	TPH	TAL CAN
Total/NA	Analysis	9060A		1	413436	12/02/19 09:48	TPH	TAL CAN
Total/NA	Analysis	SM4500 P E-2011		1	413278	12/02/19 08:32	TPH	TAL CAN

Client Sample ID: KARN EFFLUENT

Lab Sample ID: 240-123028-2

Date Collected: 11/26/19 14:50
Date Received: 11/29/19 09:05

Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total Recoverable	Prep	3005A			413321	12/02/19 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020		1	413957	12/04/19 12:04	DSH	TAL CAN
Total/NA	Analysis	2320B-2011		1	413712	12/03/19 13:34	JMR	TAL CAN
Total/NA	Analysis	2540 D-2011		1	413152	11/29/19 13:24	JMR	TAL CAN
Total/NA	Analysis	5210B-2011		1	413107	11/29/19 13:43	BLW	TAL CAN
Total/NA	Analysis	5220D-2011		1	413340	12/02/19 12:41	TPH	TAL CAN
Total/NA	Analysis	9060A		1	413436	12/02/19 10:45	TPH	TAL CAN
Total/NA	Analysis	SM4500 P E-2011		1	413278	12/02/19 08:46	TPH	TAL CAN

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396

Laboratory: Eurofins TestAmerica, Canton

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
Minnesota	NELAP	039-999-348	12-31-19 *

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
9060A		Water	TOC Result 1
9060A		Water	TOC Result 2
9060A		Water	TOC Result 3
9060A		Water	TOC Result 4

* Accreditation/Certification renewal pending - accreditation/certification considered valid.

Eurofins TestAmerica, Canton
4101 Shuffel Street NW
North Canton, OH 44720
Phone: 330-497-9396 Fax: 330-497-0772

2.5/C3.2

Chain of Custody Record

Grand Rapids

eurofins | Environment Testing TestAmerica

Client Information	Sampler:	Lab PM: Howell, Leslie	Carrier Tracking No(s): 271	COC No: 240-65880-27615.1
Client Contact: Michael Potter	Phone:	E-Mail: leslie.howell@testamericainc.com		Page: Page 1 of 2
Company: Barr Engineering Company		**Analysis Requested**		Job #:
Address: 4771 50th St SE	Due Date Requested:			
City: Grand Rapids	TAT Requested (days):			
State, Zip: MI, 49512				
Phone:	PO #: 22091016			
Email: mpotter@barr.com	WO #:			
Project Name: Kern Treatment	Project #: 24023770			
Site:	SSOW#:			

Preservation Codes:

A - HCL	M - Hexane
B - NaOH	N - None
C - Zn Acetate	O - AsNaO2
D - Nitric Acid	P - Na2O4S
E - NaHSO4	Q - Na2SO3
F - MeOH	R - Na2S2O3
G - Amchlor	S - H2SO4
H - Ascorbic Acid	T - TSP Dodecahydrate
I - Ice	U - Acetone
J - DI Water	V - MCAA
K - EDTA	W - pH 4-5
L - EDA	Z - other (specify)

Other:

Sample Identification	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	2320B - (MOD) Copy Analytes	6020 - (MOD) Fe, As	4500_P_E, 5220D	9060A - Local Method	SM5210B_Calc - Local Method	2540D - Local Method	Total Number of containers	Special Instructions/Note:
				Preservation Code:			N	D	S	S	N	N		
KARN inFluent	11-26-19	1150	G	Water			X	X	X	X	X	X		
KARN EFFluenT	"	1450	G	Water			X	X	X	X	X	X		
				Water										
				Water										
				Water										
				Water										
				Water										
				Water										
				Water										
				Water										
				Water										

240-123028 Chain of Custody

Possible Hazard Identification
☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown* ☐ *Radiological*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* ____ *Months*

Deliverable Requested: I, II, III, IV, Other (specify)

Special Instructions/QC Requirements:

Empty Kit Relinquished by:	Date:	Time:	Method of Shipment:

Relinquished by: M A Potter	Date/Time: 11/27/19 0915	Company	Received by: B Cw	Date/Time: 11-27-19 9:15	Company: T-AL
Relinquished by: Ted EK	Date/Time: 11-27-19 10:08 Am	Company: T-AL	Received by:	Date/Time: 11-29-19 905	Company: ETAC
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company

Custody Seals Intact: Δ Yes Δ No	Custody Seal No.:	Cooler Temperature(s) °C and Other Remarks:

Ver: 01/16/2019

Eurofins TestAmerica Canton Sample Receipt Form/Narrative **Login # :** 123028
Canton Facility

Client Barr Engineering Company Site Name ____________
Cooler Received on 11-29-19 Opened on 11-29-19
Cooler unpacked by:
FedEx: 1st Grd [✓ Exp] UPS FAS Clipper Client Drop Off TestAmerica Courier Other ____________

Receipt After-hours: Drop-off Date/Time ____________ Storage Location ____________

TestAmerica Cooler # 1A Foam Box Client Cooler Box Other ____________
Packing material used: Bubble Wrap Foam [✓ Plastic Bag] None Other ____________
COOLANT: [✓ Wet Ice] Blue Ice Dry Ice Water None

1. Cooler temperature upon receipt ☐ See Multiple Cooler Form
IR GUN# IR-10 (CF **+0.7** °C) Observed Cooler Temp. 2.5 °C Corrected Cooler Temp. 3.2 °C
IR GUN #IR-11 (CF **+0.9**°C) Observed Cooler Temp. ______ °C Corrected Cooler Temp. ______ °C

2. Were tamper/custody seals on the outside of the cooler(s)? If Yes Quantity 1 [✓ Yes] No
-Were the seals on the outside of the cooler(s) signed & dated? [✓ Yes] No NA
-Were tamper/custody seals on the bottle(s) or bottle kits (LLHg/MeHg)? Yes [✓ No]
-Were tamper/custody seals intact and uncompromised? [✓ Yes] No NA
3. Shippers' packing slip attached to the cooler(s)? [✓ Yes] No
4. Did custody papers accompany the sample(s)? [✓ Yes] No
5. Were the custody papers relinquished & signed in the appropriate place? [✓ Yes] No
6. Was/were the person(s) who collected the samples clearly identified on the COC? Yes [✓ No]
7. Did all bottles arrive in good condition (Unbroken)? [✓ Yes] No
8. Could all bottle labels be reconciled with the COC? [✓ Yes] No
9. Were correct bottle(s) used for the test(s) indicated? [✓ Yes] No
10. Sufficient quantity received to perform indicated analyses? [✓ Yes] No
11. Are these work share samples? Yes [✓ No]
If yes, Questions 12-16 have been checked at the originating laboratory.
12. Were all preserved sample(s) at the correct pH upon receipt? [✓ Yes] No NA pH Strip Lot# **HC995364**
13. Were VOAs on the COC? Yes [✓ No]
14. Were air bubbles >6 mm in any VOA vials? ● ⬅ Larger than this. Yes [✓ No] NA
15. Was a VOA trip blank present in the cooler(s)? Trip Blank Lot # ____________ Yes [✓ No]
16. Was a LL Hg or Me Hg trip blank present? ____________ Yes [✓ No]

Tests that are not checked for pH by Receiving:

VOAs
Oil and Grease
TOC

Contacted PM ____________ Date ____________ by ____________ via Verbal Voice Mail Other

Concerning ____________

17. CHAIN OF CUSTODY & SAMPLE DISCREPANCIES

Samples processed by: Martin

18. SAMPLE CONDITION

Sample(s) ____________ were received after the recommended holding time had expired.
Sample(s) ____________ were received in a broken container.
Sample(s) ____________ were received with bubble >6 mm in diameter. (Notify PM)

19. SAMPLE PRESERVATION

Sample(s) ____________ were further preserved in the laboratory.
Time preserved: ____________ Preservative(s) added/Lot number(s): ____________

VOA Sample Preservation - Date/Time VOAs Frozen: ____________

WI-NC-099

Login Container Summary Report

Temperature readings: ____________________

Client Sample ID	Lab ID	Container Type	Container pH	Preservative Added (mls)	Lot #
KARN INFLUENT	240-123028-E-1	Plastic 500ml - with Sulfuric Acid	<2	______	______
KARN INFLUENT	240-123028-F-1	Plastic 500ml - with Nitric Acid	<2	______	______
KARN EFFLUENT	240-123028-E-2	Plastic 500ml - with Sulfuric Acid	<2	______	______
KARN EFFLUENT	240-123028-F-2	Plastic 500ml - with Nitric Acid	<2	______	______

Appendix C-2b

June 2020 Laboratory Groundwater Extraction System Data Report

eurofins | Environment Testing America

ANALYTICAL REPORT

Eurofins TestAmerica, Canton
4101 Shuffel Street NW
North Canton, OH 44720
Tel: (330)497-9396

Laboratory Job ID: 240-131832-1
Client Project/Site: Kern Treatment

For:
Barr Engineering Company
4771 50th St SE
Grand Rapids, Michigan 49512

Attn: Michael Potter

Leslie A Howell

Authorized for release by:
6/19/2020 11:04:06 AM

Leslie Howell, Project Manager I
(330)966-9266
leslie.howell@testamericainc.com

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

Table of Contents

Definitions/Glossary

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Case Narrative

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-131832-1

Job ID: 240-131832-1

Laboratory: Eurofins TestAmerica, Canton

Narrative

Job Narrative
240-131832-1

Comments

No additional comments.

Receipt

The samples were received on 6/12/2020 9:40 AM; the samples arrived in good condition, and where required, properly preserved and on ice. The temperature of the cooler at receipt was 2.6º C.

Metals

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Method Summary

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-131832-1

Method	Method Description	Protocol	Laboratory
6020	Metals (ICP/MS)	SW846	TAL CAN
3005A	Preparation, Total Recoverable or Dissolved Metals	SW846	TAL CAN

Protocol References:

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396

Sample Summary

Client: Barr Engineering Company
Project/Site: Kern Treatment

Lab Sample ID	Client Sample ID	Matrix	Collected	Received	Asset ID
240-131832-1	KARN INFLUENT	Water	06/05/20 12:30	06/12/20 09:40	
240-131832-2	KARN EFFLUENT	Water	06/05/20 12:35	06/12/20 09:40	

Detection Summary

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-131832-1

Client Sample ID: KARN INFLUENT

Lab Sample ID: 240-131832-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	327		5.00		ug/L	1		6020	Total Recoverable
Iron	2910		200		ug/L	1		6020	Total Recoverable

Client Sample ID: KARN EFFLUENT

Lab Sample ID: 240-131832-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	431		5.00		ug/L	1		6020	Total Recoverable
Iron	14500		200		ug/L	1		6020	Total Recoverable

This Detection Summary does not include radiochemical test results.

Client Sample Results

Client Sample ID: KARN INFLUENT
Lab Sample ID: 240-131832-1
Date Collected: 06/05/20 12:30
Matrix: Water
Date Received: 06/12/20 09:40

Method: 6020 - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**327**		5.00		ug/L		06/12/20 18:00	06/15/20 13:13	1
Iron	**2910**		200		ug/L		06/12/20 18:00	06/15/20 13:13	1

Client Sample Results

Client Sample ID: KARN EFFLUENT
Lab Sample ID: 240-131832-2
Date Collected: 06/05/20 12:35
Matrix: Water
Date Received: 06/12/20 09:40

Method: 6020 - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	431		5.00		ug/L		06/12/20 18:00	06/15/20 13:15	1
Iron	14500		200		ug/L		06/12/20 18:00	06/15/20 13:15	1

QC Sample Results

Method: 6020 - Metals (ICP/MS)

Lab Sample ID: MB 240-438124/1-A
Matrix: Water
Analysis Batch: 438413

Client Sample ID: Method Blank
Prep Type: Total Recoverable
Prep Batch: 438124

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<5.00		5.00		ug/L		06/12/20 18:00	06/15/20 12:04	1
Iron	<200		200		ug/L		06/12/20 18:00	06/15/20 12:04	1

Lab Sample ID: LCS 240-438124/2-A
Matrix: Water
Analysis Batch: 438413

Client Sample ID: Lab Control Sample
Prep Type: Total Recoverable
Prep Batch: 438124

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Arsenic			1000	962.1		ug/L		96	80 - 120		
Iron			5000	4934		ug/L		99	80 - 120		

Metals

Prep Batch: 438124

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-131832-1	KARN INFLUENT	Total Recoverable	Water	3005A	
240-131832-2	KARN EFFLUENT	Total Recoverable	Water	3005A	
MB 240-438124/1-A	Method Blank	Total Recoverable	Water	3005A	
LCS 240-438124/2-A	Lab Control Sample	Total Recoverable	Water	3005A	

Analysis Batch: 438413

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-131832-1	KARN INFLUENT	Total Recoverable	Water	6020	438124
240-131832-2	KARN EFFLUENT	Total Recoverable	Water	6020	438124
MB 240-438124/1-A	Method Blank	Total Recoverable	Water	6020	438124
LCS 240-438124/2-A	Lab Control Sample	Total Recoverable	Water	6020	438124

Lab Chronicle

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-131832-1

Client Sample ID: KARN INFLUENT

Lab Sample ID: 240-131832-1

Date Collected: 06/05/20 12:30

Matrix: Water

Date Received: 06/12/20 09:40

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total Recoverable	Prep	3005A			438124	06/12/20 18:00	MRL	TAL CAN
Total Recoverable	Analysis	6020		1	438413	06/15/20 13:13	DSH	TAL CAN

Client Sample ID: KARN EFFLUENT

Lab Sample ID: 240-131832-2

Date Collected: 06/05/20 12:35

Matrix: Water

Date Received: 06/12/20 09:40

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total Recoverable	Prep	3005A			438124	06/12/20 18:00	MRL	TAL CAN
Total Recoverable	Analysis	6020		1	438413	06/15/20 13:15	DSH	TAL CAN

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396

Accreditation/Certification Summary

Client: Barr Engineering Company
Project/Site: Kern Treatment

Job ID: 240-131832-1

Laboratory: Eurofins TestAmerica, Canton

Unless otherwise noted, all analytes for this laboratory were covered under each accreditation/certification below.

Authority	Program	Identification Number	Expiration Date
Minnesota	NELAP	OH00048	12-31-20

The following analytes are included in this report, but the laboratory is not certified by the governing authority. This list may include analytes for which the agency does not offer certification.

Analysis Method	Prep Method	Matrix	Analyte
6020	3005A	Water	Arsenic
6020	3005A	Water	Iron

Eurofins TestAmerica, Chicago
2417 Bond Street
University Park, IL 60484
Phone: 708-534-5200 Fax: 708-534-5211

Project # 24023770

Chain of Custody Record

Grand Rapids
240508

1-7/26

eurofins | Environment Testing America

Client Information	Sampler: AWB	Lab PM: ~~Kintz, Robin M~~	Carrier Tracking No(s):	COC No: 500-82078-37512.3
Client Contact: ~~Charlene McCue~~ Jamie Edelyn	Phone: 616-325-0217	E-Mail: ~~[illegible]@testamericainc.com~~		Page: Page 3 of 5
Company: Barr Engineering Company				Job #:
Address: 4771 50th St SE	Due Date Requested:			
City: Grand Rapids	TAT Requested (days):			
State, Zip: MI, 49512				
Phone: 832-320-5362(Tel)	PO #: ~~4500323028~~			
Email: ~~[illegible]@barr.com~~ Jedelyn@barr.com	WO #: ~~WNFLD-BAR-05-22-20-CAM-01~~			
Project Name: ~~[illegible] WNFLD-BAR-05-22-20-CAM-01~~ Consumers Korn	Project #: ~~50017092~~ 24023770			
Site:	SSOW#:			

Analysis Requested

Preservation Codes:
A - HCL
B - NaOH
C - Zn Acetate
D - Nitric Acid
E - NaHSO4
F - MeOH
G - Amchlor
H - Ascorbic Acid
I - Ice
J - DI Water
K - EDTA
L - EDA
M - Hexane
N - None
O - AsNaO2
P - Na2O4S
Q - Na2SO3
R - Na2S2O3
S - H2SO4
T - TSP Dodecahydrate
U - Acetone
V - MCAA
W - pH 4-5
Z - other (specify)

Other:

Sample Identification	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	8260B - (MOD) MI DEQ	300 - Sulfate	2320B - Alkalinity	RSK_175 - Methane	200.7 - Dissolved Iron	8260B - VOC Client Custom List	Total Iron	Total Arsenic						Total Number of containers	Special Instructions/Note:
				Preservation Code:			A	N	N	A	D	A									
Korn Influent	6/5	1230	G	W									X	X							
Korn Effluent	6/5	1235	G	W									X	X							

240-131832 Chain of Custody

Possible Hazard Identification
☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown* ☐ *Radiological*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* ________ *Months*

Deliverable Requested: I, II, III, IV, Other (specify)

Special Instructions/QC Requirements:

Empty Kit Relinquished by:
Date: Drop off
Time:
Method of Shipment:

Relinquished by: Stone Peng	Date/Time: 6/11/2020 0830	Company: Barr	Received by: B Cr	Date/Time: 6/11/20 8:30	Company: TAL
Relinquished by: Fed Ex	Date/Time: 6-11-20 10:00 Am	Company: TAL	Received by:	Date/Time: 6/12/20 0940	Company: ETA
Relinquished by:	Date/Time:	Company:	Received by:	Date/Time:	Company:

Custody Seals Intact:
Δ Yes Δ No

Custody Seal No.:

Cooler Temperature(s) °C and Other Remarks:

Ver: 01/16/2019

Eurofins TestAmerica Canton Sample Receipt Form/Narrative
Canton Facility

Login # : 131832

Client Barr Eng Site Name ____
Cooler Received on 6/12/20 Opened on 6/12/20
Cooler unpacked by:
FedEx: 1st Grd [✓ Exp] UPS FAS Clipper Client Drop Off TestAmerica Courier Other ____
Receipt After-hours: Drop-off Date/Time ____ Storage Location ____
TestAmerica Cooler # CANTON Foam Box Client Cooler Box Other ____
Packing material used: Bubble Wrap Foam [✓ Plastic Bag] None Other ____
COOLANT: [✓ Wet Ice] Blue Ice Dry Ice Water None

1. Cooler temperature upon receipt ☐ See Multiple Cooler Form
IR GUN# IR-10 (CF +0.7 °C) Observed Cooler Temp. ____ °C Corrected Cooler Temp. ____ °C
IR GUN #IR-11 (CF +0.9°C) Observed Cooler Temp. 1.7 °C Corrected Cooler Temp. 2.6 °C
2. Were tamper/custody seals on the outside of the cooler(s)? If Yes Quantity 1 [✓ Yes] No
-Were the seals on the outside of the cooler(s) signed & dated? [✓ Yes] No NA
-Were tamper/custody seals on the bottle(s) or bottle kits (LLHg/MeHg)? Yes [✓ No]
-Were tamper/custody seals intact and uncompromised? [✓ Yes] No NA
3. Shippers' packing slip attached to the cooler(s)? [✓ Yes] No
4. Did custody papers accompany the sample(s)? [✓ Yes] No
5. Were the custody papers relinquished & signed in the appropriate place? [✓ Yes] No
6. Was/were the person(s) who collected the samples clearly identified on the COC? [✓ Yes] No
7. Did all bottles arrive in good condition (Unbroken)? [✓ Yes] No
8. Could all bottle labels be reconciled with the COC? [✓ Yes] No
9. Were correct bottle(s) used for the test(s) indicated? [✓ Yes] No
10. Sufficient quantity received to perform indicated analyses? [✓ Yes] No
11. Are these work share samples? Yes [✓ No]
If yes, Questions 12-16 have been checked at the originating laboratory.
12. Were all preserved sample(s) at the correct pH upon receipt? [✓ Yes] No NA pH Strip Lot# HC902937
13. Were VOAs on the COC? Yes [✓ No]
14. Were air bubbles >6 mm in any VOA vials? ● ⬅ Larger than this. Yes No [✓ NA]
15. Was a VOA trip blank present in the cooler(s)? Trip Blank Lot # ____ Yes [✓ No]
16. Was a LL Hg or Me Hg trip blank present? ____ Yes [✓ No]

Tests that are not checked for pH by Receiving:

VOAs
Oil and Grease
TOC

Contacted PM ____ Date ____ by ____ via Verbal Voice Mail Other

Concerning ____

17. CHAIN OF CUSTODY & SAMPLE DISCREPANCIES

Samples processed by: Ryan

18. SAMPLE CONDITION

Sample(s) ____ were received after the recommended holding time had expired.
Sample(s) ____ were received in a broken container.
Sample(s) ____ were received with bubble >6 mm in diameter. (Notify PM)

19. SAMPLE PRESERVATION

Sample(s) ____ were further preserved in the laboratory.
Time preserved: ____ Preservative(s) added/Lot number(s): ____

VOA Sample Preservation - Date/Time VOAs Frozen: ____

WI-NC-099

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6/12/2020

Login Container Summary Report

240-131832

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Temperature readings: ____________________

Client Sample ID	Lab ID	Container Type	Container		Preservative	
			pH	Temp	Added (mls)	Lot #
KARN INFLUENT	240-131832-A-1	Plastic 500ml - with Nitric Acid	<2			
KARN EFFLUENT	240-131832-A-2	Plastic 500ml - with Nitric Acid	<2			

Page 1 of 1

Appendix C-2c

July 2020 Laboratory Groundwater Extraction System Data Report

eurofins

Environment Testing America

ANALYTICAL REPORT

Eurofins TestAmerica, Canton
4101 Shuffel Street NW
North Canton, OH 44720
Tel: (330)497-9396

Laboratory Job ID: 240-133662-1
Client Project/Site: DE Karn Project #: 22/09-1015

For:
Barr Engineering Company
4300 MarketPoint Drive
Suite 200
Minneapolis, Minnesota 55435

Attn: Dana Pasi

Leslie A Howell

Authorized for release by:
7/23/2020 5:27:56 PM

Leslie Howell, Project Manager I
(330)966-9266
Leslie.Howell@Eurofinset.com

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

LINKS

Review your project results through TotalAccess

Have a Question? Ask The Expert

Visit us at: www.eurofinsus.com/Env

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Table of Contents

Definitions/Glossary

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Job ID: 240-133662-1

Laboratory: Eurofins TestAmerica, Canton

Narrative

Job Narrative
240-133662-1

Comments
No additional comments.

Receipt
The samples were received on 7/18/2020 10:00 AM; the samples arrived in good condition, and where required, properly preserved and on ice. The temperature of the cooler at receipt was 4.7° C.

Metals
No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Method Summary

Method	Method Description	Protocol	Laboratory
6020B	Metals (ICP/MS)	SW846	TAL CAN
3005A	Preparation, Total Recoverable or Dissolved Metals	SW846	TAL CAN

Protocol References:

SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396

Sample Summary

Lab Sample ID	Client Sample ID	Matrix	Collected	Received	Asset ID
240-133662-1	KARN INFLUENT	Water	07/17/20 10:30	07/18/20 10:00	
240-133662-2	KARN EFFLUENT	Water	07/17/20 10:40	07/18/20 10:00	

Detection Summary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133662-1

Client Sample ID: KARN INFLUENT

Lab Sample ID: 240-133662-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	187		5.00		ug/L	1		6020B	Total Recoverable
Iron	1550		200		ug/L	1		6020B	Total Recoverable

Client Sample ID: KARN EFFLUENT

Lab Sample ID: 240-133662-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	199		5.00		ug/L	1		6020B	Total Recoverable
Iron	2920		200		ug/L	1		6020B	Total Recoverable

This Detection Summary does not include radiochemical test results.

Client Sample Results

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133662-1

Client Sample ID: KARN INFLUENT

Lab Sample ID: 240-133662-1

Date Collected: 07/17/20 10:30

Matrix: Water

Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**187**		5.00		ug/L		07/21/20 17:00	07/22/20 12:11	1
Iron	**1550**		200		ug/L		07/21/20 17:00	07/22/20 12:11	1

Client Sample ID: KARN EFFLUENT
Date Collected: 07/17/20 10:40
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133662-2
Matrix: Water

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**199**		5.00		ug/L		07/21/20 17:00	07/22/20 12:13	1
Iron	**2920**		200		ug/L		07/21/20 17:00	07/22/20 12:13	1

Method: 6020B - Metals (ICP/MS)

Lab Sample ID: MB 240-443505/1-A
Matrix: Water
Analysis Batch: 443761

Client Sample ID: Method Blank
Prep Type: Total Recoverable
Prep Batch: 443505

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<5.00		5.00		ug/L		07/21/20 17:00	07/22/20 11:42	1
Iron	<200		200		ug/L		07/21/20 17:00	07/22/20 11:42	1

Lab Sample ID: LCS 240-443505/3-A
Matrix: Water
Analysis Batch: 443761

Client Sample ID: Lab Control Sample
Prep Type: Total Recoverable
Prep Batch: 443505

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	1000	1004		ug/L		100	80 - 120
Iron	5000	4994		ug/L		100	80 - 120

QC Association Summary

Client: Barr Engineering Company
Job ID: 240-133662-1
Project/Site: DE Karn Project #: 22/09-1015

Metals

Prep Batch: 443505

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133662-1	KARN INFLUENT	Total Recoverable	Water	3005A	
240-133662-2	KARN EFFLUENT	Total Recoverable	Water	3005A	
MB 240-443505/1-A	Method Blank	Total Recoverable	Water	3005A	
LCS 240-443505/3-A	Lab Control Sample	Total Recoverable	Water	3005A	

Analysis Batch: 443761

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133662-1	KARN INFLUENT	Total Recoverable	Water	6020B	443505
240-133662-2	KARN EFFLUENT	Total Recoverable	Water	6020B	443505
MB 240-443505/1-A	Method Blank	Total Recoverable	Water	6020B	443505
LCS 240-443505/3-A	Lab Control Sample	Total Recoverable	Water	6020B	443505

Lab Chronicle

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133662-1

Client Sample ID: KARN INFLUENT

Lab Sample ID: 240-133662-1

Date Collected: 07/17/20 10:30
Date Received: 07/18/20 10:00

Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total Recoverable	Prep	3005A			443505	07/21/20 17:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 12:11	DSH	TAL CAN

Client Sample ID: KARN EFFLUENT

Lab Sample ID: 240-133662-2

Date Collected: 07/17/20 10:40
Date Received: 07/18/20 10:00

Matrix: Water

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total Recoverable	Prep	3005A			443505	07/21/20 17:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 12:13	DSH	TAL CAN

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396

Accreditation/Certification Summary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133662-1

Laboratory: Eurofins TestAmerica, Canton

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
California	State	2927	02-23-21
Connecticut	State	PH-0590	12-31-21
Florida	NELAP	E87225	06-30-21
Georgia	State	4062	02-23-21
Illinois	NELAP	004498	07-31-20
Iowa	State	421	06-01-21
Kansas	NELAP	E-10336	04-30-21
Kentucky (UST)	State	112225	02-23-21
Kentucky (WW)	State	KY98016	12-31-20
Minnesota	NELAP	OH00048	12-31-20
Minnesota (Petrofund)	State	3506	08-01-21
New Jersey	NELAP	OH001	06-30-21
New York	NELAP	10975	03-31-21
Ohio VAP	State	CL0024	06-05-21
Oregon	NELAP	4062	02-24-21
Pennsylvania	NELAP	68-00340	08-31-20
Texas	NELAP	T104704517-18-10	08-31-20
USDA	US Federal Programs	P330-18-00281	09-17-21
Virginia	NELAP	010101	09-14-20
Washington	State	C971	01-12-21
West Virginia DEP	State	210	12-31-20

3.8/4.7

Barr Engineering Co. Chain of Custody

BARR

☐ Ann Arbor ☐ Duluth ☐ Hibbing ☐ Minneapolis
☐ Bismarck ☐ Grand Rapids ☐ Jefferson City ☐ Salt Lake City

Sample Origination State:
☐ KS ☐ MO ☐ UT
☒ MI ☐ ND ☐ WI
☐ MN ☐ SD Other: ____

COC Number: **56649**

COC 1 of 1

REPORT TO		INVOICE TO	
Company:	Barr Engineering	Company:	Same
Address:	4771 50th St	Address:	
Name:	~~AB~~ Jamie Edelyn	Name:	
email:	Jedelyn@barr.com	email:	
Copy to:	datamgt@barr.com	P.O.	
Project Name:	Karn GSI System	Barr Project No:	

Matrix Code:
GW = Groundwater
SW = Surface Water
WW = Waste Water
DW = Drinking Water
S = Soil/Solid
SD = Sediment
O = Other

Preservative Code:
A = None
B = HCl
C = HNO_3
D = H_2SO_4
E = NaOH
F = MeOH
G = $NaHSO_4$
H = $Na_2S_2O_3$
I = Ascorbic Acid
J = NH_4Cl
K = Zn Acetate
O = Other

Preservative Code

Field Filtered Y/[✓ N]

Location	Sample Depth Start	Sample Depth Stop	Unit (m./ft. or in.)	Collection Date (mm/dd/yyyy)	Collection Time (hh:mm)	Matrix Code	Perform MS/MSD Y / N	Total Number Of Containers	Analysis Requested: Water: Total Fe	Total Arsenic					Soil					% Solids
1. Karn Influent				07/17/2020	1030	W	N	1	X	X										
2. Karn Effluent				07/17/2020	1040	W	N	1	X	X										
3.																				
4.																				
5.																				
6.																				
7.																				
8.																				
9.																				
10.																				

240-133662 Chain of Custody

MICHIGAN
190

BARR USE ONLY
Sampled by: AWB
Barr Proj. Manager: Jamie Edelyn
Barr DQ Manager: DLB
Lab Name: Test America
Lab Location: North Canton, OH

Relinquished by:	On Ice?	Date	Time	Received by:	Date	Time
	[✓ Y] N	7/17/20	1100		7/17/20	1100
	[✓ Y] N	7/17/20	1605	Jen Hall	7/17/20	1604

Samples Shipped VIA: ☐ Courier ☒ Federal Express ☒ Sampler
☐ Other: ____

Air Bill Number:

Requested Due Date:
☐ Standard Turn Around Time
☐ Rush ____ (mm/dd/yyyy)

Lab WO:

Temperature on Receipt (°C):

Custody Seal Intact? ☐ Y ☐ N ☐ None

H:RLG\STDFORMS\Chain Of Custody Form 2015 RLG Rev. 01/02/18

Eurofins TestAmerica Canton Sample Receipt Form/Narrative **Login # :** 133662
Canton Facility

Client Barr Engineering Site Name ______ Cooler unpacked by:
Cooler Received on 7-18-20 Opened on 7-18-20
FedEx: 1st Grd [✓ Exp] UPS FAS Clipper Client Drop Off TestAmerica Courier Other ______
Receipt After-hours: Drop-off Date/Time ______ Storage Location ______

TestAmerica Cooler # TA Foam Box Client Cooler Box Other ______
Packing material used: Bubble Wrap Foam [✓ Plastic Bag] None Other ______
COOLANT: [✓ Wet Ice] Blue Ice Dry Ice Water None

1. Cooler temperature upon receipt ☐ See Multiple Cooler Form
IR GUN# IR-10 (CF **+0.7** °C) Observed Cooler Temp. ______ °C Corrected Cooler Temp. ______ °C
IR GUN #IR-11 (CF **+0.9**°C) Observed Cooler Temp. 3.8 °C Corrected Cooler Temp. 4.7 °C

2. Were tamper/custody seals on the outside of the cooler(s)? If Yes Quantity 1 [✓ Yes] No
-Were the seals on the outside of the cooler(s) signed & dated? [✓ Yes] No NA
-Were tamper/custody seals on the bottle(s) or bottle kits (LLHg/MeHg)? Yes [✓ No]
-Were tamper/custody seals intact and uncompromised? [✓ Yes] No NA
3. Shippers' packing slip attached to the cooler(s)? [✓ Yes] No
4. Did custody papers accompany the sample(s)? [✓ Yes] No
5. Were the custody papers relinquished & signed in the appropriate place? ~~Yes~~ [✓ No]
6. Was/were the person(s) who collected the samples clearly identified on the COC? [✓ Yes] No
7. Did all bottles arrive in good condition (Unbroken)? [✓ Yes] No
8. Could all bottle labels be reconciled with the COC? [✓ Yes] No
9. Were correct bottle(s) used for the test(s) indicated? [✓ Yes] No
10. Sufficient quantity received to perform indicated analyses? [✓ Yes] No
11. Are these work share samples? Yes [✓ No]
If yes, Questions 12-16 have been checked at the originating laboratory.
12. Were all preserved sample(s) at the correct pH upon receipt? [✓ Yes] No NA pH Strip Lot# HC911298
13. Were VOAs on the COC? Yes [✓ No]
14. Were air bubbles >6 mm in any VOA vials? ● ⬅ Larger than this. Yes [✓ No] NA
15. Was a VOA trip blank present in the cooler(s)? Trip Blank Lot #______ Yes [✓ No]
16. Was a LL Hg or Me Hg trip blank present? ______ Yes [✓ No]

Tests that are not checked for pH by Receiving:

VOAs
Oil and Grease
TOC

Contacted PM ______ Date ______ by ______ via Verbal Voice Mail Other
Concerning ______

17. CHAIN OF CUSTODY & SAMPLE DISCREPANCIES Samples processed by:

18. SAMPLE CONDITION
Sample(s) ______ were received after the recommended holding time had expired.
Sample(s) ______ were received in a broken container.
Sample(s) ______ were received with bubble >6 mm in diameter. (Notify PM)

19. SAMPLE PRESERVATION

Sample(s) ______ were further preserved in the laboratory.
Time preserved: ______ Preservative(s) added/Lot number(s): ______

VOA Sample Preservation - Date/Time VOAs Frozen: ______

WI-NC-099

7/20/2020

Login Container Summary Report

240-133662

Temperature readings: ______________________________

Client Sample ID	Lab ID	Container Type	pH	Container Temp	Preservative Added (mls)	Lot #
KARN INFLUENT	240-133662-A-1	Plastic 500ml - with Nitric Acid	<2			
KARN EFFLUENT	240-133662-A-2	Plastic 500ml - with Nitric Acid	<2			

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Appendix C-3

Groundwater Extraction System Data QA/QC Review

Appendix C-3:

Groundwater Extraction System Data Quality Assurance/Quality Control Review

A review of the quality control data was conducted to assess the validity of the analytical results for the influent and effluent water samples collected in November 2019, June 2020, and July 2020 at the DE Karn Generating Facility, located in Essexville, Michigan. This review was performed in accordance with Barr Engineering Co.'s Standard Operating Procedures for data evaluation, which are based on *The National Functional Guidelines for Organic and Inorganic Data Review* (USEPA, 2008 and 2010). The analyses were performed by Eurofins TestAmerica located in Canton, Ohio. This data evaluation discusses sample data contained within the work orders 240-123028-1, 240-131832-1, and 240-133662-1.

Laboratory analytical procedures were evaluated by assessing technical holding times, sample preservation methods, method blank samples, accuracy and precision data, and data package completeness.

Laboratory Procedures

Technical holding times and preservation were evaluated for each sample and target parameter based on United States Environmental Protection Agency and method recommendations. The technical holding times were acceptable for the majority of the water analyses, apart from biological oxygen demand for the July samples, which exceeded the recommended holding time and were qualified "H" as holding time exceeded.

Method blanks were analyzed by the laboratory for each parameter. No target compounds were detected above the reporting limit in the method blank samples.

The accuracy and precision data review included evaluation of laboratory control spike (LCS), matrix spike (MS), and matrix spike duplicate (MSD) samples. Accuracy was evaluated by comparing laboratory percent recoveries from LCS, MS, and MSD samples to laboratory acceptance criteria. Precision was evaluated by calculating the relative percent difference of the MS/MSD sample pairs.

The LCS samples displayed acceptable accuracy when compared to the laboratory acceptance criteria.

The laboratory utilized project samples as needed for MS/MSD evaluation when sufficient sample volume was available. Only the MS/MSD samples taken from project samples may be evaluated compared to project data. The MS/MSDs displayed accuracy and/or precision within laboratory acceptance criteria.

Data completeness was evaluated by comparing the analyses requested with the data package as received. The samples were analyzed in accordance with the chain-of-custody, so the data package was considered complete.

Conclusion

The data are deemed acceptable for the purposes of this project with the qualification assigned during the data evaluation process.

References

United States Environmental Protection Agency (USEPA), 2008. *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review*. EPA QA/R-5. 2008

United States Environmental Protection Agency (USEPA), 2010. *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Inorganic Methods Data Review*. EPA QA/R-5. 2010

Appendix D

Detailed Cost Estimates

Table D1 - Groundwater Extraction System Cost Estimate
D.E. Karn Generating Facility
Consumers Energy Company

Item Number	Description	Unit	Estimated Unit Cost	Estimated Quantity	Subtotal
Mobilization/Demobilization					
1	Contractor	LS	$50,000	1	$50,000
	Subtotal - Mobilization/Demobilization				**$50,000**
Extraction System Installation and Equipment					
2	Installation of Extraction Wells	EA	$30,000	7	$210,000
3	Extraction Pumps	EA	$1,400	7	$10,000
4	Level Controls and PLC	EA	$7,500	7	$53,000
5	Level Measurement Capabilities in Piezometers	EA	$5,000	11	$55,000
6	Remote Access to PLC	LS	$10,000	1	$10,000
	Subtotal - Extraction System Installation and Equipment				**$340,000**
Groundwater Treatment Building					
7	Pre-Engineered Treatment Building with Equipment Installation	SF	$180	500	$90,000
8	1500-Gallon Treatment Tanks	EA	$1,300	2	$3,000
9	Groundwater Treatment System Controls	LS	$40,000	1	$40,000
	Subtotal - Groundwater Treatment Building				**$140,000**
Electrical Power					
10	Groundwater Recovery Pumps	YR	$3,000	30	$90,000
11	Transfer Pump	YR	$700	30	$21,000
12	Blower	YR	$400	30	$12,000
13	Electric Space Heater	YR	$1,400	30	$42,000
14	General Lighting and Power Use	YR	$300	30	$9,000
	Subtotal - Electrical Power				**$180,000**
Supplies					
15	5 Micron Bag Filters	YR	$1,000	30	$30,000
16	25 Micron Bag Filters	YR	$1,000	30	$30,000
17	Ferric Chloride	YR	$400	30	$12,000
	Subtotal - Supplies				**$72,000**
Operation, Routine Maintenance and Tracking					
18	Routine O&M Labor	YR	$130,000	30	$3,900,000
19	Annual NPDES Fee	YR	$1,700	30	$51,000
20	Monthly Influent and Effluent Sampling Analytical Costs	YR	$3,300	30	$99,000
21	Monthly Water Levels/Tank Sediment Removal	YR	$22,000	30	$660,000
22	Travel for Routine O&M and Monthly Events	YR	$31,000	30	$930,000
23	Extraction Well Pump Cleaning	YR	$8,900	30	$270,000
24	Yearly Cell Phone Contract	YR	$600	30	$18,000
25	Data Tracking	YR	$11,000	30	$330,000
26	System Performance Monitoring	YR	$27,000	30	$810,000
27	Groundwater Monitoring	YR	$70,000	30	$2,100,000
28	Project Oversight	YR	$23,000	30	$690,000
	Subtotal - Operation, Routine Maintenance and Tracking				**$9,900,000**
Non-Routine Maintenance Allowances					
29	Non-Routine Maintenance Site Visits	YR	$12,600	30	$380,000
30	NPDES permit applications (every 5 years)	EA	$7,500	6	$45,000
31	Equipment Replacement Expenses	YR	$10,000	30	$300,000
	Subtotal - Non-Routine Maintenance Allowances				**$730,000**
Engineering & Administration					
32	Engineering, Permitting, CQA, Reporting	LS	$90,000	1	$90,000
	Subtotal - Engineering & Administration Costs				**$90,000**
Total Costs:					**$12,000,000**
High End Estimate of Costs (+50%)					**$18,000,000**
Low End Estimate of Costs (-30%)					**$8,000,000**

General notes and assumptions:

Costs are based on conservative assumptions. Potential variability in the assumptions that were used to develop these cost estimates are reflected in the range of costs that have been applied to the final estimated value and are intended to bracket expected construction costs. The range that has been applied is consistent with the Association for the Advancement of Cost Engineering Class 4 cost estimate, with an expected accuracy range of -30 percent to +50 percent of the final estimated value.

The following assumptions were made in developing the cost estimate:

- Contractor mobilization costs were assumed to be 10% of extraction well installation and treatment system construction costs
- Engineering fees were estimated to be 15% of the total contractor costs
- The six existing extraction wells at the site will be abandoned
- Seven new extraction wells will be installed along the northern perimeter dike to capture groundwater flow
- The new extraction wells will tie into the existing transmission piping at the site
- Existing treatment system equipment located in the equipment building will be retained for use in the new extraction and treatment system
- Two 1,500 gallon treatment tanks will be installed to allow for adequate residence time of groundwater during treatment
- A new treatment building will be required to house the large groundwater treatment tanks
- Bench testing and pilot testing would be conducted before design and installation of the treatment system which may result in changes to the treatment system design and operation and resulting cost estimates
- Power will cost $0.08/kW-hr
- A total of 168 routine and non-routine site visits will be conducted annually for the duration of the operation period
- Water level measurements and sediment removal will be performed monthly
- Extraction well cleaning will be required monthly
- Sediments from treatment system will be disposed on site
- The post-closure monitoring period of the Karn Landfill will be 30 years and include quarterly to semi-annual groundwater monitoring

Table D2 - Air Sparging Cost Estimate
D.E. Karn Generating Facility
Consumers Energy Company

Item Number	Description	Unit	Estimated Unit Cost	Estimated Quantity	Subtotal
Mobilization/Demobilization					
1	Contractor Costs	LS	$220,000	1	$220,000
	Subtotal - Mobilization/Demobilization				**$220,000**
Installation and Material Costs					
2	One Pass Trenching per 200-foot Air Sparge Gallery	EA	$72,000	15	$1,100,000
3	Support Equipment for Trenching Machine	HR	$700	120	$84,000
4	Work Bench	LF	$13	3,000	$39,000
5	3" HDPE Blower Transmission Line	LF	$16	11,400	$190,000
6	Sand/Gravel Backfill	CY	$20	7,800	$160,000
7	Cleanout Installation	EA	$4,100	15	$62,000
8	Transportation of Excavated Material, Disposal at Weadock Landfill	CY	$4	7,800	$32,000
	Subtotal - Installation and Material Costs				**$1,700,000**
Air Sparging Equipment and Installation					
9	60 HP Electrical Compressor with Installation	LS	$50,000	1	$50,000
10	Prefab metal building with HVAC	LS	$17,000	1	$17,000
11	Electrical and Mechanical Equipment with Installation	LS	$75,000	1	$75,000
12	Pressure Swing Adsorption Unit with Installation	LS	$280,000	1	$280,000
	Subtotal - Air Sparging Equipment and Installation				**$430,000**
Operation, Routine Maintenance and Tracking					
13	Routine O&M	YR	$37,000	30	$1,110,000
14	Data Tracking and Project Oversight	MO	$1,740	360	$630,000
15	Air Compressor Rental for Cleaning the Galleries	YR	$315	30	$9,500
16	Pressure Swing Adsorption Unit Maintenance	YR	$7,000	30	$210,000
17	Groundwater Monitoring	YR	$70,000	30	$2,100,000
18	Equipment Replacement Expenses	YR	$10,000	30	$300,000
	Subtotal - Operation, Routine Maintenance and Tracking				**$4,400,000**
Electrical Power					
19	60 HP Compressor	YR	$54,000	30	$1,700,000
20	Pressure Swing Adsorption Unit	YR	$313,000	30	$9,400,000
21	Electric Space Heater	YR	$1,400	30	$42,000
22	General Lighting and Power Use	YR	$300	30	$9,000
	Subtotal - Electrical Power				**$11,200,000**
Engineering & Administration					
23	Engineering, Permitting, CQA, Reporting	LS	$360,000	1	$360,000
	Subtotal - Engineering & Administration Costs				**$360,000**

Total Costs:	**$19,000,000**
High End Estimate of Costs (+50%)	**$29,000,000**
Low End Estimate of Costs (-30%)	**$13,000,000**

General notes and assumptions:

Costs are based on conservative assumptions. Potential variability in the assumptions that were used to develop these cost estimates are reflected in the range of costs that have been applied to the final estimated value and are intended to bracket expected construction costs. The range that has been applied is consistent with the Association for the Advancement of Cost Engineering Class 4 cost estimate, with an expected accuracy range of -30 percent to +50 percent of the final estimated value.

The following assumptions were made in developing the cost estimate:

- Mobilization/demobilization fees were estimated at 10% of the total contractor costs
- Engineering fees were estimated to be 15% of the total contractor costs
- Excavated material can be dewatered on the berm and construction of a dewatering pad will not be required
- Material removed from the Karn Landfill will be transported to Consumers' Weadock Landfill for disposal and grading
- The air sparging trench will be constructed using a one-pass method
- The air sparging trench and work bench will be backfilled with sand and gravel
- The air sparging trench will be 20 feet deep by 2 feet wide by 3,000 feet long
- A bench will be constructed along the length of the trench
- Other significant site preparations will not be required for the trenching equipment
- Air will be supplied using a 60 HP compressor and blower unit, and the PSA unit will feed the purified oxygen stream into this compressor and blower unit.
- The air sparging equipment building will be centrally located along the trench
- The trench will be installed along the perimeter dike in the vicinity of Transects 2, 3, 4, and 5
- Routine O&M includes three, 10-hour monthly site visits and yearly cleaning of the air sparging galleries
- The system will operate continuously 24 hours a day for 30 years
- The post-closure monitoring period of the Karn Landfill will be 30 years and include quarterly groundwater monitoring

Table D3 - Permeable Reactive Barrier Cost Estimate
D.E. Karn Generating Facility
Consumers Energy Company

Item Number	Description	Unit	Estimated Unit Cost	Estimated Quantity	Subtotal
Mobilization/Demobilization					
1	Contractor Costs	LS	$250,000	1	$250,000
	Subtotal - Mobilization/Demobilization				**$250,000**
Installation Costs					
2	One-Pass Trenching	LS	$315	3,000	$950,000
3	Support Equipment for Trenching Machine	HR	$700	120	$84,000
4	Work Bench	LF	$13	3,000	$39,000
5	Pea Gravel	CY	$33	4,000	$140,000
6	Zero Valent Iron	TN	$1,400	600	$840,000
7	Sand/Gravel Cover	CY	$20	1,700	$40,000
8	Transportation of Excavated Material, Disposal at Third Party Landfill	CY	$47	7,500	$360,000
	Subtotal - Installation Costs				**$2,500,000**
PRB Refreshment Costs					
9	Mobilization/Demobilization	EA	$250,000	2	$500,000
10	Installation Costs	EA	$2,500,000	2	$5,000,000
	Subtotal - PRB Refreshment Costs				**$5,500,000**
Operation, Routine Maintenance and Tracking					
11	Groundwater Monitoring	YR	$70,000	30	$2,100,000
12	Project Oversight	MO	$1,300	360	$470,000
	Subtotal - Operation, Routine Maintenance and Tracking				**$2,600,000**
Engineering & Administration					
13	Engineering, Permitting, CQA, Reporting	LS	$500,000	1	$500,000
	Subtotal - Engineering & Administration Costs				**$500,000**

Total Costs:	**$12,000,000**
High End Estimate of Costs (+50%)	**$18,000,000**
Low End Estimate of Costs (-30%)	**$8,000,000**

General notes and assumptions:

Costs are based on conservative assumptions. Potential variability in the assumptions that were used to develop these cost estimates are reflected in the range of costs that have been applied to the final estimated value and are intended to bracket expected construction costs. The range that has been applied is consistent with the Association for the Advancement of Cost Engineering Class 4 cost estimate, with an expected accuracy range of -30 percent to +50 percent of the final estimated value.

The following assumptions were made in developing the cost estimate:

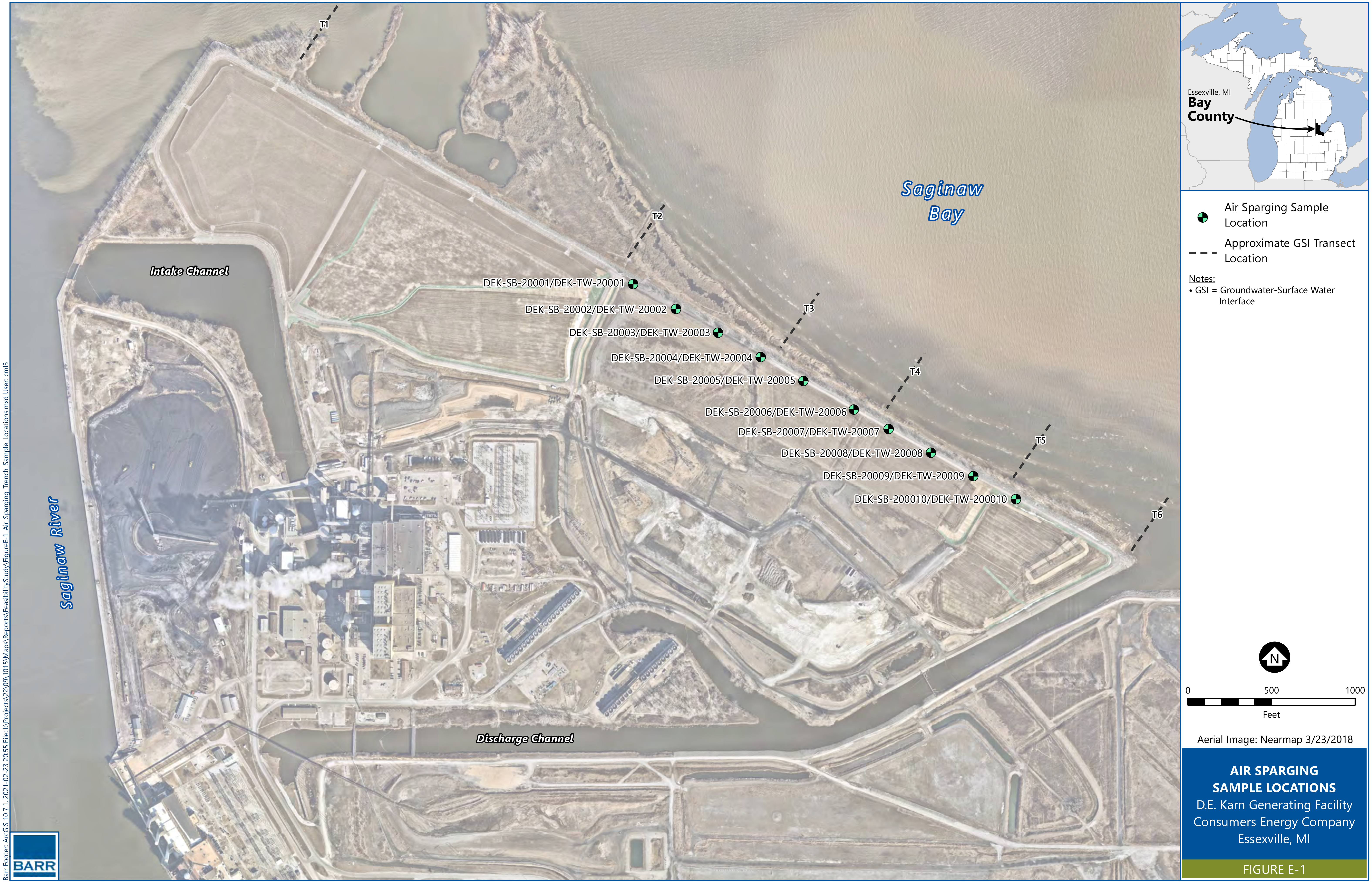
- Mobilization/demobilization fees were estimated at 10% of the total contractor costs
- Engineering fees were estimated to be 15% of the total contractor costs
- The Permeable Reactive Barrier (PRB) will be 3,000 ft long by 25 ft deep by 1.5 feet wide
- Material excavated during the PRB trench installation will be transported to Consumers' Weadock landfill for disposal and grading
- The PRB will be constructed using a one-pass method
- The PRB will consist of pea gravel mixed Zero Valent Iron (ZVI) filings at 10% by weight ratio
- The pea gravel and ZVI will be mixed onsite by a front end loader before being loaded into the trenching equipment
- The lifespan of the ZVI will be 10 years, after which the PRB will be replaced in kind
- A work bench will be constructed along the trench that is 2 feet deep by 15 feet wide
- The PRB backfill material will extend up to 1-foot below the ground surface and 1-foot of cover material will be placed overtop
- Other significant site preparations will not be required for the trenching equipment
- The PRB will be installed along the perimeter dike in the vicinity of Transects 2, 3, 4, and 5
- The PRB will be keyed into the underlying native clay unit
- The post-closure monitoring period of the Karn Landfill will be 30 years and include quarterly groundwater monitoring

Appendix E

Air Sparging Data

Appendix E-1

Air Sparging Sample Locations



Notes:
- GSI = Groundwater-Surface Water Interface

Aerial Image: Nearmap 3/23/2018

AIR SPARGING SAMPLE LOCATIONS
D.E. Karn Generating Facility
Consumers Energy Company
Essexville, MI

FIGURE E-1

BARR

Barr Footer: ArcGIS 10.7.1, 2021-02-23 20:55 File: I:\Projects\22\09\1015\Maps\Reports\FeasibilityStudy\FigureE-1_Air_Sparging_Trench_Sample_Locations.mxd User: cml3

Appendix E-2

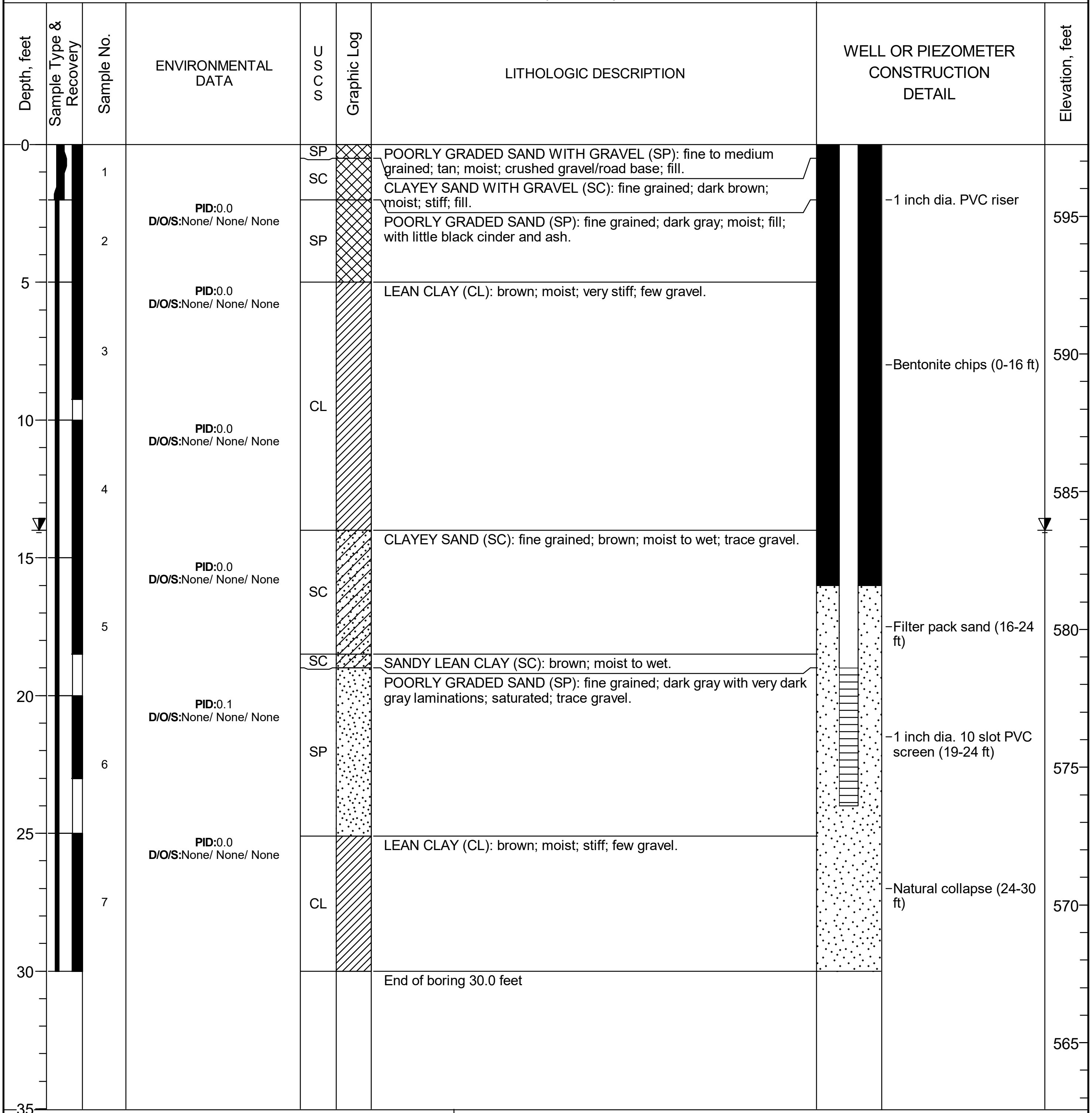
Boring Logs

BARR
Barr Engineering Company
3005 Boardwalk St, Suite 100
Ann Arbor, MI 48108
Telephone: 734-922-4400

LOG OF BORING DEK-SB-20001

SHEET 1 OF 1

Project: Consumers DE Karn Corrective Action
Project No.: 22/091015.01
Location: Essexville, MI
Coordinates: N 783,648.0 ft E 13,264,161.0 ft
Datum: NAD83 MI State Plane South International Feet
Surface Elevation: 597.6 ft
Drilling Method: Direct Push
Sampling Method: Continuous
Completion Depth: 30.0 ft
Top of Casing Elev.: 598.8 ft
Unique Well No.: DEK-TW-20001



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D/O/S:None/ None/ None

PID:0.0
D/O/S:None/ None/ None

POORLY GRADED SAND WITH GRAVEL (SP): fine to medium grained; tan; moist; crushed gravel/road base; fill.

CLAYEY SAND WITH GRAVEL (SC): fine grained; dark brown; moist; stiff; fill.

POORLY GRADED SAND (SP): fine grained; dark gray; moist; fill; with little black cinder and ash.

LEAN CLAY (CL): brown; moist; very stiff; few gravel.

CLAYEY SAND (SC): fine grained; brown; moist to wet; trace gravel.

SANDY LEAN CLAY (SC): brown; moist to wet.

POORLY GRADED SAND (SP): fine grained; dark gray with very dark gray laminations; saturated; trace gravel.

LEAN CLAY (CL): brown; moist; stiff; few gravel.

End of boring 30.0 feet

-1 inch dia. PVC riser

-Bentonite chips (0-16 ft)

-Filter pack sand (16-24 ft)

-1 inch dia. 10 slot PVC screen (19-24 ft)

-Natural collapse (24-30 ft)

Date Boring Started: 7/14/20 10:45 am
Date Boring Completed: 7/14/20 11:30 am
Logged By: AMS3
Drilling Contractor: FiberTec
Drill Rig: Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20001 (22-25') collected at 11:45 AM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
Additional data may have been collected in the field which is not included on this log.

BARR

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Telephone: 734-922-4400

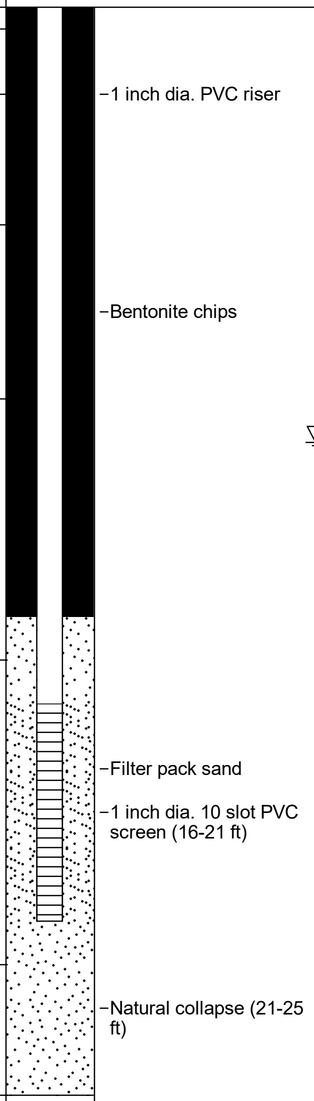
LOG OF BORING DEK-SB-20002

SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	593.1 ft	Top of Casing Elev.:	595.4 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push	Unique Well No.:	DEK-TW-20002
Location:	Essexville, MI	Sampling Method:	Continuous		
Coordinates:	N 783,501.0 ft E 13,264,417.0 ft	Completion Depth:	25.0 ft		
Datum:	NAD83 MI State Plane South International Feet				

Depth, feet	Sample No.	ENVIRONMENTAL DATA	USCS	LITHOLOGIC DESCRIPTION	Elevation, feet
0	1		SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.	
			CL	SANDY LEAN CLAY (CL): dark brown; moist; stiff; trace gravel; fill.	
	2	**PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine grained; dark gray; moist; fill; with black cinder and ash.	590
5	3	**PID:**0.0 **D/O/S:**None/ None/ None	CL	LEAN CLAY (CL): brown; moist; very stiff; trace sand and gravel; fill. Little cinders and ash from 8-8.5 ft.	585
10	4	**PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; tan; moist to wet; trace gravel.	580
15 20	5	**PID:**0.0 **D/O/S:**None/ None/ None **PID:**0.2 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine grained; dark gray with very dark gray laminations; saturated; trace gravel.	575
	6		CL	LEAN CLAY (CL): brown; moist; stiff; little silt; trace gravel.	570
25				End of boring 25.0 feet	565
30					

WELL OR PIEZOMETER CONSTRUCTION DETAIL



Date Boring Started:	7/14/20 1:15 pm
Date Boring Completed:	7/14/20 1:45 pm
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20002 (21-23') collected at 1:50 PM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
Additional data may have been collected in the field which is not included on this log.

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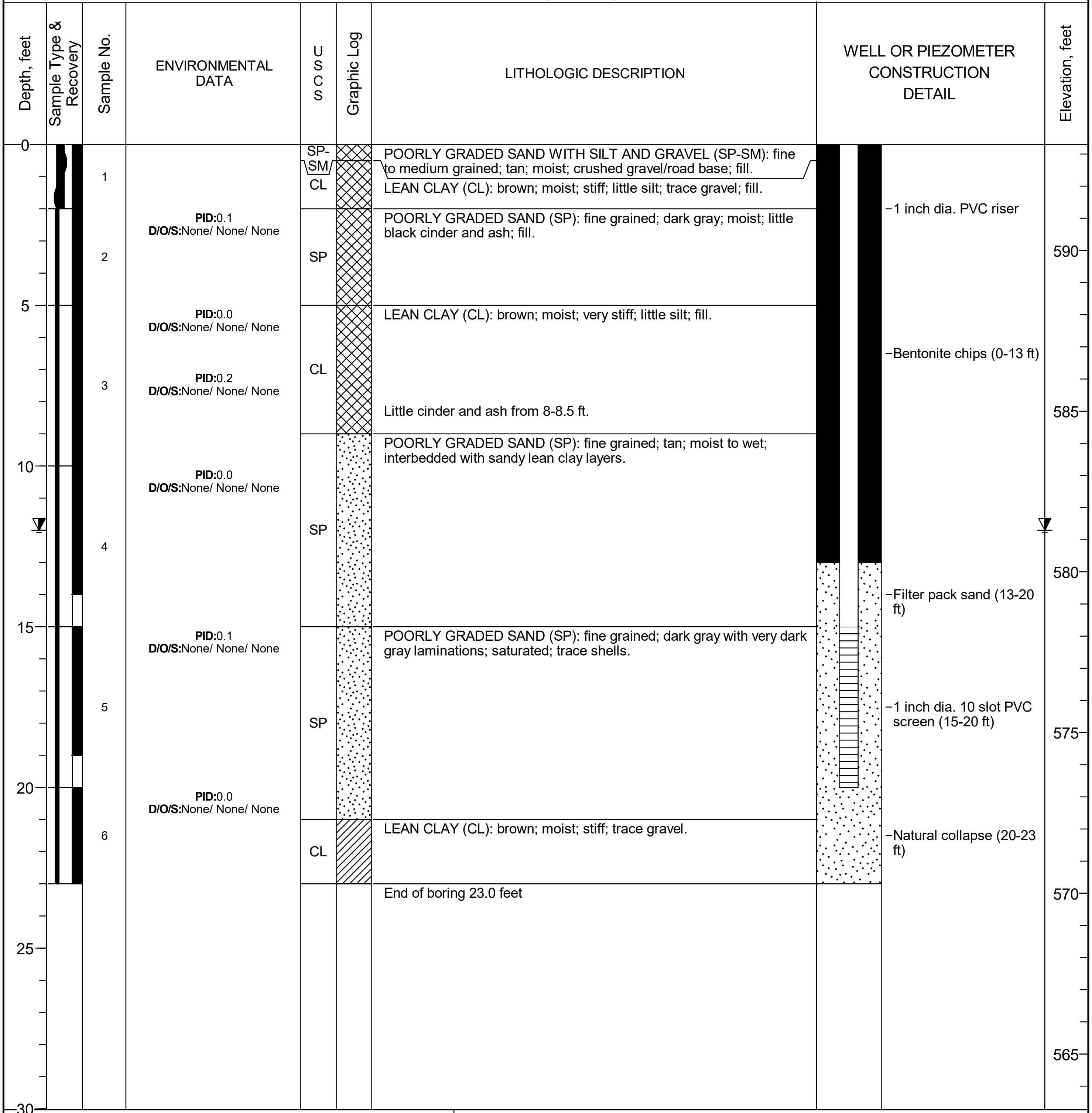
LOG OF BORING DEK-SB-20003

SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	593.3 ft	Top of Casing Elev.: 595.9 ft	
Project No.:	22/091015.01	Drilling Method:	Direct Push	Unique Well No.: DEK-TW-20003	
Location:	Essexville, MI	Sampling Method:	Continuous		
Coordinates:	N 783,358.0 ft E 13,264,670.0 ft	Completion Depth:	23.0 ft		
Datum:	NAD83 MI State Plane South International Feet				



Sample No.	ENVIRONMENTAL DATA	USCS	LITHOLOGIC DESCRIPTION
1		SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.
		CL	LEAN CLAY (CL): brown; moist; stiff; little silt; trace gravel; fill.
2	**PID:**0.1 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine grained; dark gray; moist; little black cinder and ash; fill.
3	**PID:**0.0 **D/O/S:**None/ None/ None **PID:**0.2 **D/O/S:**None/ None/ None	CL	LEAN CLAY (CL): brown; moist; very stiff; little silt; fill. Little cinder and ash from 8-8.5 ft.
4	**PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine grained; tan; moist to wet; interbedded with sandy lean clay layers.
5	**PID:**0.1 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine grained; dark gray with very dark gray laminations; saturated; trace shells.
6	**PID:**0.0 **D/O/S:**None/ None/ None	CL	LEAN CLAY (CL): brown; moist; stiff; trace gravel.
			End of boring 23.0 feet

Date Boring Started:	7/14/20 2:45 pm
Date Boring Completed:	7/14/20 3:30 pm
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20003 (15-17') collected at 3:20 PM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
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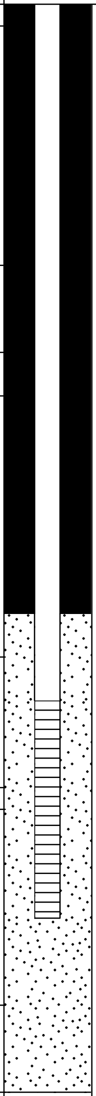
LOG OF BORING DEK-SB-20004

SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	594.4 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push
Location:	Essexville, MI	Sampling Method:	Continuous
Coordinates:	N 783,213.0 ft E 13,264,924.0 ft	Completion Depth:	25.0 ft
Datum:	NAD83 MI State Plane South International Feet		

Top of Casing Elev.: 597.3 ft
Unique Well No.: DEK-TW-20004



Depth, feet	Sample No.	ENVIRONMENTAL DATA	USCS	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0			SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.		
	1		SP	POORLY GRADED SAND (SP): fine grained; dark gray; moist; little black cinders and ash; few gravel; fill.	1 inch dia. PVC riser	
		PID:0.0 **D/O/S:**None/ None/ None				
	2					
5		**PID:**0.0 **D/O/S:**None/ None/ None				590
			CL	LEAN CLAY (CL): brown; moist; very stiff; little silt; few cinders at 6.5-7 ft; fill.	Bentonite chips (0-14 ft)	
	3					
			SP	POORLY GRADED SAND (SP): fine grained; black; moist; trace gravel; trace cinders and ash; fill.		
			SP-SM	POORLY GRADED SAND WITH SILT (SP-SM): fine to medium grained; brown; moist to wet; interbedded with sandy lean clay to clayey sand layers; trace gravel.		585
10		**PID:**0.1 **D/O/S:**None/ None/ None				
	4					
						580
15		**PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; gray; saturated; trace gravel and shells.	Filter pack sand (14-21 ft)	
	5	**PID:**0.3 **D/O/S:**None/ None/ None				
			CL	LEAN CLAY (CL): brown; moist; medium stiff; trace gravel.	1 inch dia. 10 slot PVC screen (16-21 ft)	
			SP	POORLY GRADED SAND (SP): fine grained; dark gray with very dark gray laminations; saturated; trace gravel.		575
20		**PID:**0.0 **D/O/S:**None/ None/ None				
	6				Natural collapse (21-25 ft)	
			CL	LEAN CLAY (CL): brown; moist; stiff; trace gravel.		570
25				End of boring 25.0 feet		
						565
30						

Date Boring Started:	7/14/20 4:15 pm
Date Boring Completed:	7/14/20 4:55 pm
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20004 (17-19') collected at 4:50 PM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
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LOG OF BORING DEK-SB-20005

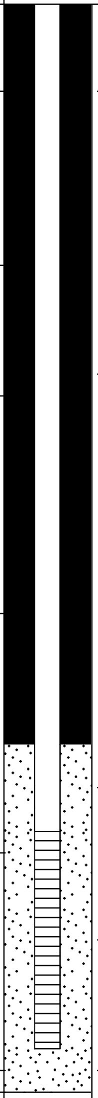
SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	595.9 ft	Top of Casing Elev.:	597.0 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push	Unique Well No.:	DEK-TW-20005
Location:	Essexville, MI	Sampling Method:	Continuous		
Coordinates:	N 783,068.0 ft E 13,265,179.0 ft	Completion Depth:	25.0 ft		
Datum:	NAD83 MI State Plane South International Feet				

Depth, feet: 0, 5, 10, 15, 20, 25, 30
Elevation, feet: 595, 590, 585, 580, 575, 570

Sample No.	ENVIRONMENTAL DATA	USCS	LITHOLOGIC DESCRIPTION
1		SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine grained; tan; moist; crushed gravel/road base; fill.
2	**PID:**0.0 **D/O/S:**None/ None/ None **PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray; moist; little black cinder and ash; trace gravel; fill.
3		CL	LEAN CLAY (CL): brown; moist; very stiff; little silt; trace gravel.
4	**PID:**0.0 **D/O/S:**None/ None/ None	SP-SC	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC): fine grained; brown; moist. Little crushed rock from 13.5-14 ft.
5	**PID:**0.1 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; brown; wet to saturated; trace gravel and shells.
6	**PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine grained; dark gray with very dark gray laminations; saturated; trace shells.
		CL	LEAN CLAY (CL): brown; moist; stiff; few sand. End of boring 25.0 feet

WELL OR PIEZOMETER CONSTRUCTION DETAIL



- 1 inch dia. PVC riser
- Bentonite chips (0-17 ft)
- Filter pack sand (17-24 ft)
- 1 inch dia. 10 slot PVC screen (19-24 ft)
- Natural collapse (24-25 ft)

Date Boring Started:	7/15/20 7:55 am
Date Boring Completed:	7/15/20 8:35 am
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20005 (19-21') collected at 8:50 AM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
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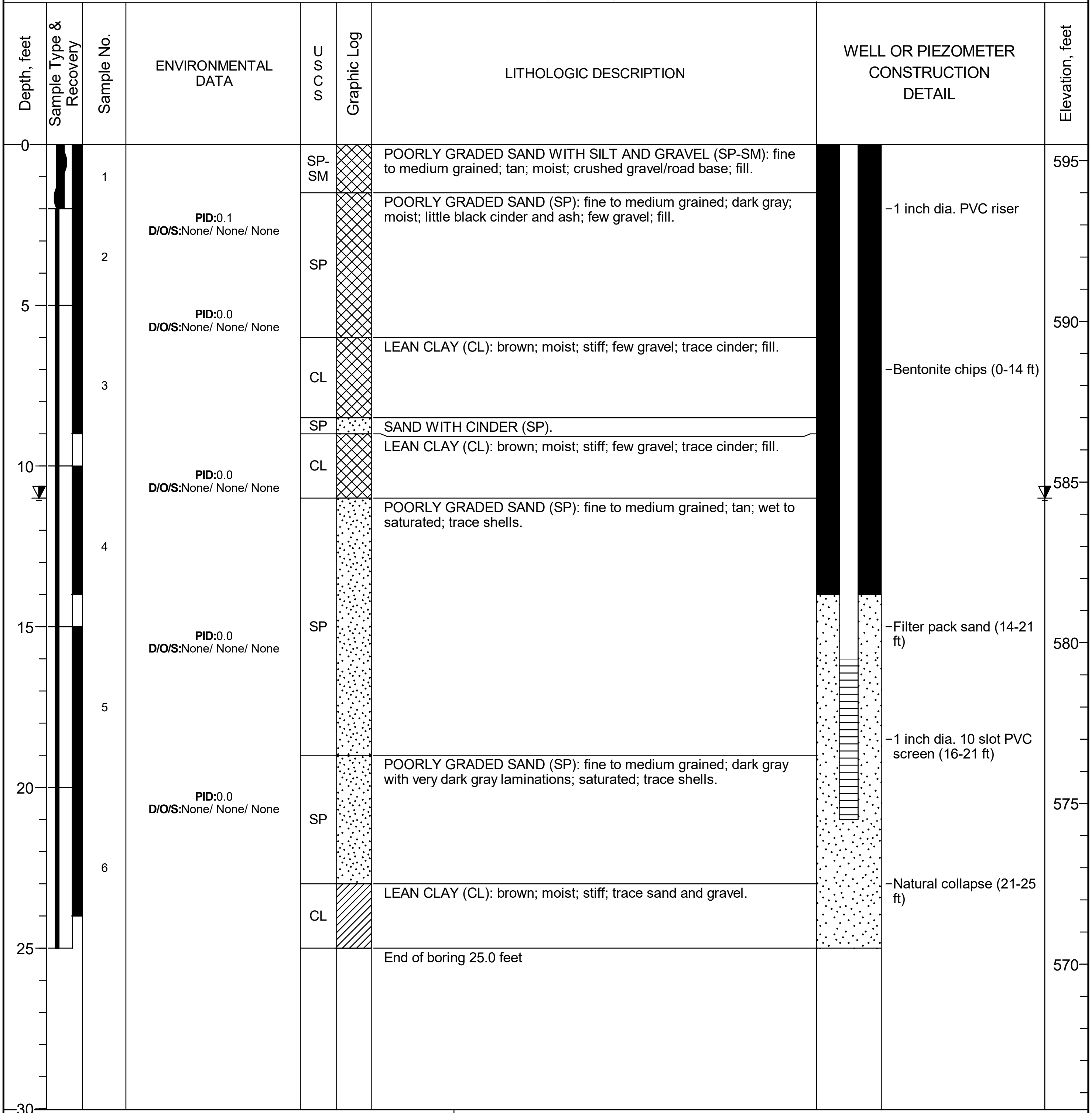
LOG OF BORING DEK-SB-20006

SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	595.5 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push
Location:	Essexville, MI	Sampling Method:	Continuous
Coordinates:	N 782,899.0 ft E 13,265,482.0 ft	Completion Depth:	25.0 ft
Datum:	NAD83 MI State Plane South International Feet		

Top of Casing Elev.: 597.1 ft
Unique Well No.: DEK-TW-20006



ENVIRONMENTAL DATA
PID:0.1 **D/O/S:**None/ None/ None
PID:0.0 **D/O/S:**None/ None/ None
PID:0.0 **D/O/S:**None/ None/ None
PID:0.0 **D/O/S:**None/ None/ None
PID:0.0 **D/O/S:**None/ None/ None

USCS	LITHOLOGIC DESCRIPTION
SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.
SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray; moist; little black cinder and ash; few gravel; fill.
CL	LEAN CLAY (CL): brown; moist; stiff; few gravel; trace cinder; fill.
SP	SAND WITH CINDER (SP).
CL	LEAN CLAY (CL): brown; moist; stiff; few gravel; trace cinder; fill.
SP	POORLY GRADED SAND (SP): fine to medium grained; tan; wet to saturated; trace shells.
SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray with very dark gray laminations; saturated; trace shells.
CL	LEAN CLAY (CL): brown; moist; stiff; trace sand and gravel.
	End of boring 25.0 feet

Date Boring Started:	7/15/20 9:20 am
Date Boring Completed:	7/15/20 10:00 am
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20006 (11-13') collected at 10:20 AM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
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LOG OF BORING DEK-SB-20007

SHEET 1 OF 1

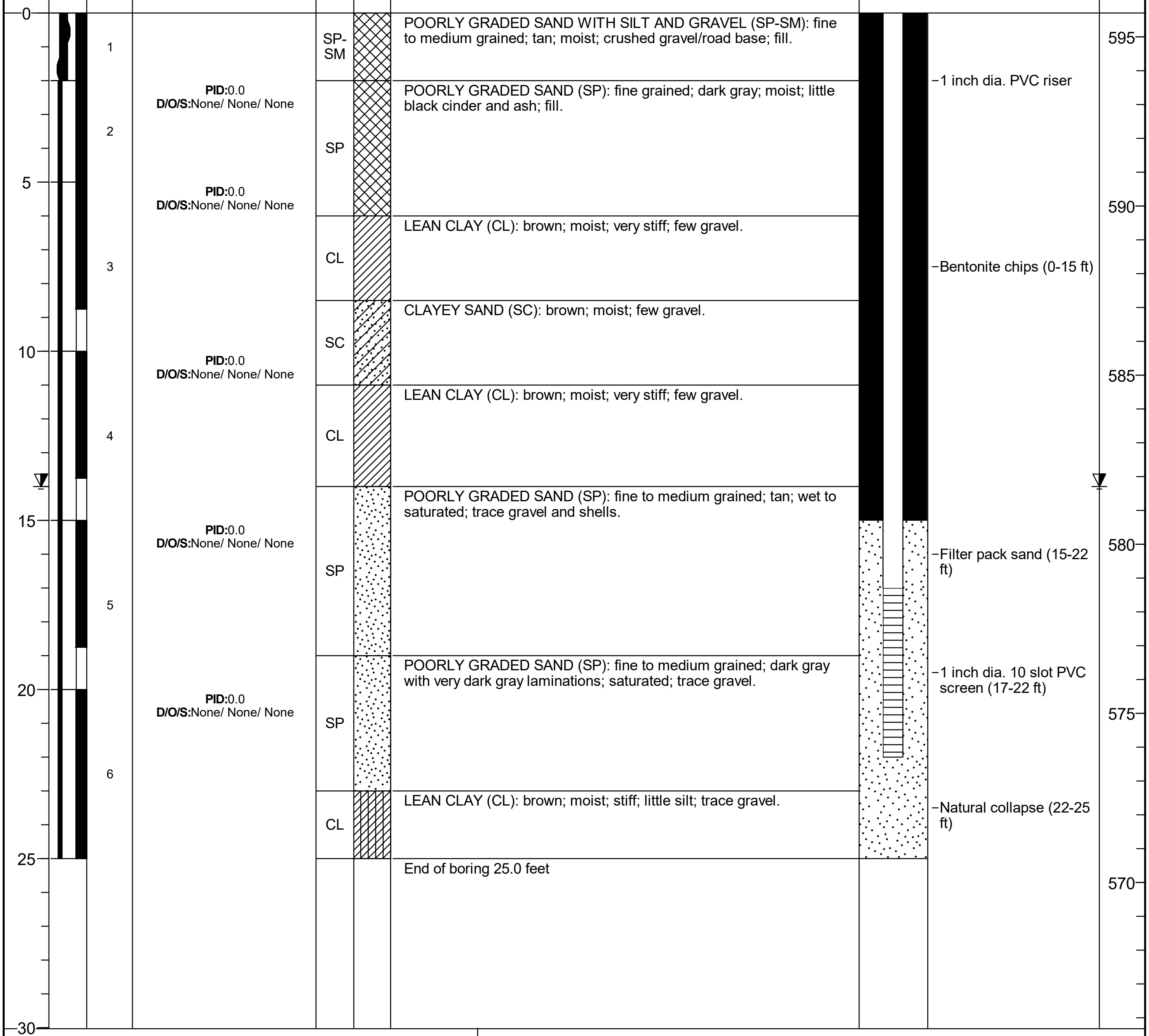
Project:	Consumers DE Karn Corrective Action	Surface Elevation:	595.7 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push
Location:	Essexville, MI	Sampling Method:	Continuous
Coordinates:	N 782,782.0 ft E 13,265,689.0 ft	Completion Depth:	25.0 ft
Datum:	NAD83 MI State Plane South International Feet		

Top of Casing Elev.: 597.1 ft
Unique Well No.: DEK-TW-20007

Sample No.	ENVIRONMENTAL DATA
1	
2	**PID:**0.0 **D/O/S:**None/ None/ None
3	**PID:**0.0 **D/O/S:**None/ None/ None
4	**PID:**0.0 **D/O/S:**None/ None/ None
5	**PID:**0.0 **D/O/S:**None/ None/ None
6	**PID:**0.0 **D/O/S:**None/ None/ None

USCS	LITHOLOGIC DESCRIPTION
SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.
SP	POORLY GRADED SAND (SP): fine grained; dark gray; moist; little black cinder and ash; fill.
CL	LEAN CLAY (CL): brown; moist; very stiff; few gravel.
SC	CLAYEY SAND (SC): brown; moist; few gravel.
CL	LEAN CLAY (CL): brown; moist; very stiff; few gravel.
SP	POORLY GRADED SAND (SP): fine to medium grained; tan; wet to saturated; trace gravel and shells.
SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray with very dark gray laminations; saturated; trace gravel.
CL	LEAN CLAY (CL): brown; moist; stiff; little silt; trace gravel.
	End of boring 25.0 feet

WELL OR PIEZOMETER CONSTRUCTION DETAIL



Date Boring Started:	7/15/20 10:50 am
Date Boring Completed:	7/15/20 11:35 am
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20007 (14-16') collected at 11:45 AM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
Additional data may have been collected in the field which is not included on this log.

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LOG OF BORING DEK-SB-20008

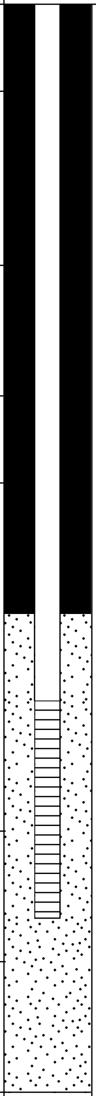
SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	594.9 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push
Location:	Essexville, MI	Sampling Method:	Continuous
Coordinates:	N 782,641.0 ft E 13,265,943.0 ft	Completion Depth:	25.0 ft
Datum:	NAD83 MI State Plane South International Feet		

Top of Casing Elev.: 596.9 ft
Unique Well No.: DEK-TW-20008

Sample No.	ENVIRONMENTAL DATA	USCS	LITHOLOGIC DESCRIPTION
1		SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.
2	**PID:**0.0 **D/O/S:**None/ None/ None **PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray; moist; little black cinder and ash; few gravel; fill.
3		CL	LEAN CLAY (CL): brown; moist; very stiff; few gravel; trace sand; fill.
	PID:0.0 **D/O/S:**None/ None/ None	SP-SC	POORLY GRADED SAND WITH CLAY AND GRAVEL (SP-SC): fine to medium grained; brown; moist; trace cinder; fill. Little crushed rock from 10-10.3 ft.
4 5	**PID:**0.0 **D/O/S:**None/ None/ None **PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; tan; wet to saturated; trace gravel and shells. Clayey sand from 13-13.3 ft. Clayey sand from 14-14.3 ft.
	PID:0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray with very dark gray laminations; saturated; trace shells.
6		CL	LEAN CLAY (CL): brown; moist; medium stiff to stiff; little silt; trace gravel.
			End of boring 25.0 feet

WELL OR PIEZOMETER CONSTRUCTION DETAIL



- 1 inch dia. PVC riser
- Bentonite chips (0-14 ft)
- Filter pack sand (14-21 ft)
- 1 inch dia. 10 slot PVC screen (16-21 ft)
- Natural collapse (21-25 ft)

Date Boring Started:	7/15/20 1:00 pm
Date Boring Completed:	7/15/20 1:40 pm
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20008 (17-19') collected at 1:55 PM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
Additional data may have been collected in the field which is not included on this log.

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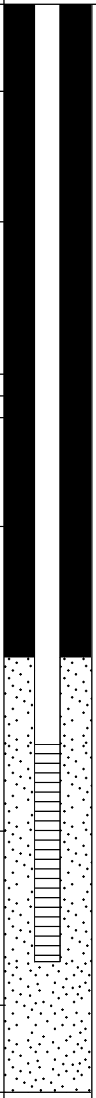
LOG OF BORING DEK-SB-20009

SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	594.8 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push
Location:	Essexville, MI	Sampling Method:	Continuous
Coordinates:	N 782,501.0 ft E 13,266,196.0 ft	Completion Depth:	25.0 ft
Datum:	NAD83 MI State Plane South International Feet		

Top of Casing Elev.: 597.1 ft
Unique Well No.: DEK-TW-20009

Depth, feet	Sample No.	ENVIRONMENTAL DATA	USCS	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0	1		SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.		
					1 inch dia. PVC riser	
	2	**PID:**0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND WITH CINDER AND ASH (SP): fine to medium grained; dark gray; moist; few gravel; fill.		
5		**PID:**0.1 **D/O/S:**None/ None/ None	CL	LEAN CLAY (CL): brown; moist; very stiff; few gravel; trace cinders; fill.		590
	3				Bentonite chips (0-15 ft)	
			SP	SAND WITH CINDERS (SP).		
			CL	LEAN CLAY (CL): brown; moist; very stiff; few gravel; trace cinders; fill.		
10		**PID:**0.1 **D/O/S:**None/ None/ None	SP-SC	POORLY GRADED SAND WITH CLAY (SP-SC): fine to medium grained; brown; moist. Little crushed rock from 9.8-10 ft.		585
	4		SP-SM	POORLY GRADED SAND WITH SILT AND CLAY (SP-SM): fine to medium grained; brown; moist to wet; trace shells.		
▽						▽
15		**PID:**0.3 **D/O/S:**None/ None/ None			Filter pack sand (15-22 ft)	580
	5					
			SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray with very dark gray laminations; saturated; trace shells.	1 inch dia. 10 slot PVC screen (17-22 ft)	
20		**PID:**0.2 **D/O/S:**None/ None/ None				575
	6					
			CL	LEAN CLAY (CL): brown; moist; stiff; few gravel.	Natural collapse (22-25 ft)	
25				End of boring 25.0 feet		570
30						565



Date Boring Started:	7/15/20 2:10 pm
Date Boring Completed:	7/15/20 3:05 pm
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20009 (15-17') collected at 3:15 PM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
Additional data may have been collected in the field which is not included on this log.

Barr Engineering Company
3005 Boardwalk St, Suite 100
Ann Arbor, MI 48108
Telephone: 734-922-4400

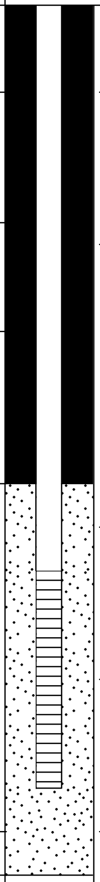
LOG OF BORING DEK-SB-20010

SHEET 1 OF 1

Project:	Consumers DE Karn Corrective Action	Surface Elevation:	591.5 ft
Project No.:	22/091015.01	Drilling Method:	Direct Push
Location:	Essexville, MI	Sampling Method:	Continuous
Coordinates:	N 782,363.0 ft E 13,266,450.0 ft	Completion Depth:	20.0 ft
Datum:	NAD83 MI State Plane South International Feet		

Top of Casing Elev.: 593.2 ft
Unique Well No.: DEK-TW-20010

Sample No.	ENVIRONMENTAL DATA	USCS	LITHOLOGIC DESCRIPTION
1		SP-SM	POORLY GRADED SAND WITH SILT AND GRAVEL (SP-SM): fine to medium grained; tan; moist; crushed gravel/road base; fill.
2	**PID:**0.0 **D/O/S:**None/ None/ None	CL	LEAN CLAY (CL): brown; moist; stiff; few gravel; fill.
3	**PID:**0.0 **D/O/S:**None/ None/ None	SP-SM	POORLY GRADED SAND WITH SILT AND CLAY (SP-SM): fine grained; brown; moist; trace gravel and cinders; fill.
	PID:0.0 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; tan; moist to wet; trace shells.
4 5	**PID:**0.3 **D/O/S:**None/ None/ None **PID:**0.8 **D/O/S:**None/ None/ None	SP	POORLY GRADED SAND (SP): fine to medium grained; dark gray with very dark gray laminations; saturated; trace shells.
		CL	LEAN CLAY (CL): brown; moist; stiff; little silt; trace gravel.
			End of boring 20.0 feet



WELL OR PIEZOMETER CONSTRUCTION DETAIL

- 1 inch dia. PVC riser
- Bentonite chips (0-11 ft)
- Filter pack sand (11-18 ft)
- 1 inch dia. 10 slot PVC screen (13-18 ft)
- Natural collapse (18-20 ft)

Date Boring Started:	7/15/20 3:45 pm
Date Boring Completed:	7/15/20 4:15 pm
Logged By:	AMS3
Drilling Contractor:	FiberTec
Drill Rig:	Geoprobe 6620DT

Remarks: Hand augered from 0-2 ft; Soil sample DEK-SB-20010 (9-12') collected at 4:30 PM; 1 inch dia. temporary well installed within borehole

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected; G/S/F = Gravel/Sand/Fines
Additional data may have been collected in the field which is not included on this log.

Appendix E-3a

Soil Analytical Data

Appendix E-3a
Soil Analytical Data
D.E. Karn Generating Facility
Consumers Energy Company

Location		DEK-SB-20001	DEK-SB-20002	DEK-SB-20003	DEK-SB-20004	DEK-SB-20005	DEK-SB-20006	DEK-SB-20007	DEK-SB-20008	DEK-SB-20009	DEK-SB-20010
Date		7/14/2020	7/14/2020	7/14/2020	7/14/2020	7/15/2020	7/15/2020	7/15/2020	7/15/2020	7/15/2020	7/15/2020
Depth		22 - 25 ft	21 - 23 ft	15 - 17 ft	17 - 19 ft	19 - 21 ft	11 - 13 ft	14 - 16 ft	17 - 19 ft	15 - 17 ft	9 - 12 ft
Sample Type		N	N	N	N	N	N	N	N	N	N
Parameter	Units										
General Parameters											
Biochemical Oxygen Demand (5-day)	mg/l	< 20.0 U	< 20.0 U	**24.0**	< 20.0 U	< 20.0 U	< 20.0 U	< 20.0 U	< 20.0 U	< 20.0 U	< 20.0 U
Carbon, total organic	mg/kg	**2160**	**2230**	**3580**	**1430**	**3100**	**2040**	**1980**	**2650**	**2410**	**2210**
Chemical Oxygen Demand	mg/l	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U
Moisture	%	**14.4**	**19.5**	**20.0**	**13.3**	**16.8**	**10.8**	**20.7**	**14.3**	**12.3**	**16.8**
pH	pH units	**8.1 H**	**7.9 H**	**8.1 H**	**8.3 H**	**8.5 H**	**8.5 H**	**8.5 H**	**8.3 H**	**8.1 H**	**8.3 H**
Redox (oxidation potential)	mV	**370**	**345**	**378**	**375**	**395**	**479**	**456**	**452**	**428**	**443**
Solids, percent	%	**85.6**	**80.5**	**80.0**	**86.7**	**83.2**	**89.2**	**79.3**	**85.7**	**87.7**	**83.2**
Metals											
Arsenic	mg/kg	**4.65**	**7.02**	**9.81**	**3.89**	**9.81**	**16.6**	**12.8**	**6.10**	**2.76**	**3.84**
Iron	mg/kg	**2780**	**2830**	**5180**	**2620**	**3750**	**3690**	**7010**	**3280**	**5420**	**4210**

LEGEND

Detections are presented in **bold**.

Footnotes

N Sample Type: Normal
H Recommended sample

preservation, extraction, or analysis

U The analyte was analyzed for, but was not detected.

Data Footnotes and Qualifiers

Barr Standard Footnotes and Qualifiers

N	Sample Type: Normal
H	Recommended sample preservation, extraction or analysis holding time was exceeded.
U	The analyte was analyzed for, but was not detected.

Appendix E-3b

Groundwater Analytical Data

Appendix E-3b
Groundwater Analytical Data
D.E. Karn Generating Facility
Consumers Energy Company

			Location	DEK-TW-20001	DEK-TW-20002	DEK-TW-20003	DEK-TW-20004	DEK-TW-20005	DEK-TW-20006	DEK-TW-20007	DEK-TW-20008	DEK-TW-20009	DEK-TW-20010
			Date	7/16/2020	7/16/2020	7/16/2020	7/17/2020	7/17/2020	7/17/2020	7/17/2020	7/17/2020	7/17/2020	7/17/2020
			Sample Type	N	N	N	N	N	N	N	N	N	N
Parameter	Total or Dissolved	Analysis Location	Units										
General Parameters													
Biochemical Oxygen Demand (5-day)	NA	Lab	mg/l	< 2.00 U	< 2.00 U	< 2.00 U	< 60.0 U	< 60.0 U	< 60.0 U	< 60.0 U	< 60.0 U	< 60.0 U	< 60.0 U
Carbon, total organic	NA	Lab	mg/l	**3.01**	**3.05**	**2.75**	**2.49**	**3.89**	**3.51**	**3.09**	**4.36**	**4.26**	**3.50**
Chemical Oxygen Demand	NA	Lab	mg/l	< 10.0 U	< 10.0 U	< 10.0 U	< 10.0 U	**12.7**	**11.0**	< 10.0 U	**13.0**	**11.7**	**10.0**
Dissolved oxygen	NA	Field	mg/l	**1.30**	**1.18**	**0.95**	**1.26**	**1.27**	**1.11**	**1.32**	**1.29**	**1.31**	**1.12**
pH	NA	Field	pH units	**7.33**	**7.36**	**7.55**	**7.13**	**7.22**	**7.48**	**7.56**	**7.40**	**7.23**	**7.36**
Redox (oxidation potential)	NA	Field	mV	**-240.2**	**-155.5**	**-263.4**	**-245.1**	**-229.2**	**-257.5**	**-307.2**	**-248.9**	**-191.0**	**-258.2**
Specific conductance @ 25 ºC	NA	Field	umhos/cm	**1443**	**1471**	**1066**	**1436**	**1166**	**883**	**1213**	**1086**	**1346**	**1759**
Temperature	NA	Field	deg C	**12.7**	**12.6**	**13.0**	**11.6**	**11.8**	**11.9**	**12.3**	**12.8**	**12.0**	**12.8**
Turbidity	NA	Field	NTU	**1.08**	**1.55**	**1.50**	**1.83**	**0.33**	**3.01**	**1.45**	**1.08**	**1.33**	**4.40**
Metals													
Arsenic	Dissolved	Lab	ug/l	**442**	**821**	**579**	**497**	**271**	**502**	**803**	**400**	**333**	**428**
Iron	Dissolved	Lab	ug/l	**3300**	**2990**	**3620**	**12200**	**3760**	**4120**	**4600**	**7340**	**6090**	**3500**
Arsenic	Total	Lab	ug/l	**430**	**873**	**583**	**496**	**265**	**501**	**780**	**392**	**324**	**444**
Iron	Total	Lab	ug/l	**3460**	**3280**	**3930**	**12500**	**3730**	**4260**	**4650**	**7270**	**6090**	**3650**

LEGEND

Detections are presented in **bold**.

Footnotes

N Sample Type: Normal

U The analyte was analyzed for, but was not detected.

Data Footnotes and Qualifiers

Barr Standard Footnotes and Qualifiers

N	Sample Type: Normal
NA	NA (not applicable) indicates that a fractional portion of the sample is not part of the analytical testing or field collection procedures.
U	The analyte was analyzed for, but was not detected.

Appendix E-4

Laboratory Soil and Groundwater Data Report

eurofins | Environment Testing America

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ANALYTICAL REPORT

Eurofins TestAmerica, Canton
4101 Shuffel Street NW
North Canton, OH 44720
Tel: (330)497-9396

Laboratory Job ID: 240-133624-1
Client Project/Site: DE Karn Project #: 22/09-1015
Revision: 3

For:
Barr Engineering Company
4300 MarketPoint Drive
Suite 200
Minneapolis, Minnesota 55435

Attn: Dana Pasi

Leslie A Howell

Authorized for release by:
9/30/2020 10:18:25 AM

Leslie Howell, Project Manager I
(330)966-9266
Leslie.Howell@Eurofinset.com

This report has been electronically signed and authorized by the signatory. Electronic signature is intended to be the legally binding equivalent of a traditionally handwritten signature.

Results relate only to the items tested and the sample(s) as received by the laboratory.

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Table of Contents

Definitions/Glossary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Qualifiers

Metals

Qualifier	Qualifier Description
4	MS, MSD: The analyte present in the original sample is greater than 4 times the matrix spike concentration; therefore, control limits are not applicable.

General Chemistry

Qualifier	Qualifier Description
H	Sample was prepped or analyzed beyond the specified holding time
HF	Field parameter with a holding time of 15 minutes. Test performed by laboratory at client's request.
s	Seeded Control Blank (SCB) Recovery High
s	Seeded Control Blank (SCB) Recovery Low

Glossary

Abbreviation	These commonly used abbreviations may or may not be present in this report.
¤	Listed under the "D" column to designate that the result is reported on a dry weight basis
%R	Percent Recovery
CFL	Contains Free Liquid
CFU	Colony Forming Unit
CNF	Contains No Free Liquid
DER	Duplicate Error Ratio (normalized absolute difference)
Dil Fac	Dilution Factor
DL	Detection Limit (DoD/DOE)
DL, RA, RE, IN	Indicates a Dilution, Re-analysis, Re-extraction, or additional Initial metals/anion analysis of the sample
DLC	Decision Level Concentration (Radiochemistry)
EDL	Estimated Detection Limit (Dioxin)
LOD	Limit of Detection (DoD/DOE)
LOQ	Limit of Quantitation (DoD/DOE)
MCL	EPA recommended "Maximum Contaminant Level"
MDA	Minimum Detectable Activity (Radiochemistry)
MDC	Minimum Detectable Concentration (Radiochemistry)
MDL	Method Detection Limit
ML	Minimum Level (Dioxin)
MPN	Most Probable Number
MQL	Method Quantitation Limit
NC	Not Calculated
ND	Not Detected at the reporting limit (or MDL or EDL if shown)
NEG	Negative / Absent
POS	Positive / Present
PQL	Practical Quantitation Limit
PRES	Presumptive
QC	Quality Control
RER	Relative Error Ratio (Radiochemistry)
RL	Reporting Limit or Requested Limit (Radiochemistry)
RPD	Relative Percent Difference, a measure of the relative difference between two points
TEF	Toxicity Equivalent Factor (Dioxin)
TEQ	Toxicity Equivalent Quotient (Dioxin)
TNTC	Too Numerous To Count

Job ID: 240-133624-1

Laboratory: Eurofins TestAmerica, Canton

Narrative

Job Narrative
240-133624-1
REVISED

Comments

Revised report 9/30/2020: report has been revised to correct the results for BOD for a few samples after client request for verification which revealed some of the samples were over diluted and incorrectly reported previously.

Revised report 9/23/2020: report has been revised to remove the Corrosivity results in the report.

Revised report 8/11/2020: report has been revised to remove the H flags from the soil samples for 5210B which were actually completed within hold time.

No additional comments.

Receipt

The samples were received on 7/18/2020 10:00 AM; the samples arrived in good condition, and where required, properly preserved and on ice. The temperature of the cooler at receipt was 4.9º C.

Metals

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

Field Service / Mobile Lab

No analytical or quality issues were noted, other than those described in the Definitions/Glossary page.

General Chemistry

Method SM 5210B: The USB dilution water D.O. depletion was greater than 0.2 mg/L. The associated sample results in batch 240-443216 are qualified and reported.

Method SM 5210B: The following sample(s) was received with less than 2 days remaining on the holding time or less than one shift (8 hours) remaining on a test with a holding time of 48 hours or less. As such, the laboratory had insufficient time remaining to perform the analysis within holding time: DEK-TW-20001 (240-133624-11), DEK-TW-20002 (240-133624-12) and DEK-TW-20003 (240-133624-13).

No additional analytical or quality issues were noted, other than those described above or in the Definitions/Glossary page.

Method Summary

Client: Barr Engineering Company
Job ID: 240-133624-1
Project/Site: DE Karn Project #: 22/09-1015

Method	Method Description	Protocol	Laboratory
6020B	Metals (ICP/MS)	SW846	TAL CAN
410.4	COD	MCAWW	TAL EDI
410.4-1993 R2.0	COD	MCAWW	TAL CAN
5210B-2011	BOD, 5-Day	SM	TAL CAN
9045D	pH	SW846	TAL EDI
9060A	Organic Carbon, Total (TOC)	SW846	TAL CAN
Moisture	Percent Moisture	EPA	TAL CAN
SM 2580B	Reduction-Oxidation (REDOX) Potential	SM	TAL EDI
SM 5210B	BOD, 5-Day	SM	TAL EDI
Walkley Black	Organic Carbon, Total (TOC)	MSA	TAL CAN
3005A	Preparation, Total Recoverable or Dissolved Metals	SW846	TAL CAN
3050B	Preparation, Metals	SW846	TAL CAN
D3987-85	ASTM Leaching Procedure	ASTM	TAL EDI
DI Leach	Deionized Water Leaching Procedure	ASTM	TAL EDI

Protocol References:

ASTM = ASTM International
EPA = US Environmental Protection Agency
MCAWW = "Methods For Chemical Analysis Of Water And Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions.
MSA = "Methods Of Soil Analysis, Chemical And Microbiological Properties", Part 2, 2nd Ed., 1982 And Subsequent Revisions.
SM = "Standard Methods For The Examination Of Water And Wastewater"
SW846 = "Test Methods For Evaluating Solid Waste, Physical/Chemical Methods", Third Edition, November 1986 And Its Updates.

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396
TAL EDI = Eurofins TestAmerica, Edison, 777 New Durham Road, Edison, NJ 08817, TEL (732)549-3900

Sample Summary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Lab Sample ID	Client Sample ID	Matrix	Collected	Received	Asset ID
240-133624-1	DEK-SB-20001 (22-25')	Solid	07/14/20 11:45	07/18/20 10:00	
240-133624-2	DEK-SB-20002 (21-23')	Solid	07/14/20 13:50	07/18/20 10:00	
240-133624-3	DEK-SB-20003 (15-17')	Solid	07/14/20 15:20	07/18/20 10:00	
240-133624-4	DEK-SB-20004 (17-19')	Solid	07/14/20 16:50	07/18/20 10:00	
240-133624-5	DEK-SB-20005 (19-21')	Solid	07/15/20 08:50	07/18/20 10:00	
240-133624-6	DEK-SB-20006 (11-13')	Solid	07/15/20 10:20	07/18/20 10:00	
240-133624-7	DEK-SB-20007 (14-16')	Solid	07/15/20 11:45	07/18/20 10:00	
240-133624-8	DEK-SB-20008 (17-19')	Solid	07/15/20 13:55	07/18/20 10:00	
240-133624-9	DEK-SB-20009 (15-17')	Solid	07/15/20 15:15	07/18/20 10:00	
240-133624-10	DEK-SB-20010 (9-12')	Solid	07/15/20 16:30	07/18/20 10:00	
240-133624-11	DEK-TW-20001	Water	07/16/20 13:40	07/18/20 10:00	
240-133624-12	DEK-TW-20002	Water	07/16/20 14:25	07/18/20 10:00	
240-133624-13	DEK-TW-20003	Water	07/16/20 16:10	07/18/20 10:00	
240-133624-14	DEK-TW-20004	Water	07/17/20 08:25	07/18/20 10:00	
240-133624-15	DEK-TW-20005	Water	07/17/20 09:20	07/18/20 10:00	
240-133624-16	DEK-TW-20006	Water	07/17/20 10:25	07/18/20 10:00	
240-133624-17	DEK-TW-20007	Water	07/17/20 11:30	07/18/20 10:00	
240-133624-18	DEK-TW-20008	Water	07/17/20 12:25	07/18/20 10:00	
240-133624-19	DEK-TW-20009	Water	07/17/20 13:15	07/18/20 10:00	
240-133624-20	DEK-TW-20010	Water	07/17/20 13:50	07/18/20 10:00	

Detection Summary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-SB-20001 (22-25') Lab Sample ID: 240-133624-1

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	4.65		1.04		mg/Kg	2	☼	6020B	Total/NA
Iron	2780		41.7		mg/Kg	2	☼	6020B	Total/NA
pH	8.1	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	2160		1180		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	370				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-SB-20002 (21-23') Lab Sample ID: 240-133624-2

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	7.02		1.08		mg/Kg	2	☼	6020B	Total/NA
Iron	2830		43.2		mg/Kg	2	☼	6020B	Total/NA
pH	7.9	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	2230		1250		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	345				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-SB-20003 (15-17') Lab Sample ID: 240-133624-3

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	9.81		1.00		mg/Kg	2	☼	6020B	Total/NA
Iron	5180		40.0		mg/Kg	2	☼	6020B	Total/NA
pH	8.1	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	3580		1230		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	378				millivolts	1		SM 2580B	Soluble
Biochemical Oxygen Demand	24.0		20.0		mg/L	1		SM 5210B	ASTM Leach

Client Sample ID: DEK-SB-20004 (17-19') Lab Sample ID: 240-133624-4

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	3.89		1.11		mg/Kg	2	☼	6020B	Total/NA
Iron	2620		44.3		mg/Kg	2	☼	6020B	Total/NA
pH	8.3	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	1430		1140		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	375				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-SB-20005 (19-21') Lab Sample ID: 240-133624-5

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	9.81		0.864		mg/Kg	2	☼	6020B	Total/NA
Iron	3750		34.6		mg/Kg	2	☼	6020B	Total/NA
pH	8.5	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	3100		1180		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	395				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-SB-20006 (11-13') Lab Sample ID: 240-133624-6

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	16.6		0.843		mg/Kg	2	☼	6020B	Total/NA
Iron	3690		33.7		mg/Kg	2	☼	6020B	Total/NA
pH	8.5	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	2040		1120		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	479				millivolts	1		SM 2580B	Soluble

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: Barr Engineering Company
Job ID: 240-133624-1
Project/Site: DE Karn Project #: 22/09-1015

Client Sample ID: DEK-SB-20007 (14-16')
Lab Sample ID: 240-133624-7

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	12.8		1.13		mg/Kg	2	☼	6020B	Total/NA
Iron	7010		45.0		mg/Kg	2	☼	6020B	Total/NA
pH	8.5	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	1980		1240		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	456				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-SB-20008 (17-19')
Lab Sample ID: 240-133624-8

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	6.10		0.919		mg/Kg	2	☼	6020B	Total/NA
Iron	3280		36.8		mg/Kg	2	☼	6020B	Total/NA
pH	8.3	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	2650		1160		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	452				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-SB-20009 (15-17')
Lab Sample ID: 240-133624-9

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	2.76		1.01		mg/Kg	2	☼	6020B	Total/NA
Iron	5420		40.4		mg/Kg	2	☼	6020B	Total/NA
pH	8.1	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	2410		1130		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	428				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-SB-20010 (9-12')
Lab Sample ID: 240-133624-10

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	3.84		0.846		mg/Kg	2	☼	6020B	Total/NA
Iron	4210		33.9		mg/Kg	2	☼	6020B	Total/NA
pH	8.3	HF	0.1		SU	1		9045D	Total/NA
Total Organic Carbon	2210		1180		mg/Kg	1	☼	Walkley Black	Total/NA
Oxidation Reduction Potential	443				millivolts	1		SM 2580B	Soluble

Client Sample ID: DEK-TW-20001
Lab Sample ID: 240-133624-11

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	430		5.00		ug/L	1		6020B	Total Recoverable
Iron	3460		200		ug/L	1		6020B	Total Recoverable
Arsenic	442		5.00		ug/L	1		6020B	Dissolved
Iron	3300		200		ug/L	1		6020B	Dissolved
Total Organic Carbon	3.01		1.00		mg/L	1		9060A	Total/NA

Client Sample ID: DEK-TW-20002
Lab Sample ID: 240-133624-12

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	873		5.00		ug/L	1		6020B	Total Recoverable
Iron	3280		200		ug/L	1		6020B	Total Recoverable
Arsenic	821		5.00		ug/L	1		6020B	Dissolved
Iron	2990		200		ug/L	1		6020B	Dissolved
Total Organic Carbon	3.05		1.00		mg/L	1		9060A	Total/NA

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-TW-20003

Lab Sample ID: 240-133624-13

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	583		5.00		ug/L	1		6020B	Total Recoverable
Iron	3930		200		ug/L	1		6020B	Total Recoverable
Arsenic	579		5.00		ug/L	1		6020B	Dissolved
Iron	3620		200		ug/L	1		6020B	Dissolved
Total Organic Carbon	2.75		1.00		mg/L	1		9060A	Total/NA

Client Sample ID: DEK-TW-20004

Lab Sample ID: 240-133624-14

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	496		5.00		ug/L	1		6020B	Total Recoverable
Iron	12500		200		ug/L	1		6020B	Total Recoverable
Arsenic	497		5.00		ug/L	1		6020B	Dissolved
Iron	12200		200		ug/L	1		6020B	Dissolved
Total Organic Carbon	2.49		1.00		mg/L	1		9060A	Total/NA

Client Sample ID: DEK-TW-20005

Lab Sample ID: 240-133624-15

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	265		5.00		ug/L	1		6020B	Total Recoverable
Iron	3730		200		ug/L	1		6020B	Total Recoverable
Arsenic	271		5.00		ug/L	1		6020B	Dissolved
Iron	3760		200		ug/L	1		6020B	Dissolved
Chemical Oxygen Demand	12.7		10.0		mg/L	1		410.4-1993 R2.0	Total/NA
Total Organic Carbon	3.89		1.00		mg/L	1		9060A	Total/NA

Client Sample ID: DEK-TW-20006

Lab Sample ID: 240-133624-16

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	501		5.00		ug/L	1		6020B	Total Recoverable
Iron	4260		200		ug/L	1		6020B	Total Recoverable
Arsenic	502		5.00		ug/L	1		6020B	Dissolved
Iron	4120		200		ug/L	1		6020B	Dissolved
Chemical Oxygen Demand	11.0		10.0		mg/L	1		410.4-1993 R2.0	Total/NA
Total Organic Carbon	3.51		1.00		mg/L	1		9060A	Total/NA

Client Sample ID: DEK-TW-20007

Lab Sample ID: 240-133624-17

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	780		5.00		ug/L	1		6020B	Total Recoverable
Iron	4650		200		ug/L	1		6020B	Total Recoverable
Arsenic	803		5.00		ug/L	1		6020B	Dissolved
Iron	4600		200		ug/L	1		6020B	Dissolved
Total Organic Carbon	3.09		1.00		mg/L	1		9060A	Total/NA

This Detection Summary does not include radiochemical test results.

Detection Summary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-TW-20008 Lab Sample ID: 240-133624-18

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	392		5.00		ug/L	1		6020B	Total Recoverable
Iron	7270		200		ug/L	1		6020B	Total Recoverable
Arsenic	400		5.00		ug/L	1		6020B	Dissolved
Iron	7340		200		ug/L	1		6020B	Dissolved
Chemical Oxygen Demand	13.0		10.0		mg/L	1		410.4-1993 R2.0	Total/NA
Total Organic Carbon	4.36		1.00		mg/L	1		9060A	Total/NA

Client Sample ID: DEK-TW-20009 Lab Sample ID: 240-133624-19

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	324		5.00		ug/L	1		6020B	Total Recoverable
Iron	6090		200		ug/L	1		6020B	Total Recoverable
Arsenic	333		5.00		ug/L	1		6020B	Dissolved
Iron	6090		200		ug/L	1		6020B	Dissolved
Chemical Oxygen Demand	11.7		10.0		mg/L	1		410.4-1993 R2.0	Total/NA
Total Organic Carbon	4.26		1.00		mg/L	1		9060A	Total/NA

Client Sample ID: DEK-TW-20010 Lab Sample ID: 240-133624-20

Analyte	Result	Qualifier	RL	MDL	Unit	Dil Fac	D	Method	Prep Type
Arsenic	444		5.00		ug/L	1		6020B	Total Recoverable
Iron	3650		200		ug/L	1		6020B	Total Recoverable
Arsenic	428		5.00		ug/L	1		6020B	Dissolved
Iron	3500		200		ug/L	1		6020B	Dissolved
Chemical Oxygen Demand	10.0		10.0		mg/L	1		410.4-1993 R2.0	Total/NA
Total Organic Carbon	3.50		1.00		mg/L	1		9060A	Total/NA

This Detection Summary does not include radiochemical test results.

Client Sample ID: DEK-SB-20001 (22-25')

Lab Sample ID: 240-133624-1

Date Collected: 07/14/20 11:45
Date Received: 07/18/20 10:00

Matrix: Solid

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.1**	**HF**	0.1		SU			08/01/20 10:43	1
Percent Solids	**85.6**		0.1		%			07/20/20 09:41	1
Percent Moisture	**14.4**		0.1		%			07/20/20 09:41	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**370**				millivolts			08/05/20 12:39	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/23/20 21:20	1

Client Sample Results

Client Sample ID: DEK-SB-20001 (22-25')
Date Collected: 07/14/20 11:45
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-1
Matrix: Solid
Percent Solids: 85.6

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**4.65**		1.04		mg/Kg	☼	07/21/20 14:00	07/22/20 13:51	2
Iron	**2780**		41.7		mg/Kg	☼	07/21/20 14:00	07/22/20 13:51	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**2160**		1180		mg/Kg	☼		07/20/20 06:29	1

Client Sample ID: DEK-SB-20002 (21-23')

Lab Sample ID: 240-133624-2

Date Collected: 07/14/20 13:50
Date Received: 07/18/20 10:00

Matrix: Solid

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**7.9**	**HF**	0.1		SU			08/01/20 10:45	1
Percent Solids	**80.5**		0.1		%			07/20/20 09:41	1
Percent Moisture	**19.5**		0.1		%			07/20/20 09:41	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**345**				millivolts			08/05/20 12:43	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/23/20 21:25	1

1
2
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14

Client Sample Results

Client Sample ID: DEK-SB-20002 (21-23')

Lab Sample ID: 240-133624-2

Date Collected: 07/14/20 13:50
Matrix: Solid
Date Received: 07/18/20 10:00
Percent Solids: 80.5

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**7.02**		1.08		mg/Kg	☼	07/21/20 14:00	07/22/20 14:03	2
Iron	**2830**		43.2		mg/Kg	☼	07/21/20 14:00	07/22/20 14:03	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**2230**		1250		mg/Kg	☼		07/20/20 06:32	1

Client Sample Results

Client Sample ID: DEK-SB-20003 (15-17')

Lab Sample ID: 240-133624-3

Date Collected: 07/14/20 15:20
Matrix: Solid
Date Received: 07/18/20 10:00

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.1**	**HF**	0.1		SU			08/01/20 10:46	1
Percent Solids	**80.0**		0.1		%			07/20/20 10:05	1
Percent Moisture	**20.0**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**378**				millivolts			08/05/20 12:45	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	**24.0**		20.0		mg/L			07/23/20 21:30	1

Client Sample Results

Client Sample ID: DEK-SB-20003 (15-17')
Date Collected: 07/14/20 15:20
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-3
Matrix: Solid
Percent Solids: 80.0

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**9.81**		1.00		mg/Kg	☼	07/21/20 14:00	07/22/20 14:06	2
Iron	**5180**		40.0		mg/Kg	☼	07/21/20 14:00	07/22/20 14:06	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**3580**		1230		mg/Kg	☼		07/20/20 06:35	1

Client Sample ID: DEK-SB-20004 (17-19')

Lab Sample ID: 240-133624-4

Date Collected: 07/14/20 16:50

Matrix: Solid

Date Received: 07/18/20 10:00

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.3**	**HF**	0.1		SU			08/01/20 10:47	1
Percent Solids	**86.7**		0.1		%			07/20/20 10:05	1
Percent Moisture	**13.3**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**375**				millivolts			08/05/20 12:47	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/23/20 21:35	1

Client Sample Results

Client Sample ID: DEK-SB-20004 (17-19')

Lab Sample ID: 240-133624-4

Date Collected: 07/14/20 16:50
Date Received: 07/18/20 10:00

Matrix: Solid
Percent Solids: 86.7

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**3.89**		1.11		mg/Kg	☼	07/21/20 14:00	07/22/20 14:08	2
Iron	**2620**		44.3		mg/Kg	☼	07/21/20 14:00	07/22/20 14:08	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**1430**		1140		mg/Kg	☼		07/20/20 06:39	1

Client Sample Results

Client Sample ID: DEK-SB-20005 (19-21')

Lab Sample ID: 240-133624-5

Date Collected: 07/15/20 08:50

Matrix: Solid

Date Received: 07/18/20 10:00

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.5**	**HF**	0.1		SU			08/01/20 10:48	1
Percent Solids	**83.2**		0.1		%			07/20/20 10:05	1
Percent Moisture	**16.8**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**395**				millivolts			08/05/20 12:49	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/23/20 21:40	1

Client Sample Results

Client Sample ID: DEK-SB-20005 (19-21')
Date Collected: 07/15/20 08:50
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-5
Matrix: Solid
Percent Solids: 83.2

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**9.81**		0.864		mg/Kg	☼	07/21/20 14:00	07/22/20 14:15	2
Iron	**3750**		34.6		mg/Kg	☼	07/21/20 14:00	07/22/20 14:15	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**3100**		1180		mg/Kg	☼		07/20/20 06:42	1

Client Sample ID: DEK-SB-20006 (11-13')

Lab Sample ID: 240-133624-6

Date Collected: 07/15/20 10:20
Date Received: 07/18/20 10:00

Matrix: Solid

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.5**	**HF**	0.1		SU			08/01/20 10:49	1
Percent Solids	**89.2**		0.1		%			07/20/20 10:05	1
Percent Moisture	**10.8**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**479**				millivolts			08/05/20 12:51	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/24/20 13:22	1

Client Sample ID: DEK-SB-20006 (11-13')

Date Collected: 07/15/20 10:20
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-6
Matrix: Solid
Percent Solids: 89.2

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	16.6		0.843		mg/Kg	☼	07/21/20 14:00	07/22/20 14:18	2
Iron	3690		33.7		mg/Kg	☼	07/21/20 14:00	07/22/20 14:18	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	2040		1120		mg/Kg	☼		07/20/20 06:45	1

Client Sample ID: DEK-SB-20007 (14-16')
Date Collected: 07/15/20 11:45
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-7
Matrix: Solid

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.5**	**HF**	0.1		SU			08/01/20 10:51	1
Percent Solids	**79.3**		0.1		%			07/20/20 10:05	1
Percent Moisture	**20.7**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**456**				millivolts			08/05/20 12:53	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/24/20 13:39	1

Client Sample Results

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-SB-20007 (14-16')

Date Collected: 07/15/20 11:45
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-7
Matrix: Solid
Percent Solids: 79.3

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**12.8**		1.13		mg/Kg	☼	07/21/20 14:00	07/22/20 14:21	2
Iron	**7010**		45.0		mg/Kg	☼	07/21/20 14:00	07/22/20 14:21	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**1980**		1240		mg/Kg	☼		07/20/20 06:48	1

Client Sample ID: DEK-SB-20008 (17-19')

Date Collected: 07/15/20 13:55
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-8
Matrix: Solid

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.3**	**HF**	0.1		SU			08/01/20 10:52	1
Percent Solids	**85.7**		0.1		%			07/20/20 10:05	1
Percent Moisture	**14.3**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**452**				millivolts			08/05/20 12:55	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/24/20 13:48	1

Client Sample ID: DEK-SB-20008 (17-19')
Date Collected: 07/15/20 13:55
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-8
Matrix: Solid
Percent Solids: 85.7

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**6.10**		0.919		mg/Kg	☼	07/21/20 14:00	07/22/20 14:23	2
Iron	**3280**		36.8		mg/Kg	☼	07/21/20 14:00	07/22/20 14:23	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**2650**		1160		mg/Kg	☼		07/20/20 06:55	1

Client Sample ID: DEK-SB-20009 (15-17')

Lab Sample ID: 240-133624-9

Date Collected: 07/15/20 15:15

Matrix: Solid

Date Received: 07/18/20 10:00

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.1**	**HF**	0.1		SU			08/01/20 10:53	1
Percent Solids	**87.7**		0.1		%			07/20/20 10:05	1
Percent Moisture	**12.3**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**428**				millivolts			08/05/20 13:00	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/24/20 13:54	1

Client Sample Results

Client Sample ID: DEK-SB-20009 (15-17')
Lab Sample ID: 240-133624-9
Date Collected: 07/15/20 15:15
Matrix: Solid
Date Received: 07/18/20 10:00
Percent Solids: 87.7

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**2.76**		1.01		mg/Kg	☼	07/21/20 14:00	07/22/20 14:26	2
Iron	**5420**		40.4		mg/Kg	☼	07/21/20 14:00	07/22/20 14:26	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**2410**		1130		mg/Kg	☼		07/20/20 06:58	1

Client Sample Results

Client Sample ID: DEK-SB-20010 (9-12')

Date Collected: 07/15/20 16:30
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-10
Matrix: Solid

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	**8.3**	**HF**	0.1		SU			08/01/20 10:54	1
Percent Solids	**83.2**		0.1		%			07/20/20 10:05	1
Percent Moisture	**16.8**		0.1		%			07/20/20 10:05	1

General Chemistry - Soluble

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Oxidation Reduction Potential	**443**				millivolts			08/05/20 13:02	1

General Chemistry - ASTM Leach

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/24/20 13:58	1

Client Sample ID: DEK-SB-20010 (9-12')

Lab Sample ID: 240-133624-10

Date Collected: 07/15/20 16:30
Matrix: Solid
Date Received: 07/18/20 10:00
Percent Solids: 83.2

Method: 6020B - Metals (ICP/MS)

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**3.84**		0.846		mg/Kg	☼	07/21/20 14:00	07/22/20 14:28	2
Iron	**4210**		33.9		mg/Kg	☼	07/21/20 14:00	07/22/20 14:28	2

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	**2210**		1180		mg/Kg	☼		07/20/20 07:01	1

Client Sample ID: DEK-TW-20001

Lab Sample ID: 240-133624-11

Date Collected: 07/16/20 13:40

Matrix: Water

Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**430**		5.00		ug/L		07/21/20 14:00	07/22/20 12:33	1
Iron	**3460**		200		ug/L		07/21/20 14:00	07/22/20 12:33	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**442**		5.00		ug/L		07/21/20 14:00	07/22/20 12:45	1
Iron	**3300**		200		ug/L		07/21/20 14:00	07/22/20 12:45	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/23/20 09:10	1
Biochemical Oxygen Demand	<2.00	H	2.00		mg/L			07/18/20 16:26	1
Total Organic Carbon	**3.01**		1.00		mg/L			07/22/20 17:47	1

Client Sample ID: DEK-TW-20002

Date Collected: 07/16/20 14:25
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-12
Matrix: Water

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**873**		5.00		ug/L		07/21/20 14:00	07/22/20 12:47	1
Iron	**3280**		200		ug/L		07/21/20 14:00	07/22/20 12:47	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**821**		5.00		ug/L		07/21/20 14:00	07/22/20 12:50	1
Iron	**2990**		200		ug/L		07/21/20 14:00	07/22/20 12:50	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/23/20 09:10	1
Biochemical Oxygen Demand	<2.00	H	2.00		mg/L			07/18/20 16:32	1
Total Organic Carbon	**3.05**		1.00		mg/L			07/22/20 18:20	1

Client Sample Results

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-TW-20003

Lab Sample ID: 240-133624-13

Date Collected: 07/16/20 16:10
Matrix: Water
Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**583**		5.00		ug/L		07/21/20 14:00	07/22/20 12:57	1
Iron	**3930**		200		ug/L		07/21/20 14:00	07/22/20 12:57	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**579**		5.00		ug/L		07/21/20 14:00	07/22/20 12:59	1
Iron	**3620**		200		ug/L		07/21/20 14:00	07/22/20 12:59	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/23/20 09:11	1
Biochemical Oxygen Demand	<2.00	H	2.00		mg/L			07/18/20 16:39	1
Total Organic Carbon	**2.75**		1.00		mg/L			07/22/20 18:53	1

Client Sample ID: DEK-TW-20004

Lab Sample ID: 240-133624-14

Date Collected: 07/17/20 08:25

Matrix: Water

Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**496**		5.00		ug/L		07/21/20 14:00	07/22/20 13:02	1
Iron	**12500**		200		ug/L		07/21/20 14:00	07/22/20 13:02	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**497**		5.00		ug/L		07/21/20 14:00	07/22/20 13:04	1
Iron	**12200**		200		ug/L		07/21/20 14:00	07/22/20 13:04	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/23/20 09:13	1
Biochemical Oxygen Demand	<60.0		60.0		mg/L			07/18/20 16:49	1
Total Organic Carbon	**2.49**		1.00		mg/L			07/22/20 19:26	1

Client Sample ID: DEK-TW-20005

Date Collected: 07/17/20 09:20
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-15
Matrix: Water

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**265**		5.00		ug/L		07/21/20 14:00	07/22/20 13:07	1
Iron	**3730**		200		ug/L		07/21/20 14:00	07/22/20 13:07	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**271**		5.00		ug/L		07/21/20 14:00	07/22/20 13:09	1
Iron	**3760**		200		ug/L		07/21/20 14:00	07/22/20 13:09	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	**12.7**		10.0		mg/L			07/23/20 09:13	1
Biochemical Oxygen Demand	<60.0		60.0		mg/L			07/18/20 17:29	1
Total Organic Carbon	**3.89**		1.00		mg/L			07/22/20 19:59	1

Client Sample ID: DEK-TW-20006

Lab Sample ID: 240-133624-16

Date Collected: 07/17/20 10:25

Matrix: Water

Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**501**		5.00		ug/L		07/21/20 14:00	07/22/20 13:12	1
Iron	**4260**		200		ug/L		07/21/20 14:00	07/22/20 13:12	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**502**		5.00		ug/L		07/21/20 14:00	07/22/20 13:14	1
Iron	**4120**		200		ug/L		07/21/20 14:00	07/22/20 13:14	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	**11.0**		10.0		mg/L			07/23/20 09:14	1
Biochemical Oxygen Demand	<60.0		60.0		mg/L			07/18/20 17:44	1
Total Organic Carbon	**3.51**		1.00		mg/L			07/22/20 20:32	1

Client Sample ID: DEK-TW-20007

Lab Sample ID: 240-133624-17

Date Collected: 07/17/20 11:30

Matrix: Water

Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**780**		5.00		ug/L		07/21/20 14:00	07/22/20 13:17	1
Iron	**4650**		200		ug/L		07/21/20 14:00	07/22/20 13:17	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**803**		5.00		ug/L		07/21/20 14:00	07/22/20 13:19	1
Iron	**4600**		200		ug/L		07/21/20 14:00	07/22/20 13:19	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/23/20 09:14	1
Biochemical Oxygen Demand	<60.0		60.0		mg/L			07/18/20 17:52	1
Total Organic Carbon	**3.09**		1.00		mg/L			07/22/20 21:58	1

Client Sample Results

Client Sample ID: DEK-TW-20008

Lab Sample ID: 240-133624-18

Date Collected: 07/17/20 12:25

Matrix: Water

Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**392**		5.00		ug/L		07/21/20 14:00	07/22/20 13:27	1
Iron	**7270**		200		ug/L		07/21/20 14:00	07/22/20 13:27	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**400**		5.00		ug/L		07/21/20 14:00	07/22/20 13:29	1
Iron	**7340**		200		ug/L		07/21/20 14:00	07/22/20 13:29	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	**13.0**		10.0		mg/L			07/23/20 09:18	1
Biochemical Oxygen Demand	<60.0		60.0		mg/L			07/18/20 17:59	1
Total Organic Carbon	**4.36**		1.00		mg/L			07/22/20 22:51	1

Client Sample Results

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-TW-20009

Lab Sample ID: 240-133624-19

Date Collected: 07/17/20 13:15

Matrix: Water

Date Received: 07/18/20 10:00

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**324**		5.00		ug/L		07/21/20 14:00	07/22/20 13:31	1
Iron	**6090**		200		ug/L		07/21/20 14:00	07/22/20 13:31	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**333**		5.00		ug/L		07/21/20 14:00	07/22/20 13:34	1
Iron	**6090**		200		ug/L		07/21/20 14:00	07/22/20 13:34	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	**11.7**		10.0		mg/L			07/23/20 09:20	1
Biochemical Oxygen Demand	<60.0		60.0		mg/L			07/18/20 18:07	1
Total Organic Carbon	**4.26**		1.00		mg/L			07/22/20 23:24	1

Client Sample Results

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-TW-20010

Date Collected: 07/17/20 13:50
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-20
Matrix: Water

Method: 6020B - Metals (ICP/MS) - Total Recoverable

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**444**		5.00		ug/L		07/21/20 14:00	07/22/20 13:36	1
Iron	**3650**		200		ug/L		07/21/20 14:00	07/22/20 13:36	1

Method: 6020B - Metals (ICP/MS) - Dissolved

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	**428**		5.00		ug/L		07/21/20 14:00	07/22/20 13:39	1
Iron	**3500**		200		ug/L		07/21/20 14:00	07/22/20 13:39	1

General Chemistry

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	**10.0**		10.0		mg/L			07/23/20 09:20	1
Biochemical Oxygen Demand	<60.0		60.0		mg/L			07/18/20 18:15	1
Total Organic Carbon	**3.50**		1.00		mg/L			07/22/20 23:57	1

QC Sample Results

Method: 6020B - Metals (ICP/MS)

Lab Sample ID: MB 240-443513/1-A ^2
Matrix: Solid
Analysis Batch: 443761
Client Sample ID: Method Blank
Prep Type: Total/NA
Prep Batch: 443513

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<1.00		1.00		mg/Kg		07/21/20 14:00	07/22/20 13:46	2
Iron	<40.0		40.0		mg/Kg		07/21/20 14:00	07/22/20 13:46	2

Lab Sample ID: LCS 240-443513/3-A ^2
Matrix: Solid
Analysis Batch: 443761
Client Sample ID: Lab Control Sample
Prep Type: Total/NA
Prep Batch: 443513

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	100	96.69		mg/Kg		97	80 - 120
Iron	500	498.8		mg/Kg		100	80 - 120

Lab Sample ID: 240-133624-1 MS
Matrix: Solid
Analysis Batch: 443761
Client Sample ID: DEK-SB-20001 (22-25')
Prep Type: Total/NA
Prep Batch: 443513

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	4.65		97.4	97.15		mg/Kg	☼	95	80 - 120
Iron	2780		487	3190	4	mg/Kg	☼	85	80 - 120

Lab Sample ID: 240-133624-1 MSD
Matrix: Solid
Analysis Batch: 443761
Client Sample ID: DEK-SB-20001 (22-25')
Prep Type: Total/NA
Prep Batch: 443513

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	4.65		97.4	97.23		mg/Kg	☼	95	80 - 120	0	20
Iron	2780		487	3162	4	mg/Kg	☼	79	80 - 120	1	20

Lab Sample ID: MB 240-443503/1-A
Matrix: Water
Analysis Batch: 443761
Client Sample ID: Method Blank
Prep Type: Total Recoverable
Prep Batch: 443503

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Arsenic	<5.00		5.00		ug/L		07/21/20 14:00	07/22/20 12:28	1
Iron	<200		200		ug/L		07/21/20 14:00	07/22/20 12:28	1

Lab Sample ID: LCS 240-443503/2-A
Matrix: Water
Analysis Batch: 443761
Client Sample ID: Lab Control Sample
Prep Type: Total Recoverable
Prep Batch: 443503

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	1000	975.7		ug/L		98	80 - 120
Iron	5000	4843		ug/L		97	80 - 120

Lab Sample ID: 240-133624-11 MS
Matrix: Water
Analysis Batch: 443761
Client Sample ID: DEK-TW-20001
Prep Type: Total Recoverable
Prep Batch: 443503

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits
Arsenic	430		1000	1434		ug/L		100	80 - 120
Iron	3460		5000	8336		ug/L		98	80 - 120

QC Sample Results

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Method: 6020B - Metals (ICP/MS)

Lab Sample ID: 240-133624-11 MSD
Matrix: Water
Analysis Batch: 443761

Client Sample ID: DEK-TW-20001
Prep Type: Total Recoverable
Prep Batch: 443503

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Arsenic	430		1000	1466		ug/L		104	80 - 120	2	20
Iron	3460		5000	8523		ug/L		101	80 - 120	2	20

Method: 410.4 - COD

Lab Sample ID: MB 460-711228/3
Matrix: Solid
Analysis Batch: 711228

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/24/20 19:07	1

Lab Sample ID: LCSSRM 460-711228/4
Matrix: Solid
Analysis Batch: 711228

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCSSRM Result	LCSSRM Qualifier	Unit	D	%Rec	%Rec. Limits
Chemical Oxygen Demand	117	111.4		mg/L		95.2	77.2 - 118.8

Method: 410.4-1993 R2.0 - COD

Lab Sample ID: MB 240-443889/40
Matrix: Water
Analysis Batch: 443889

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/23/20 09:17	1

Lab Sample ID: MB 240-443889/9
Matrix: Water
Analysis Batch: 443889

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Chemical Oxygen Demand	<10.0		10.0		mg/L			07/23/20 08:59	1

Lab Sample ID: LCS 240-443889/10
Matrix: Water
Analysis Batch: 443889

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Chemical Oxygen Demand	98.5	90.67		mg/L		92	90 - 110

Lab Sample ID: LCS 240-443889/41
Matrix: Water
Analysis Batch: 443889

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Chemical Oxygen Demand	98.5	95.61		mg/L		97	90 - 110

Method: 410.4-1993 R2.0 - COD (Continued)

Lab Sample ID: 240-133624-18 MS
Matrix: Water
Analysis Batch: 443889

Client Sample ID: DEK-TW-20008
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Chemical Oxygen Demand	13.0		50.0	61.05		mg/L		96	90 - 110		

Lab Sample ID: 240-133624-18 MSD
Matrix: Water
Analysis Batch: 443889

Client Sample ID: DEK-TW-20008
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Chemical Oxygen Demand	13.0		50.0	59.73		mg/L		93	90 - 110	2	20

Method: 5210B-2011 - BOD, 5-Day

Lab Sample ID: SCB 240-443216/2
Matrix: Water
Analysis Batch: 443216

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	SCB Result	SCB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Biochemical Oxygen Demand	<2.00	s	2.00		mg/L			07/18/20 13:42	1

Lab Sample ID: USB 240-443216/1
Matrix: Water
Analysis Batch: 443216

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	USB Result	USB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Biochemical Oxygen Demand	<2.00		2.00		mg/L			07/18/20 13:40	1

Lab Sample ID: LCS 240-443216/3
Matrix: Water
Analysis Batch: 443216

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Biochemical Oxygen Demand			198	192.7		mg/L		97	85 - 115		

Lab Sample ID: SCB 240-443217/2
Matrix: Water
Analysis Batch: 443217

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	SCB Result	SCB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Biochemical Oxygen Demand	<2.00	s	2.00		mg/L			07/18/20 17:21	1

Lab Sample ID: USB 240-443217/1
Matrix: Water
Analysis Batch: 443217

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	USB Result	USB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Biochemical Oxygen Demand	<2.00		2.00		mg/L			07/18/20 17:19	1

QC Sample Results

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Method: 5210B-2011 - BOD, 5-Day (Continued)

Lab Sample ID: 240-133624-15 DU
Matrix: Water
Analysis Batch: 443217

Client Sample ID: DEK-TW-20005
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Biochemical Oxygen Demand	<60.0			<60.0		mg/L				NC	15

Method: 9045D - pH

Lab Sample ID: MB 460-713283/2
Matrix: Solid
Analysis Batch: 713283

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
pH	6.4		0.1		SU			08/01/20 10:39	1

Lab Sample ID: LCSSRM 460-713283/3
Matrix: Solid
Analysis Batch: 713283

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCSSRM Result	LCSSRM Qualifier	Unit	D	%Rec	%Rec. Limits		
pH			8.31	8.3		SU		99.3	97.6 - 102.4		

Lab Sample ID: 240-133624-1 DU
Matrix: Solid
Analysis Batch: 713283

Client Sample ID: DEK-SB-20001 (22-25')
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
pH	8.1	HF		8.1		SU				0.4	10

Method: 9060A - Organic Carbon, Total (TOC)

Lab Sample ID: MB 240-443852/37
Matrix: Water
Analysis Batch: 443852

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	<1.00		1.00		mg/L			07/22/20 21:26	1

Lab Sample ID: MB 240-443852/4
Matrix: Water
Analysis Batch: 443852

Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	<1.00		1.00		mg/L			07/22/20 07:47	1

Lab Sample ID: LCS 240-443852/39
Matrix: Water
Analysis Batch: 443852

Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Organic Carbon			38.9	36.35		mg/L		93	80 - 120		

Method: 9060A - Organic Carbon, Total (TOC) (Continued)

Lab Sample ID: LCS 240-443852/6
Client Sample ID: Lab Control Sample
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 443852

Analyte			Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Organic Carbon			38.9	37.41		mg/L		96	80 - 120		

Lab Sample ID: LLCS 240-443852/38
Client Sample ID: Lab Control Sample
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 443852

Analyte			Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Organic Carbon			3.89	3.529		mg/L		91	88 - 115		

Lab Sample ID: LLCS 240-443852/5
Client Sample ID: Lab Control Sample
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 443852

Analyte			Spike Added	LLCS Result	LLCS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Organic Carbon			3.89	4.006		mg/L		103	88 - 115		

Lab Sample ID: 240-133624-17 MS
Client Sample ID: DEK-TW-20007
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 443852

Analyte	Sample Result	Sample Qualifier	Spike Added	MS Result	MS Qualifier	Unit	D	%Rec	%Rec. Limits		
Total Organic Carbon	3.09		25.0	28.30		mg/L		101	65 - 134		

Lab Sample ID: 240-133624-17 MSD
Client Sample ID: DEK-TW-20007
Matrix: Water
Prep Type: Total/NA
Analysis Batch: 443852

Analyte	Sample Result	Sample Qualifier	Spike Added	MSD Result	MSD Qualifier	Unit	D	%Rec	%Rec. Limits	RPD	RPD Limit
Total Organic Carbon	3.09		25.0	29.04		mg/L		104	65 - 134	3	10

Method: Moisture - Percent Moisture

Lab Sample ID: 240-133624-8 DU
Client Sample ID: DEK-SB-20008 (17-19')
Matrix: Solid
Prep Type: Total/NA
Analysis Batch: 443293

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Percent Solids	85.7			86.6		%				1	20
Percent Moisture	14.3			13.4		%				6	20

Method: SM 2580B - Reduction-Oxidation (REDOX) Potential

Lab Sample ID: 240-133624-1 DU
Client Sample ID: DEK-SB-20001 (22-25')
Matrix: Solid
Prep Type: Soluble
Analysis Batch: 714223

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Oxidation Reduction Potential	370			373.0		millivolts				0.8	10

QC Sample Results

Method: SM 5210B - BOD, 5-Day

Lab Sample ID: USB 460-710796/8
Matrix: Solid
Analysis Batch: 710796
Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	USB Result	USB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Biochemical Oxygen Demand	<1.00		1.00		mg/L			07/23/20 13:18	1

Lab Sample ID: LCS 460-710796/2
Matrix: Solid
Analysis Batch: 710796
Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Biochemical Oxygen Demand	131	129.0		mg/L		98	84.6 - 115.4

Lab Sample ID: USB 460-711120/7
Matrix: Solid
Analysis Batch: 711120
Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	USB Result	USB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Biochemical Oxygen Demand	<1.00		1.00		mg/L			07/24/20 12:55	1

Lab Sample ID: LCS 460-711120/2
Matrix: Solid
Analysis Batch: 711120
Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Biochemical Oxygen Demand	131	132.0		mg/L		101	84.6 - 115.4

Lab Sample ID: LB 460-710595/1-A
Matrix: Solid
Analysis Batch: 711120
Client Sample ID: Method Blank
Prep Type: ASTM Leach

Analyte	LB Result	LB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Biochemical Oxygen Demand	<20.0		20.0		mg/L			07/24/20 14:01	1

Method: Walkley Black - Organic Carbon, Total (TOC)

Lab Sample ID: MB 240-443264/4
Matrix: Solid
Analysis Batch: 443264
Client Sample ID: Method Blank
Prep Type: Total/NA

Analyte	MB Result	MB Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Total Organic Carbon	<988		988		mg/Kg			07/20/20 06:09	1

Lab Sample ID: LCS 240-443264/5
Matrix: Solid
Analysis Batch: 443264
Client Sample ID: Lab Control Sample
Prep Type: Total/NA

Analyte	Spike Added	LCS Result	LCS Qualifier	Unit	D	%Rec	%Rec. Limits
Total Organic Carbon	1920	1908		mg/Kg		99	51 - 126

Method: Walkley Black - Organic Carbon, Total (TOC) (Continued)

Lab Sample ID: 240-133624-8 DU
Matrix: Solid
Analysis Batch: 443264

Client Sample ID: DEK-SB-20008 (17-19')
Prep Type: Total/NA

Analyte	Sample Result	Sample Qualifier		DU Result	DU Qualifier	Unit	D			RPD	RPD Limit
Total Organic Carbon	2650			2162		mg/Kg	☼			20	20

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Metals

Prep Batch: 443503

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-11	DEK-TW-20001	Dissolved	Water	3005A	
240-133624-11	DEK-TW-20001	Total Recoverable	Water	3005A	
240-133624-12	DEK-TW-20002	Dissolved	Water	3005A	
240-133624-12	DEK-TW-20002	Total Recoverable	Water	3005A	
240-133624-13	DEK-TW-20003	Dissolved	Water	3005A	
240-133624-13	DEK-TW-20003	Total Recoverable	Water	3005A	
240-133624-14	DEK-TW-20004	Dissolved	Water	3005A	
240-133624-14	DEK-TW-20004	Total Recoverable	Water	3005A	
240-133624-15	DEK-TW-20005	Dissolved	Water	3005A	
240-133624-15	DEK-TW-20005	Total Recoverable	Water	3005A	
240-133624-16	DEK-TW-20006	Dissolved	Water	3005A	
240-133624-16	DEK-TW-20006	Total Recoverable	Water	3005A	
240-133624-17	DEK-TW-20007	Dissolved	Water	3005A	
240-133624-17	DEK-TW-20007	Total Recoverable	Water	3005A	
240-133624-18	DEK-TW-20008	Dissolved	Water	3005A	
240-133624-18	DEK-TW-20008	Total Recoverable	Water	3005A	
240-133624-19	DEK-TW-20009	Dissolved	Water	3005A	
240-133624-19	DEK-TW-20009	Total Recoverable	Water	3005A	
240-133624-20	DEK-TW-20010	Dissolved	Water	3005A	
240-133624-20	DEK-TW-20010	Total Recoverable	Water	3005A	
MB 240-443503/1-A	Method Blank	Total Recoverable	Water	3005A	
LCS 240-443503/2-A	Lab Control Sample	Total Recoverable	Water	3005A	
240-133624-11 MS	DEK-TW-20001	Total Recoverable	Water	3005A	
240-133624-11 MSD	DEK-TW-20001	Total Recoverable	Water	3005A	

Prep Batch: 443513

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	Total/NA	Solid	3050B	
240-133624-2	DEK-SB-20002 (21-23')	Total/NA	Solid	3050B	
240-133624-3	DEK-SB-20003 (15-17')	Total/NA	Solid	3050B	
240-133624-4	DEK-SB-20004 (17-19')	Total/NA	Solid	3050B	
240-133624-5	DEK-SB-20005 (19-21')	Total/NA	Solid	3050B	
240-133624-6	DEK-SB-20006 (11-13')	Total/NA	Solid	3050B	
240-133624-7	DEK-SB-20007 (14-16')	Total/NA	Solid	3050B	
240-133624-8	DEK-SB-20008 (17-19')	Total/NA	Solid	3050B	
240-133624-9	DEK-SB-20009 (15-17')	Total/NA	Solid	3050B	
240-133624-10	DEK-SB-20010 (9-12')	Total/NA	Solid	3050B	
MB 240-443513/1-A ^2	Method Blank	Total/NA	Solid	3050B	
LCS 240-443513/3-A ^2	Lab Control Sample	Total/NA	Solid	3050B	
240-133624-1 MS	DEK-SB-20001 (22-25')	Total/NA	Solid	3050B	
240-133624-1 MSD	DEK-SB-20001 (22-25')	Total/NA	Solid	3050B	

Analysis Batch: 443761

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	Total/NA	Solid	6020B	443513
240-133624-2	DEK-SB-20002 (21-23')	Total/NA	Solid	6020B	443513
240-133624-3	DEK-SB-20003 (15-17')	Total/NA	Solid	6020B	443513
240-133624-4	DEK-SB-20004 (17-19')	Total/NA	Solid	6020B	443513
240-133624-5	DEK-SB-20005 (19-21')	Total/NA	Solid	6020B	443513
240-133624-6	DEK-SB-20006 (11-13')	Total/NA	Solid	6020B	443513
240-133624-7	DEK-SB-20007 (14-16')	Total/NA	Solid	6020B	443513

Metals (Continued)

Analysis Batch: 443761 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-8	DEK-SB-20008 (17-19')	Total/NA	Solid	6020B	443513
240-133624-9	DEK-SB-20009 (15-17')	Total/NA	Solid	6020B	443513
240-133624-10	DEK-SB-20010 (9-12')	Total/NA	Solid	6020B	443513
240-133624-11	DEK-TW-20001	Dissolved	Water	6020B	443503
240-133624-11	DEK-TW-20001	Total Recoverable	Water	6020B	443503
240-133624-12	DEK-TW-20002	Dissolved	Water	6020B	443503
240-133624-12	DEK-TW-20002	Total Recoverable	Water	6020B	443503
240-133624-13	DEK-TW-20003	Dissolved	Water	6020B	443503
240-133624-13	DEK-TW-20003	Total Recoverable	Water	6020B	443503
240-133624-14	DEK-TW-20004	Dissolved	Water	6020B	443503
240-133624-14	DEK-TW-20004	Total Recoverable	Water	6020B	443503
240-133624-15	DEK-TW-20005	Dissolved	Water	6020B	443503
240-133624-15	DEK-TW-20005	Total Recoverable	Water	6020B	443503
240-133624-16	DEK-TW-20006	Dissolved	Water	6020B	443503
240-133624-16	DEK-TW-20006	Total Recoverable	Water	6020B	443503
240-133624-17	DEK-TW-20007	Dissolved	Water	6020B	443503
240-133624-17	DEK-TW-20007	Total Recoverable	Water	6020B	443503
240-133624-18	DEK-TW-20008	Dissolved	Water	6020B	443503
240-133624-18	DEK-TW-20008	Total Recoverable	Water	6020B	443503
240-133624-19	DEK-TW-20009	Dissolved	Water	6020B	443503
240-133624-19	DEK-TW-20009	Total Recoverable	Water	6020B	443503
240-133624-20	DEK-TW-20010	Dissolved	Water	6020B	443503
240-133624-20	DEK-TW-20010	Total Recoverable	Water	6020B	443503
MB 240-443503/1-A	Method Blank	Total Recoverable	Water	6020B	443503
MB 240-443513/1-A ^2	Method Blank	Total/NA	Solid	6020B	443513
LCS 240-443503/2-A	Lab Control Sample	Total Recoverable	Water	6020B	443503
LCS 240-443513/3-A ^2	Lab Control Sample	Total/NA	Solid	6020B	443513
240-133624-1 MS	DEK-SB-20001 (22-25')	Total/NA	Solid	6020B	443513
240-133624-1 MSD	DEK-SB-20001 (22-25')	Total/NA	Solid	6020B	443513
240-133624-11 MS	DEK-TW-20001	Total Recoverable	Water	6020B	443503
240-133624-11 MSD	DEK-TW-20001	Total Recoverable	Water	6020B	443503

General Chemistry

Analysis Batch: 443216

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-11	DEK-TW-20001	Total/NA	Water	5210B-2011	
240-133624-12	DEK-TW-20002	Total/NA	Water	5210B-2011	
240-133624-13	DEK-TW-20003	Total/NA	Water	5210B-2011	
240-133624-14	DEK-TW-20004	Total/NA	Water	5210B-2011	
SCB 240-443216/2	Method Blank	Total/NA	Water	5210B-2011	
USB 240-443216/1	Method Blank	Total/NA	Water	5210B-2011	
LCS 240-443216/3	Lab Control Sample	Total/NA	Water	5210B-2011	

Analysis Batch: 443217

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-15	DEK-TW-20005	Total/NA	Water	5210B-2011	
240-133624-16	DEK-TW-20006	Total/NA	Water	5210B-2011	
240-133624-17	DEK-TW-20007	Total/NA	Water	5210B-2011	
240-133624-18	DEK-TW-20008	Total/NA	Water	5210B-2011	
240-133624-19	DEK-TW-20009	Total/NA	Water	5210B-2011	

General Chemistry (Continued)

Analysis Batch: 443217 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-20	DEK-TW-20010	Total/NA	Water	5210B-2011	
SCB 240-443217/2	Method Blank	Total/NA	Water	5210B-2011	
USB 240-443217/1	Method Blank	Total/NA	Water	5210B-2011	
LCS 240-443217/3	Lab Control Sample	Total/NA	Water	5210B-2011	
240-133624-15 DU	DEK-TW-20005	Total/NA	Water	5210B-2011	

Analysis Batch: 443264

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	Total/NA	Solid	Walkley Black	
240-133624-2	DEK-SB-20002 (21-23')	Total/NA	Solid	Walkley Black	
240-133624-3	DEK-SB-20003 (15-17')	Total/NA	Solid	Walkley Black	
240-133624-4	DEK-SB-20004 (17-19')	Total/NA	Solid	Walkley Black	
240-133624-5	DEK-SB-20005 (19-21')	Total/NA	Solid	Walkley Black	
240-133624-6	DEK-SB-20006 (11-13')	Total/NA	Solid	Walkley Black	
240-133624-7	DEK-SB-20007 (14-16')	Total/NA	Solid	Walkley Black	
240-133624-8	DEK-SB-20008 (17-19')	Total/NA	Solid	Walkley Black	
240-133624-9	DEK-SB-20009 (15-17')	Total/NA	Solid	Walkley Black	
240-133624-10	DEK-SB-20010 (9-12')	Total/NA	Solid	Walkley Black	
MB 240-443264/4	Method Blank	Total/NA	Solid	Walkley Black	
LCS 240-443264/5	Lab Control Sample	Total/NA	Solid	Walkley Black	
240-133624-8 DU	DEK-SB-20008 (17-19')	Total/NA	Solid	Walkley Black	

Analysis Batch: 443293

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	Total/NA	Solid	Moisture	
240-133624-2	DEK-SB-20002 (21-23')	Total/NA	Solid	Moisture	
240-133624-3	DEK-SB-20003 (15-17')	Total/NA	Solid	Moisture	
240-133624-4	DEK-SB-20004 (17-19')	Total/NA	Solid	Moisture	
240-133624-5	DEK-SB-20005 (19-21')	Total/NA	Solid	Moisture	
240-133624-6	DEK-SB-20006 (11-13')	Total/NA	Solid	Moisture	
240-133624-7	DEK-SB-20007 (14-16')	Total/NA	Solid	Moisture	
240-133624-8	DEK-SB-20008 (17-19')	Total/NA	Solid	Moisture	
240-133624-9	DEK-SB-20009 (15-17')	Total/NA	Solid	Moisture	
240-133624-10	DEK-SB-20010 (9-12')	Total/NA	Solid	Moisture	
240-133624-8 DU	DEK-SB-20008 (17-19')	Total/NA	Solid	Moisture	

Analysis Batch: 443852

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-11	DEK-TW-20001	Total/NA	Water	9060A	
240-133624-12	DEK-TW-20002	Total/NA	Water	9060A	
240-133624-13	DEK-TW-20003	Total/NA	Water	9060A	
240-133624-14	DEK-TW-20004	Total/NA	Water	9060A	
240-133624-15	DEK-TW-20005	Total/NA	Water	9060A	
240-133624-16	DEK-TW-20006	Total/NA	Water	9060A	
240-133624-17	DEK-TW-20007	Total/NA	Water	9060A	
240-133624-18	DEK-TW-20008	Total/NA	Water	9060A	
240-133624-19	DEK-TW-20009	Total/NA	Water	9060A	
240-133624-20	DEK-TW-20010	Total/NA	Water	9060A	
MB 240-443852/37	Method Blank	Total/NA	Water	9060A	
MB 240-443852/4	Method Blank	Total/NA	Water	9060A	
LCS 240-443852/39	Lab Control Sample	Total/NA	Water	9060A	

General Chemistry (Continued)

Analysis Batch: 443852 (Continued)

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
LCS 240-443852/6	Lab Control Sample	Total/NA	Water	9060A	
LLCS 240-443852/38	Lab Control Sample	Total/NA	Water	9060A	
LLCS 240-443852/5	Lab Control Sample	Total/NA	Water	9060A	
240-133624-17 MS	DEK-TW-20007	Total/NA	Water	9060A	
240-133624-17 MSD	DEK-TW-20007	Total/NA	Water	9060A	

Analysis Batch: 443889

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-11	DEK-TW-20001	Total/NA	Water	410.4-1993 R2.0	
240-133624-12	DEK-TW-20002	Total/NA	Water	410.4-1993 R2.0	
240-133624-13	DEK-TW-20003	Total/NA	Water	410.4-1993 R2.0	
240-133624-14	DEK-TW-20004	Total/NA	Water	410.4-1993 R2.0	
240-133624-15	DEK-TW-20005	Total/NA	Water	410.4-1993 R2.0	
240-133624-16	DEK-TW-20006	Total/NA	Water	410.4-1993 R2.0	
240-133624-17	DEK-TW-20007	Total/NA	Water	410.4-1993 R2.0	
240-133624-18	DEK-TW-20008	Total/NA	Water	410.4-1993 R2.0	
240-133624-19	DEK-TW-20009	Total/NA	Water	410.4-1993 R2.0	
240-133624-20	DEK-TW-20010	Total/NA	Water	410.4-1993 R2.0	
MB 240-443889/40	Method Blank	Total/NA	Water	410.4-1993 R2.0	
MB 240-443889/9	Method Blank	Total/NA	Water	410.4-1993 R2.0	
LCS 240-443889/10	Lab Control Sample	Total/NA	Water	410.4-1993 R2.0	
LCS 240-443889/41	Lab Control Sample	Total/NA	Water	410.4-1993 R2.0	
240-133624-18 MS	DEK-TW-20008	Total/NA	Water	410.4-1993 R2.0	
240-133624-18 MSD	DEK-TW-20008	Total/NA	Water	410.4-1993 R2.0	

Leach Batch: 710595

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	ASTM Leach	Solid	D3987-85	
240-133624-2	DEK-SB-20002 (21-23')	ASTM Leach	Solid	D3987-85	
240-133624-3	DEK-SB-20003 (15-17')	ASTM Leach	Solid	D3987-85	
240-133624-4	DEK-SB-20004 (17-19')	ASTM Leach	Solid	D3987-85	
240-133624-5	DEK-SB-20005 (19-21')	ASTM Leach	Solid	D3987-85	
240-133624-6	DEK-SB-20006 (11-13')	ASTM Leach	Solid	D3987-85	
240-133624-7	DEK-SB-20007 (14-16')	ASTM Leach	Solid	D3987-85	
240-133624-8	DEK-SB-20008 (17-19')	ASTM Leach	Solid	D3987-85	
240-133624-9	DEK-SB-20009 (15-17')	ASTM Leach	Solid	D3987-85	
240-133624-10	DEK-SB-20010 (9-12')	ASTM Leach	Solid	D3987-85	
LB 460-710595/1-A	Method Blank	ASTM Leach	Solid	D3987-85	

Leach Batch: 710596

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	ASTM Leach	Solid	D3987-85	
240-133624-2	DEK-SB-20002 (21-23')	ASTM Leach	Solid	D3987-85	
240-133624-3	DEK-SB-20003 (15-17')	ASTM Leach	Solid	D3987-85	
240-133624-4	DEK-SB-20004 (17-19')	ASTM Leach	Solid	D3987-85	
240-133624-5	DEK-SB-20005 (19-21')	ASTM Leach	Solid	D3987-85	
240-133624-6	DEK-SB-20006 (11-13')	ASTM Leach	Solid	D3987-85	
240-133624-7	DEK-SB-20007 (14-16')	ASTM Leach	Solid	D3987-85	
240-133624-8	DEK-SB-20008 (17-19')	ASTM Leach	Solid	D3987-85	
240-133624-9	DEK-SB-20009 (15-17')	ASTM Leach	Solid	D3987-85	
240-133624-10	DEK-SB-20010 (9-12')	ASTM Leach	Solid	D3987-85	

QC Association Summary

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

General Chemistry

Analysis Batch: 710796

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	ASTM Leach	Solid	SM 5210B	710595
240-133624-2	DEK-SB-20002 (21-23')	ASTM Leach	Solid	SM 5210B	710595
240-133624-3	DEK-SB-20003 (15-17')	ASTM Leach	Solid	SM 5210B	710595
240-133624-4	DEK-SB-20004 (17-19')	ASTM Leach	Solid	SM 5210B	710595
240-133624-5	DEK-SB-20005 (19-21')	ASTM Leach	Solid	SM 5210B	710595
USB 460-710796/8	Method Blank	Total/NA	Solid	SM 5210B	
LCS 460-710796/2	Lab Control Sample	Total/NA	Solid	SM 5210B	

Analysis Batch: 711120

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-6	DEK-SB-20006 (11-13')	ASTM Leach	Solid	SM 5210B	710595
240-133624-7	DEK-SB-20007 (14-16')	ASTM Leach	Solid	SM 5210B	710595
240-133624-8	DEK-SB-20008 (17-19')	ASTM Leach	Solid	SM 5210B	710595
240-133624-9	DEK-SB-20009 (15-17')	ASTM Leach	Solid	SM 5210B	710595
240-133624-10	DEK-SB-20010 (9-12')	ASTM Leach	Solid	SM 5210B	710595
LB 460-710595/1-A	Method Blank	ASTM Leach	Solid	SM 5210B	710595
USB 460-711120/7	Method Blank	Total/NA	Solid	SM 5210B	
LCS 460-711120/2	Lab Control Sample	Total/NA	Solid	SM 5210B	

Analysis Batch: 711228

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	ASTM Leach	Solid	410.4	710596
240-133624-2	DEK-SB-20002 (21-23')	ASTM Leach	Solid	410.4	710596
240-133624-3	DEK-SB-20003 (15-17')	ASTM Leach	Solid	410.4	710596
240-133624-4	DEK-SB-20004 (17-19')	ASTM Leach	Solid	410.4	710596
240-133624-5	DEK-SB-20005 (19-21')	ASTM Leach	Solid	410.4	710596
240-133624-6	DEK-SB-20006 (11-13')	ASTM Leach	Solid	410.4	710596
240-133624-7	DEK-SB-20007 (14-16')	ASTM Leach	Solid	410.4	710596
240-133624-8	DEK-SB-20008 (17-19')	ASTM Leach	Solid	410.4	710596
240-133624-9	DEK-SB-20009 (15-17')	ASTM Leach	Solid	410.4	710596
240-133624-10	DEK-SB-20010 (9-12')	ASTM Leach	Solid	410.4	710596
MB 460-711228/3	Method Blank	Total/NA	Solid	410.4	
LCSSRM 460-711228/4	Lab Control Sample	Total/NA	Solid	410.4	

Analysis Batch: 713283

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	Total/NA	Solid	9045D	
240-133624-2	DEK-SB-20002 (21-23')	Total/NA	Solid	9045D	
240-133624-3	DEK-SB-20003 (15-17')	Total/NA	Solid	9045D	
240-133624-4	DEK-SB-20004 (17-19')	Total/NA	Solid	9045D	
240-133624-5	DEK-SB-20005 (19-21')	Total/NA	Solid	9045D	
240-133624-6	DEK-SB-20006 (11-13')	Total/NA	Solid	9045D	
240-133624-7	DEK-SB-20007 (14-16')	Total/NA	Solid	9045D	
240-133624-8	DEK-SB-20008 (17-19')	Total/NA	Solid	9045D	
240-133624-9	DEK-SB-20009 (15-17')	Total/NA	Solid	9045D	
240-133624-10	DEK-SB-20010 (9-12')	Total/NA	Solid	9045D	
MB 460-713283/2	Method Blank	Total/NA	Solid	9045D	
LCSSRM 460-713283/3	Lab Control Sample	Total/NA	Solid	9045D	
240-133624-1 DU	DEK-SB-20001 (22-25')	Total/NA	Solid	9045D	

General Chemistry

Leach Batch: 714186

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	Soluble	Solid	DI Leach	
240-133624-2	DEK-SB-20002 (21-23')	Soluble	Solid	DI Leach	
240-133624-3	DEK-SB-20003 (15-17')	Soluble	Solid	DI Leach	
240-133624-4	DEK-SB-20004 (17-19')	Soluble	Solid	DI Leach	
240-133624-5	DEK-SB-20005 (19-21')	Soluble	Solid	DI Leach	
240-133624-6	DEK-SB-20006 (11-13')	Soluble	Solid	DI Leach	
240-133624-7	DEK-SB-20007 (14-16')	Soluble	Solid	DI Leach	
240-133624-8	DEK-SB-20008 (17-19')	Soluble	Solid	DI Leach	
240-133624-9	DEK-SB-20009 (15-17')	Soluble	Solid	DI Leach	
240-133624-10	DEK-SB-20010 (9-12')	Soluble	Solid	DI Leach	
240-133624-1 DU	DEK-SB-20001 (22-25')	Soluble	Solid	DI Leach	

Analysis Batch: 714223

Lab Sample ID	Client Sample ID	Prep Type	Matrix	Method	Prep Batch
240-133624-1	DEK-SB-20001 (22-25')	Soluble	Solid	SM 2580B	714186
240-133624-2	DEK-SB-20002 (21-23')	Soluble	Solid	SM 2580B	714186
240-133624-3	DEK-SB-20003 (15-17')	Soluble	Solid	SM 2580B	714186
240-133624-4	DEK-SB-20004 (17-19')	Soluble	Solid	SM 2580B	714186
240-133624-5	DEK-SB-20005 (19-21')	Soluble	Solid	SM 2580B	714186
240-133624-6	DEK-SB-20006 (11-13')	Soluble	Solid	SM 2580B	714186
240-133624-7	DEK-SB-20007 (14-16')	Soluble	Solid	SM 2580B	714186
240-133624-8	DEK-SB-20008 (17-19')	Soluble	Solid	SM 2580B	714186
240-133624-9	DEK-SB-20009 (15-17')	Soluble	Solid	SM 2580B	714186
240-133624-10	DEK-SB-20010 (9-12')	Soluble	Solid	SM 2580B	714186
240-133624-1 DU	DEK-SB-20001 (22-25')	Soluble	Solid	SM 2580B	714186

Client Sample ID: DEK-SB-20001 (22-25') Lab Sample ID: 240-133624-1

Date Collected: 07/14/20 11:45 **Matrix: Solid**

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:43	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 09:41	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:39	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	710796	07/23/20 21:20	PLS	TAL EDI

Client Sample ID: DEK-SB-20001 (22-25') Lab Sample ID: 240-133624-1

Date Collected: 07/14/20 11:45 **Matrix: Solid**

Date Received: 07/18/20 10:00 **Percent Solids: 85.6**

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 13:51	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:29	TPH	TAL CAN

Client Sample ID: DEK-SB-20002 (21-23') Lab Sample ID: 240-133624-2

Date Collected: 07/14/20 13:50 **Matrix: Solid**

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:45	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 09:41	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:43	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	710796	07/23/20 21:25	PLS	TAL EDI

Client Sample ID: DEK-SB-20002 (21-23') Lab Sample ID: 240-133624-2

Date Collected: 07/14/20 13:50 **Matrix: Solid**

Date Received: 07/18/20 10:00 **Percent Solids: 80.5**

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:03	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:32	TPH	TAL CAN

Lab Chronicle

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-SB-20003 (15-17')

Lab Sample ID: 240-133624-3

Date Collected: 07/14/20 15:20
Date Received: 07/18/20 10:00

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:46	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:45	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	710796	07/23/20 21:30	PLS	TAL EDI

Client Sample ID: DEK-SB-20003 (15-17')

Lab Sample ID: 240-133624-3

Date Collected: 07/14/20 15:20
Date Received: 07/18/20 10:00

Matrix: Solid
Percent Solids: 80.0

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:06	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:35	TPH	TAL CAN

Client Sample ID: DEK-SB-20004 (17-19')

Lab Sample ID: 240-133624-4

Date Collected: 07/14/20 16:50
Date Received: 07/18/20 10:00

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:47	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:47	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	710796	07/23/20 21:35	PLS	TAL EDI

Client Sample ID: DEK-SB-20004 (17-19')

Lab Sample ID: 240-133624-4

Date Collected: 07/14/20 16:50
Date Received: 07/18/20 10:00

Matrix: Solid
Percent Solids: 86.7

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:08	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:39	TPH	TAL CAN

Lab Chronicle

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-SB-20005 (19-21')

Lab Sample ID: 240-133624-5

Date Collected: 07/15/20 08:50
Date Received: 07/18/20 10:00

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:48	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:49	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	710796	07/23/20 21:40	PLS	TAL EDI

Client Sample ID: DEK-SB-20005 (19-21')

Lab Sample ID: 240-133624-5

Date Collected: 07/15/20 08:50
Date Received: 07/18/20 10:00

Matrix: Solid
Percent Solids: 83.2

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:15	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:42	TPH	TAL CAN

Client Sample ID: DEK-SB-20006 (11-13')

Lab Sample ID: 240-133624-6

Date Collected: 07/15/20 10:20
Date Received: 07/18/20 10:00

Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:49	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:51	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	711120	07/24/20 13:22	PLS	TAL EDI

Client Sample ID: DEK-SB-20006 (11-13')

Lab Sample ID: 240-133624-6

Date Collected: 07/15/20 10:20
Date Received: 07/18/20 10:00

Matrix: Solid
Percent Solids: 89.2

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:18	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:45	TPH	TAL CAN

Client Sample ID: DEK-SB-20007 (14-16')
Date Collected: 07/15/20 11:45
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-7
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:51	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:53	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	711120	07/24/20 13:39	PLS	TAL EDI

Client Sample ID: DEK-SB-20007 (14-16')
Date Collected: 07/15/20 11:45
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-7
Matrix: Solid
Percent Solids: 79.3

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:21	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:48	TPH	TAL CAN

Client Sample ID: DEK-SB-20008 (17-19')
Date Collected: 07/15/20 13:55
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-8
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:52	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 12:55	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	711120	07/24/20 13:48	PLS	TAL EDI

Client Sample ID: DEK-SB-20008 (17-19')
Date Collected: 07/15/20 13:55
Date Received: 07/18/20 10:00

Lab Sample ID: 240-133624-8
Matrix: Solid
Percent Solids: 85.7

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:23	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:55	TPH	TAL CAN

Lab Chronicle

Client Sample ID: DEK-SB-20009 (15-17')
Lab Sample ID: 240-133624-9

Date Collected: 07/15/20 15:15
Date Received: 07/18/20 10:00
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:53	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 13:00	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	711120	07/24/20 13:54	PLS	TAL EDI

Client Sample ID: DEK-SB-20009 (15-17')
Lab Sample ID: 240-133624-9

Date Collected: 07/15/20 15:15
Date Received: 07/18/20 10:00
Matrix: Solid
Percent Solids: 87.7

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:26	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 06:58	TPH	TAL CAN

Client Sample ID: DEK-SB-20010 (9-12')
Lab Sample ID: 240-133624-10

Date Collected: 07/15/20 16:30
Date Received: 07/18/20 10:00
Matrix: Solid

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
ASTM Leach	Leach	D3987-85			710596	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	410.4		1	711228	07/24/20 19:07	HTV	TAL EDI
Total/NA	Analysis	9045D		1	713283	08/01/20 10:54	AAP	TAL EDI
Total/NA	Analysis	Moisture		1	443293	07/20/20 10:05	BWL	TAL CAN
Soluble	Leach	DI Leach			714186	08/05/20 08:42	AAP	TAL EDI
Soluble	Analysis	SM 2580B		1	714223	08/05/20 13:02	AAP	TAL EDI
ASTM Leach	Leach	D3987-85			710595	07/22/20 15:00	YXG	TAL EDI
ASTM Leach	Analysis	SM 5210B		1	711120	07/24/20 13:58	PLS	TAL EDI

Client Sample ID: DEK-SB-20010 (9-12')
Lab Sample ID: 240-133624-10

Date Collected: 07/15/20 16:30
Date Received: 07/18/20 10:00
Matrix: Solid
Percent Solids: 83.2

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Prep	3050B			443513	07/21/20 14:00	DEE	TAL CAN
Total/NA	Analysis	6020B		2	443761	07/22/20 14:28	DSH	TAL CAN
Total/NA	Analysis	Walkley Black		1	443264	07/20/20 07:01	TPH	TAL CAN

Lab Chronicle

Client Sample ID: DEK-TW-20001

Lab Sample ID: 240-133624-11

Date Collected: 07/16/20 13:40

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 12:45	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 12:33	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:10	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443216	07/18/20 16:26	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 17:47	TPH	TAL CAN

Client Sample ID: DEK-TW-20002

Lab Sample ID: 240-133624-12

Date Collected: 07/16/20 14:25

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 12:50	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 12:47	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:10	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443216	07/18/20 16:32	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 18:20	TPH	TAL CAN

Client Sample ID: DEK-TW-20003

Lab Sample ID: 240-133624-13

Date Collected: 07/16/20 16:10

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 12:59	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 12:57	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:11	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443216	07/18/20 16:39	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 18:53	TPH	TAL CAN

Client Sample ID: DEK-TW-20004

Lab Sample ID: 240-133624-14

Date Collected: 07/17/20 08:25

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 13:04	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 13:02	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:13	TPH	TAL CAN

Lab Chronicle

Client: Barr Engineering Company
Project/Site: DE Karn Project #: 22/09-1015

Job ID: 240-133624-1

Client Sample ID: DEK-TW-20004

Lab Sample ID: 240-133624-14

Date Collected: 07/17/20 08:25

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Total/NA	Analysis	5210B-2011		1	443216	07/18/20 16:49	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 19:26	TPH	TAL CAN

Client Sample ID: DEK-TW-20005

Lab Sample ID: 240-133624-15

Date Collected: 07/17/20 09:20

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 13:09	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 13:07	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:13	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443217	07/18/20 17:29	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 19:59	TPH	TAL CAN

Client Sample ID: DEK-TW-20006

Lab Sample ID: 240-133624-16

Date Collected: 07/17/20 10:25

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 13:14	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 13:12	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:14	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443217	07/18/20 17:44	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 20:32	TPH	TAL CAN

Client Sample ID: DEK-TW-20007

Lab Sample ID: 240-133624-17

Date Collected: 07/17/20 11:30

Matrix: Water

Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 13:19	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 13:17	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:14	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443217	07/18/20 17:52	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 21:58	TPH	TAL CAN

Lab Chronicle

Client Sample ID: DEK-TW-20008

Lab Sample ID: 240-133624-18
Date Collected: 07/17/20 12:25
Matrix: Water
Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 13:29	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 13:27	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:18	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443217	07/18/20 17:59	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 22:51	TPH	TAL CAN

Client Sample ID: DEK-TW-20009

Lab Sample ID: 240-133624-19
Date Collected: 07/17/20 13:15
Matrix: Water
Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 13:34	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 13:31	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:20	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443217	07/18/20 18:07	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 23:24	TPH	TAL CAN

Client Sample ID: DEK-TW-20010

Lab Sample ID: 240-133624-20
Date Collected: 07/17/20 13:50
Matrix: Water
Date Received: 07/18/20 10:00

Prep Type	Batch Type	Batch Method	Run	Dilution Factor	Batch Number	Prepared or Analyzed	Analyst	Lab
Dissolved	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Dissolved	Analysis	6020B		1	443761	07/22/20 13:39	DSH	TAL CAN
Total Recoverable	Prep	3005A			443503	07/21/20 14:00	MRL	TAL CAN
Total Recoverable	Analysis	6020B		1	443761	07/22/20 13:36	DSH	TAL CAN
Total/NA	Analysis	410.4-1993 R2.0		1	443889	07/23/20 09:20	TPH	TAL CAN
Total/NA	Analysis	5210B-2011		1	443217	07/18/20 18:15	JMR	TAL CAN
Total/NA	Analysis	9060A		1	443852	07/22/20 23:57	TPH	TAL CAN

Laboratory References:

TAL CAN = Eurofins TestAmerica, Canton, 4101 Shuffel Street NW, North Canton, OH 44720, TEL (330)497-9396
TAL EDI = Eurofins TestAmerica, Edison, 777 New Durham Road, Edison, NJ 08817, TEL (732)549-3900

Accreditation/Certification Summary

Laboratory: Eurofins TestAmerica, Canton

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
California	State	2927	02-23-21
Connecticut	State	PH-0590	12-31-21
Florida	NELAP	E87225	06-30-21
Georgia	State	4062	02-23-21
Illinois	NELAP	004498	07-31-20
Iowa	State	421	06-01-21
Kansas	NELAP	E-10336	04-30-21
Kentucky (UST)	State	112225	02-23-21
Kentucky (WW)	State	KY98016	12-31-20
Minnesota	NELAP	OH00048	12-31-20
Minnesota (Petrofund)	State	3506	08-01-21
New Jersey	NELAP	OH001	06-30-21
New York	NELAP	10975	03-31-21
Ohio VAP	State	CL0024	06-05-21
Oregon	NELAP	4062	02-24-21
Pennsylvania	NELAP	68-00340	08-31-20
Texas	NELAP	T104704517-18-10	08-31-20
USDA	US Federal Programs	P330-18-00281	09-17-21
Virginia	NELAP	010101	09-14-20
Washington	State	C971	01-12-21
West Virginia DEP	State	210	12-31-20

Laboratory: Eurofins TestAmerica, Edison

All accreditations/certifications held by this laboratory are listed. Not all accreditations/certifications are applicable to this report.

Authority	Program	Identification Number	Expiration Date
Connecticut	State	PH-0200	09-30-20
DE Haz. Subst. Cleanup Act (HSCA)	State	<cert No.>	12-31-21
Georgia	State	12028 (NJ)	07-01-21
Massachusetts	State	M-NJ312	06-30-21
New Jersey	NELAP	12028	06-30-21
New York	NELAP	11452	04-01-21
Pennsylvania	NELAP	68-00522	02-28-21
Rhode Island	State	LAO00132	12-31-20
USDA	US Federal Programs	P330-18-00135	05-03-21

MICHIGAN
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Chain of Custody Record

eurofins | Environment Testing America

Client Information	Sampler: AMS3	Lab PM: Howell, Leslie	Carrier Tracking No(s):	COC No: 240-73522-29653.1
Client Contact: Accounts Payables	Phone:	E-Mail: Leslie.Howell@Eurofinset.com		Page: Page 1 of 2
Company: Barr Engineering Company				Job #:
Address: 4300 MarketPoint Drive Suite 200	Due Date Requested:			
City: Minneapolis	TAT Requested (days):			
State, Zip: MN, 55435				
Phone: 952-832-2756(Tel)	PO #: 22091015			
Email: accountspayableinvoices@barr.com	WO #:			
Project Name: DE Karn Project #: 22/09-1015	Project #: 24025307			
Site: Consumers - DE Karn	SSOW#:			

Analysis Requested

Preservation Codes:

A - HCL
B - NaOH
C - Zn Acetate
D - Nitric Acid
E - NaHSO4
F - MeOH
G - Amchlor
H - Ascorbic Acid
I - Ice
J - DI Water
K - EDTA
L - EDA

M - Hexane
N - None
O - AsNaO2
P - Na2O4S
Q - Na2SO3
R - Na2S2O3
S - H2SO4
T - TSP Dodecahydrate
U - Acetone
V - MCAA
W - pH 4-5
Z - other (specify)

Other:

Sample Identification	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	6020B, WalkleyBlk_Calc	410.4, 9045D	6020B - (MOD) Fe, As	6020B - Field Filtered - (MOD) Fe, As	5210B - Local Method	410.4 - Local Method	9060A - Local Method	Total Number of containers	Special Instructions/Note:
				Preservation Code:			N	N	D	D	N	S	S		
DEK-SB-20001 (22-25')	7/14/20	1145	C	Solid	N	N	X	X	~~X~~ AMS3					3	
DEK-SB-20002 (21-23')	↓	1350	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20003 (15-17')	↓	1520	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20004 (17-19')	↓	1650	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20005 (19-21')	7/15/20	0850	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20006 (11-13')	↓	1020	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20007 (14-16')	↓	1145	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20008 (17-19')	↓	1355	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20009 (15-17')	↓	1515	↓	Solid	↓	↓	↓	2						3	
DEK-SB-20010 (9-12')	↓	1630	↓	Solid	↓	↓	↓	↓						3	
DEK-TW-20001	7/16/20	~~1030~~ AMS3 1340	–	Water	Y	N			X	X	X	X	X	6	

240-133624 Chain of Custody

Possible Hazard Identification
☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown ☐ Radiological

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ Return To Client ☐ Disposal By Lab ☐ Archive For ____ Months

Deliverable Requested: I, II, III, IV, Other (specify)

Special Instructions/QC Requirements:

Empty Kit Relinquished by:	Date:		Time:		Method of Shipment:
Relinquished by:	Date/Time: 7/16/20 1605	Company: BARR	Received by:	Date/Time: 7/17/20 1609	Company: ETA
Relinquished by:	Date/Time:	Company:	Received by:	Date/Time: 7-18-20 1000	Company: ETA
Relinquished by:	Date/Time:	Company:	Received by:	Date/Time:	Company:
Custody Seals Intact: Δ Yes Δ No	Custody Seal No.:		Cooler Temperature(s) °C and Other Remarks:		

Ver: 01/16/2019

MICHIGAN
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Chain of Custody Record

40149

eurofins | Environment Testing America

Client Information	Sampler:	Lab PM: Howell, Leslie	Carrier Tracking No(s):	COC No: 240-73522-29653.2
Client Contact: Accounts Payables	Phone:	E-Mail: Leslie.Howell@Eurofinset.com		Page: Page 2 of 2
Company: Barr Engineering Company		**Analysis Requested**		Job #:
Address: 4300 MarketPoint Drive Suite 200	**Due Date Requested:**			
City: Minneapolis	**TAT Requested (days):**			
State, Zip: MN, 55435				
Phone: 952-832-2756(Tel)	PO #: 22091015			
Email: accountspayableinvoices@barr.com	WO #:			
Project Name: DE Karn Project #: 22/09-1015	Project #: 24025307			
Site:	SSOW#:			**Other:**

Preservation Codes:

A - HCL
B - NaOH
C - Zn Acetate
D - Nitric Acid
E - NaHSO4
F - MeOH
G - Amchlor
H - Ascorbic Acid
I - Ice
J - DI Water
K - EDTA
L - EDA
M - Hexane
N - None
O - AsNaO2
P - Na2O4S
Q - Na2SO3
R - Na2S2O3
S - H2SO4
T - TSP Dodecahydrate
U - Acetone
V - MCAA
W - pH 4-5
Z - other (specify)

Sample Identification	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	6020B, WalkleyBlk_Calc	410.4, 9045D	6020B - (MOD) Fe, As	6020B - Field Filtered - (MOD) Fe, As	5210B - Local Method	410.4 - Local Method	9060A - Local Method							Total Number of containers	Special Instructions/Note:
				Preservation Code:			N	N	D	D	N	S	S								
DEK-TW-20002	7/16/20	1425	—	Water	Y	N			X	X	X	X	X								
DEK-TW-20003	↓	1610	—	Water	↓	↓			↓	↓	↓	↓	↓								
DEK-TW-20004	7/17/20	0825	—	Water	↓	↓			↓	↓	↓	↓	↓								
DEK-TW-20005	↓	0920	—	Water	↓	↓			↓	↓	↓	↓	↓								
DEK-TW-20006	↓	1025	—	Water	↓	↓			↓	↓	↓	↓	↓								
DEK-TW-20007	↓	1130	—	Water	↓	↓			↓	↓	↓	↓	↓								
DEK-TW-20008	↓	1225	—	Water	↓	↓			↓	↓	↓	↓	↓								
DEK-TW-20009	↓	1315	—	Water	↓	↓			↓	↓	↓	↓	↓								
DEK-TW-20010	↓	1350	—	Water	↓	↓			↓	↓	↓	↓	↓								

Possible Hazard Identification
☐ *Non-Hazard* ☐ *Flammable* ☐ *Skin Irritant* ☐ *Poison B* ☐ *Unknown* ☐ *Radiological*

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* ________ *Months*

Deliverable Requested: I, II, III, IV, Other (specify)

Special Instructions/QC Requirements:

Empty Kit Relinquished by:	Date:	Time:	Method of Shipment:

Relinquished by: (BARR)	Date/Time: 7/17/20 1605	Company BARR	Received by:	Date/Time: 07/17/20 1609	Company ETA
Relinquished by:	Date/Time: 7/17/20 1610	Company	Received by:	Date/Time: 7-18-20 1000	Company ETAC
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company

Custody Seals Intact: Δ Yes Δ No	Custody Seal No.:	Cooler Temperature(s) °C and Other Remarks:

Ver: 01/16/2019

Eurofins TestAmerica Canton Sample Receipt Form/Narrative **Login # :** 133624
Canton Facility

Client Barr Engineering Company Site Name ______ Cooler unpacked by:
Cooler Received on 7-18-20 Opened on 7-18-20
FedEx: 1st Grd [✓ Exp] UPS FAS Clipper Client Drop Off TestAmerica Courier Other

Receipt After-hours: Drop-off Date/Time ______ Storage Location ______

TestAmerica Cooler # 14 Foam Box Client Cooler Box Other ______
Packing material used: [✓ Bubble Wrap] Foam [✓ Plastic Bag] None Other ______
COOLANT: [✓ Wet Ice] Blue Ice Dry Ice Water None

1. Cooler temperature upon receipt ☐ See Multiple Cooler Form
IR GUN# IR-10 (CF **+0.7** °C) Observed Cooler Temp. ______ °C Corrected Cooler Temp. ______ °C
IR GUN #IR-11 (CF **+0.9**°C) Observed Cooler Temp. 4.0 °C Corrected Cooler Temp. 4.9 °C

2. Were tamper/custody seals on the outside of the cooler(s)? If Yes Quantity ______ Yes [✓ No]
-Were the seals on the outside of the cooler(s) signed & dated? Yes No [✓ NA]
-Were tamper/custody seals on the bottle(s) or bottle kits (LLHg/MeHg)? Yes [✓ No]
-Were tamper/custody seals intact and uncompromised? Yes No [✓ NA]
3. Shippers' packing slip attached to the cooler(s)? [✓ Yes] No
4. Did custody papers accompany the sample(s)? [✓ Yes] No
5. Were the custody papers relinquished & signed in the appropriate place? [✓ Yes] No
6. Was/were the person(s) who collected the samples clearly identified on the COC? Yes [✓ No]
7. Did all bottles arrive in good condition (Unbroken)? [✓ Yes] No
8. Could all bottle labels be reconciled with the COC? [✓ Yes] No
9. Were correct bottle(s) used for the test(s) indicated? [✓ Yes] No
10. Sufficient quantity received to perform indicated analyses? [✓ Yes] No
11. Are these work share samples? Yes [✓ No]
If yes, Questions 12-16 have been checked at the originating laboratory.
12. Were all preserved sample(s) at the correct pH upon receipt? [✓ Yes] No NA pH Strip Lot# HC911298
13. Were VOAs on the COC? Yes [✓ No]
14. Were air bubbles >6 mm in any VOA vials? ● ⬅ Larger than this. Yes [✓ No] NA
15. Was a VOA trip blank present in the cooler(s)? Trip Blank Lot # ______ Yes [✓ No]
16. Was a LL Hg or Me Hg trip blank present? ______ Yes [✓ No]

Tests that are not checked for pH by Receiving:

VOAs
Oil and Grease
TOC

Contacted PM ______ Date ______ by ______ via Verbal Voice Mail Other

Concerning ______

17. CHAIN OF CUSTODY & SAMPLE DISCREPANCIES Samples processed by:

18. SAMPLE CONDITION
Sample(s) ______ were received after the recommended holding time had expired.
Sample(s) ______ were received in a broken container.
Sample(s) ______ were received with bubble >6 mm in diameter. (Notify PM)

19. SAMPLE PRESERVATION

Sample(s) ______ were further preserved in the laboratory.
Time preserved: ______ Preservative(s) added/Lot number(s): ______

VOA Sample Preservation - Date/Time VOAs Frozen: ______

WI-NC-099

7/18/2020

Login Container Summary Report

240-133624

Temperature readings: ________________

			Container		Preservative	
Client Sample ID	Lab ID	Container Type	pH	Temp	Added (mls)	Lot #
DEK-TW-20001	240-133624-C-11	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20001	240-133624-D-11	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20001	240-133624-E-11	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20002	240-133624-C-12	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20002	240-133624-D-12	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20002	240-133624-E-12	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20003	240-133624-C-13	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20003	240-133624-D-13	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20003	240-133624-E-13	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20004	240-133624-C-14	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20004	240-133624-D-14	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20004	240-133624-E-14	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20005	240-133624-C-15	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20005	240-133624-D-15	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20005	240-133624-E-15	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20006	240-133624-C-16	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20006	240-133624-D-16	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20006	240-133624-E-16	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20007	240-133624-C-17	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20007	240-133624-D-17	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20007	240-133624-E-17	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20008	240-133624-C-18	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20008	240-133624-D-18	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20008	240-133624-E-18	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20009	240-133624-C-19	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20009	240-133624-D-19	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20009	240-133624-E-19	Plastic 500ml - w/ Nitric - Dis.	<2			
DEK-TW-20010	240-133624-C-20	Plastic 500ml - with Sulfuric Acid	<2			
DEK-TW-20010	240-133624-D-20	Plastic 500ml - with Nitric Acid	<2			
DEK-TW-20010	240-133624-E-20	Plastic 500ml - w/ Nitric - Dis.	<2			

Eurofins TestAmerica, Canton
4101 Shuffel Street NW
North Canton, OH 44720
Phone: 330-497-9396 Fax: 330-497-0772

Chain of Custody Record

eurofins | Environment Testing America

Client Information (Sub Contract Lab)

Sampler:
Lab PM: Howell, Leslie
Carrier Tracking No(s):
COC No: 240-123075.1

Client Contact: Shipping/Receiving
Phone:
E-Mail: Leslie.Howell@Eurofinset.com
State of Origin: Michigan
Page: Page 1 of 2

Company: TestAmerica Laboratories, Inc.
Accreditations Required (See note):
Job #: 240-133624-1

Address: 777 New Durham Road, ,
Due Date Requested: 7/24/2020
City: Edison
TAT Requested (days):
State, Zip: NJ, 08817
Phone: 732-549-3900(Tel) 732-549-3679(Fax)
PO #:
Email:
WO #:
Project Name: DE Karn Project #: 22/09-1015
Project #: 24025307
Site:
SSOW#:

Analysis Requested

Preservation Codes:

A - HCL	M - Hexane
B - NaOH	N - None
C - Zn Acetate	O - AsNaO2
D - Nitric Acid	P - Na2O4S
E - NaHSO4	Q - Na2SO3
F - MeOH	R - Na2S2O3
G - Amchlor	S - H2SO4
H - Ascorbic Acid	T - TSP Dodecahydrate
I - Ice	U - Acetone
J - DI Water	V - MCAA
K - EDTA	W - pH 4-5
L - EDA	Z - other (specify)

Other:

Sample Identification - Client ID (Lab ID)	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	410.4/ASTM_LEACH_NP	9045D	5210B/ASTM_LEACH	SM2580B_RDX_F/DI_LEACH	Total Number of containers	Special Instructions/Note:
			Preservation Code:									
DEK-SB-20001 (22-25') (240-133624-1)	7/14/20	11:45 Eastern		Solid			X	X	X	X	2	
DEK-SB-20002 (21-23') (240-133624-2)	7/14/20	13:50 Eastern		Solid			X	X	X	X	2	
DEK-SB-20003 (15-17') (240-133624-3)	7/14/20	15:20 Eastern		Solid			X	X	X	X	2	
DEK-SB-20004 (17-19') (240-133624-4)	7/14/20	16:50 Eastern		Solid			X	X	X	X	2	
DEK-SB-20005 (19-21') (240-133624-5)	7/15/20	08:50 Eastern		Solid			X	X	X	X	2	
DEK-SB-20006 (11-13') (240-133624-6)	7/15/20	10:20 Eastern		Solid			X	X	X	X	2	
DEK-SB-20007 (14-16') (240-133624-7)	7/15/20	11:45 Eastern		Solid			X	X	X	X	2	
DEK-SB-20008 (17-19') (240-133624-8)	7/15/20	13:55 Eastern		Solid			X	X	X	X	2	
DEK-SB-20009 (15-17') (240-133624-9)	7/15/20	15:15 Eastern		Solid			X	X	X	X	2	

Note: Since laboratory accreditations are subject to change, Eurofins TestAmerica places the ownership of method, analyte & accreditation compliance upon out subcontract laboratories. This sample shipment is forwarded under chain-of-custody. If the laboratory does not currently maintain accreditation in the State of Origin listed above for analysis/tests/matrix being analyzed, the samples must be shipped back to the Eurofins TestAmerica laboratory or other instructions will be provided. Any changes to accreditation status should be brought to Eurofins TestAmerica attention immediately. If all requested accreditations are current to date, return the signed Chain of Custody attesting to said complicance to Eurofins TestAmerica.

Possible Hazard Identification
Unconfirmed

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)
☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* ________ *Months*

Deliverable Requested: I, II, III, IV, Other (specify)
Primary Deliverable Rank: 2
Special Instructions/QC Requirements:

Empty Kit Relinquished by:
Date:
Time:
Method of Shipment:

Relinquished by:
Date/Time: 7-20-20 1140
Company 240
Received by: Corinne DiCopua
Date/Time: 7.21.20 9.15
Company EcTa

Relinquished by:
Date/Time:
Company
Received by:
Date/Time:
Company

Relinquished by:
Date/Time:
Company
Received by: Via fedex
Date/Time:
Company

Custody Seals Intact: Δ Yes Δ No
Custody Seal No.:
Cooler Temperature(s) °C and Other Remarks: 2.6° IR11

Ver: 01/16/2019

Eurofins TestAmerica, Canton

4101 Shuffel Street NW
North Canton, OH 44720
Phone: 330-497-9396 Fax: 330-497-0772

Chain of Custody Record

eurofins | Environment Testing America

Client Information (Sub Contract Lab)	Sampler:	Lab PM: Howell, Leslie	Carrier Tracking No(s):	COC No: 240-123075.2
Client Contact: Shipping/Receiving	Phone:	E-Mail: Leslie.Howell@Eurofinset.com	State of Origin: Michigan	Page: Page 2 of 2
Company: TestAmerica Laboratories, Inc.		Accreditations Required (See note):		Job #: 240-133624-1
Address: 777 New Durham Road, ,	**Due Date Requested:** 7/24/2020	**Analysis Requested**		**Preservation Codes:**
City: Edison	**TAT Requested (days):**			
State, Zip: NJ, 08817				
Phone: 732-549-3900(Tel) 732-549-3679(Fax)	PO #:			
Email:	WO #:			
Project Name: DE Karn Project #: 22/09-1015	Project #: 24025307			
Site:	SSOW#:			Other:

Preservation Codes:

A - HCL
B - NaOH
C - Zn Acetate
D - Nitric Acid
E - NaHSO4
F - MeOH
G - Amchlor
H - Ascorbic Acid
I - Ice
J - DI Water
K - EDTA
L - EDA
M - Hexane
N - None
O - AsNaO2
P - Na2O4S
Q - Na2SO3
R - Na2S2O3
S - H2SO4
T - TSP Dodecahydrate
U - Acetone
V - MCAA
W - pH 4-5
Z - other (specify)

Sample Identification - Client ID (Lab ID)	Sample Date	Sample Time	Sample Type (C=comp, G=grab)	Matrix (W=water, S=solid, O=waste/oil, BT=Tissue, A=Air)	Field Filtered Sample (Yes or No)	Perform MS/MSD (Yes or No)	410.4/ASTM_LEACH_NP	9045D	5210B/ASTM_LEACH	SM2580B_RDX_F/DI_LEACH	Total Number of containers	Special Instructions/Note:
				Preservation Code:								
DEK-SB-20010 (9-12') (240-133624-10)	7/15/20	16:30 Eastern		Solid			X	X	X	X	2	

Note: Since laboratory accreditations are subject to change, Eurofins TestAmerica places the ownership of method, analyte & accreditation compliance upon out subcontract laboratories. This sample shipment is forwarded under chain-of-custody. If the laboratory does not currently maintain accreditation in the State of Origin listed above for analysis/tests/matrix being analyzed, the samples must be shipped back to the Eurofins TestAmerica laboratory or other instructions will be provided. Any changes to accreditation status should be brought to Eurofins TestAmerica attention immediately. If all requested accreditations are current to date, return the signed Chain of Custody attesting to said complicance to Eurofins TestAmerica.

Possible Hazard Identification

Unconfirmed

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ *Return To Client* ☐ *Disposal By Lab* ☐ *Archive For* ________ *Months*

Deliverable Requested: I, II, III, IV, Other (specify)

Primary Deliverable Rank: 2

Special Instructions/QC Requirements:

Empty Kit Relinquished by:

Date:

Time:

Method of Shipment:

Relinquished by:	Date/Time: 7-20-20 1140	Company 240	Received by: Corinna DiCapua	Date/Time: 7.21.20 9.15	Company Edison
Relinquished by:	Date/Time:	Company	Received by:	Date/Time:	Company
Relinquished by:	Date/Time:	Company	Received by: Via fedex	Date/Time:	Company

Custody Seals Intact: Δ Yes Δ No

Custody Seal No.:

Cooler Temperature(s) °C and Other Remarks: 2.6° IR U

NORS

Ver: 01/16/2019

Login Sample Receipt Checklist

Client: Barr Engineering Company
Job Number: 240-133624-1

Login Number: 133624
List Number: 2
Creator: Armbruster, Chris

List Source: Eurofins TestAmerica, Edison
List Creation: 07/21/20 12:26 PM

Question	Answer	Comment
Radioactivity wasn't checked or is </= background as measured by a survey meter.	N/A	
The cooler's custody seal, if present, is intact.	N/A	
Sample custody seals, if present, are intact.	N/A	
The cooler or samples do not appear to have been compromised or tampered with.	True	
Samples were received on ice.	True	
Cooler Temperature is acceptable.	True	
Cooler Temperature is recorded.	True	2.6°C IR11
COC is present.	True	
COC is filled out in ink and legible.	True	
COC is filled out with all pertinent information.	True	
Is the Field Sampler's name present on COC?	True	
There are no discrepancies between the containers received and the COC.	True	
Samples are received within Holding Time (excluding tests with immediate HTs)	True	
Sample containers have legible labels.	True	
Containers are not broken or leaking.	True	
Sample collection date/times are provided.	True	
Appropriate sample containers are used.	True	
Sample bottles are completely filled.	True	
Sample Preservation Verified.	True	
There is sufficient vol. for all requested analyses, incl. any requested MS/MSDs	True	
Containers requiring zero headspace have no headspace or bubble is <6mm (1/4").	True	
Multiphasic samples are not present.	True	
Samples do not require splitting or compositing.	True	
Residual Chlorine Checked.	N/A	

Appendix E-5

Air Sparging Soil and Groundwater Data QA/QC Review

Appendix E-5:

Air Sparging Soil and Groundwater Data Quality Assurance/Quality Control Review

A review of the quality control data was conducted to assess the validity of the analytical results for the soil and groundwater samples collected July 14 – 15 and July 16 – 17, 2020, respectively, at the DE Karn Generating Facility, located in Essexville, Michigan. This review was performed in accordance with Barr Engineering Co.'s Standard Operating Procedures for data evaluation, which are based on *The National Functional Guidelines for Organic and Inorganic Data Review* (USEPA, 2008 and 2010). The analyses were performed by Eurofins TestAmerica located in Canton, Ohio and Edison, New Jersey. This data evaluation discusses sample data contained within the work order 240-133624-1.

Laboratory analytical procedures were evaluated by assessing technical holding times, sample preservation methods, method blank samples, accuracy and precision data, and data package completeness.

Laboratory Procedures

Technical holding times and preservation were evaluated for each sample and target parameter based on United States Environmental Protection Agency and method recommendations. The technical holding times were within these recommendations for all of the groundwater analyses, and the groundwater samples arrived at the laboratory at the correct temperatures and with the correct chemical preservatives. The technical holding times were acceptable for the majority of the soil analyses, apart from laboratory pH, which exceeded the recommended holding time and were qualified "H" as holding time exceeded. The holding time for laboratory pH is always qualified "H" as holding time exceeded because the method for pH analysis is intended to be performed in the field.

Method blanks were analyzed by the laboratory for each parameter. No target compounds were detected above the reporting limit (RL) in the method blank samples.

The accuracy and precision data review included evaluation of laboratory control spike (LCS), matrix spike (MS), matrix spike duplicate (MSD), and laboratory duplicate samples. Accuracy was evaluated by comparing laboratory percent recoveries from LCS, MS, and MSD samples to laboratory acceptance criteria. Precision was evaluated by calculating the relative percent difference of the MS/MSD and laboratory duplicate sample pairs.

The LCS samples displayed acceptable accuracy when compared to the laboratory acceptance criteria.

The laboratory utilized project samples as needed for MS/MSD evaluation when sufficient sample volume was available. Only the MS/MSD samples taken from project samples may be evaluated compared to project data. In instances where MS recoveries failed acceptance criteria and the native sample concentration was significantly greater than the spike added (greater than four times), the spike recovery could not be accurately evaluated; therefore, the criteria did not apply, and acceptance of the sample results were based on the acceptable LCS data. The MS/MSDs displayed accuracy and/or precision within laboratory acceptance criteria.

The laboratory duplicate sample data displayed acceptable precision when compared to the laboratory acceptance criteria.

Data completeness was evaluated by comparing the analyses requested with the data package as received. The samples were analyzed in accordance with the chain-of-custody, so the data package was considered complete.

Conclusion

The data are deemed acceptable for the purposes of this project with the qualification assigned during the data evaluation process.

References

United States Environmental Protection Agency (USEPA), 2008. *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Organic Methods Data Review*. EPA QA/R-5. 2008

United States Environmental Protection Agency (USEPA), 2010. *USEPA Contract Laboratory Program National Functional Guidelines for Superfund Inorganic Methods Data Review*. EPA QA/R-5. 2010