Inflow Design Flood Control System Plan

D.E. KARN GENERATING FACILITY

KARN LINED IMPOUNDMENT INFLOW DESIGN FLOOD CONTROL SYSTEM PLAN

Essexville, Michigan

Pursuant to 40 CFR 257.82

Submitted To: Consumers Energy Company
1945 W. Parnall Road
Jackson, Michigan 49201

Submitted By: Golder Associates Inc.
15851 South US 27, Suite 50
Lansing, Michigan 48906

June 2018 **1781451**

Golder Associates

CERTIFICATION

Professional Engineer Certification Statement [40 CFR 257.82(c)]

I hereby certify that, having reviewed the attached documentation and being familiar with the provisions of Title 40 of the Code of Federal Regulations Section 257.82 (40 CFR Part 257.82), I attest that this Inflow Design Flood Control System Plan is accurate and has been prepared in accordance with good engineering practices, including the consideration of applicable industry standards, and with the requirements of 40 CFR Part 257.82.

Golder Associates Inc.

Signature

June 4, 2018

Date of Report Certification

John D. Puls, PE

Name

6201055787

Professional Engineer Certification Number

Table of Contents

CERTIFICATION C-1
Professional Engineer Certification Statement [40 CFR 257.82(c)] C-1
1.0 INTRODUCTION 1
1.1 Background 1
1.2 Purpose 1
2.0 FLOOD CONTROL SYSTEM 2
2.1 External Floodwater Protection 2
2.2 Internal Flood Control 2
3.0 PLAN REVISION AND RECORDKEEPING 4
4.0 REFERENCES 5

List of Tables

Table 2.2.1 Discharge Structure Summary
Table 2.2.2 Storm Flow Data

List of Figures

Figure 1 Site Location Map
Figure 2 Site Plan

List of Appendices

Appendix A FEMA Flood Elevation and Lake Huron Normal Elevation
Appendix B Rainfall Data
Appendix C Hydrologic and Hydraulic Model Output

1.0 INTRODUCTION

1.1 Background

D.E. Karn Generating Facility (DE Karn) is a coal-fired power generation facility located near Essexville, Michigan as presented on Figure 1 – Site Location Map. The location of the Karn Lined Impoundment is illustrated on Figure 2 – Site Plan. Bottom ash is sluiced from the DE Karn Unit 1&2 electrical generating units to the Karn Lined Impoundment. An elevated trestle and pipe system hydraulically conveys bottom ash to the pond system. Stored bottom ash is removed via mechanical equipment from the pond as required to maintain storage capacity on a yearly basis. Water is discharged from the Karn Lined Impoundment via two 18-inch diameter DR 11 HDPE pipes into a polishing basin. Flow is then conveyed through a series of internal ditches to the permitted National Pollutant Discharge Elimination System (NPDES) outfall.

1.2 Purpose

The purpose of the Inflow Design Flood Control System Plan (Plan) is to provide a basis for the certification required by 40 CFR 257.82 Hydrologic and Hydraulic Capacity Requirements for Coal Combustion Residual (CCR) Surface Impoundments. The Karn Lined Impoundment has been rated a low hazard potential as determined under 40 CFR 257.74(a)(2). 40 CFR 257.82(a) requires the owner or operator of the low hazard potential CCR surface impoundment to design, construct, operate, and maintain an inflow design flood control system as follows:

- Adequately manage the flow into the CCR unit during and following the peak discharge of the inflow of the 100-year flood event
- Adequately manage the flow from the CCR unit to collect and control the peak discharge resulting from the 100-year flood event
- Handle discharge from the CCR unit in accordance with the surface water requirements under 40 CFR 257.3-3

2.0 FLOOD CONTROL SYSTEM

To meet the requirements of 40 CFR 257.82(a), the flood control system must provide flood protection to the CCR unit during the inflow design flood (100-year event) for two cases: 1) floodwater from outside the unit from the Saginaw River and from Saginaw Bay, and 2) controlling internal water levels within the unit.

2.1 External Floodwater Protection

The Karn Lined Impoundment is surrounded by a perimeter berm that provides external flood water protection.

A publicly available 100-year flood elevation for Saginaw Bay has been determined by Federal Emergency Management Agency (FEMA). Based on FEMA Firm Map Numbers 26017C0239E, both Saginaw River and Saginaw Bay have 100-year flood elevations of 585.00 feet (NAVD88) as provided in Appendix A – FEMA Flood Elevation and Lake Huron Normal Elevation. The lowest elevation along the perimeter berm is 600.5 feet (NAVD88), which allows for 15.50 feet of freeboard during the 100-year flood event. Therefore, the Saginaw Bay and Saginaw River should not to be an inflow source to the Karn Lined Impoundment.

2.2 Internal Flood Control

The only inflow other than process water will be precipitation directly falling on the Karn Lined Impoundment and surrounding drainage areas from a 100-year 24-hour storm event of 5.99 inches, as provided in Appendix B - Rainfall Data. Process water flow is approximately 2,370 gpm that cycles for 2.5 hours every 8 hours. The discharge structure in the perimeter berm includes two 18-inch DR 11 HDPE pipes. Table 2.2.1 below provides a summary of the outflow structure.

Table 2.2.1 - Discharge Structure Summary

Discharge Structure	Type	Size (Inches)	Length (Feet)	Upstream Invert (NAVD88)	Downstream Invert (NAVD88)	Slope (%)
Karn Lined Impoundment	HDPE	18	40	597.0	596.6	1.00

Table 2.2.2 below provides a storm flow summary that indicates that the Karn Lined Impoundment is contained with 2.40 feet of freeboard and a peak discharge rate of 6.62 cubic feet per second (cfs) during the design storm event (100-year 24-hour). The modeled results indicate that:

- The inflow design flood control system adequately manages flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood (100-year 24-hour storm event)

The hydrologic and hydraulic model output is provided in Appendix C - Hydrologic and Hydraulic Model Output. It should be noted that the pond elevations presented in Table 2.2.2 were used to assess the maximum storage pool loading condition pursuant to 40 CFR 257.74(e)(1)(i).

Table 2.2.2 – Storm Flow Data

Area	Perimeter Berm Elevation (NAVD 88)	Pond Elevation 100-year,24-hour (NAVD 88)	Peak Outflow (cfs)
Karn Lined Impoundment	600.5	598.10	6.62

3.0 PLAN REVISION AND RECORDKEEPING

Per 40 CFR 257.82(c)(2); “The owner or operator of the CCR unit may amend the written inflow design flood control system plan at any time provided the revised plan is placed in the facility's operating record as required by Section 257.105(g)(4). The owner or operator must amend the written inflow design flood control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.”

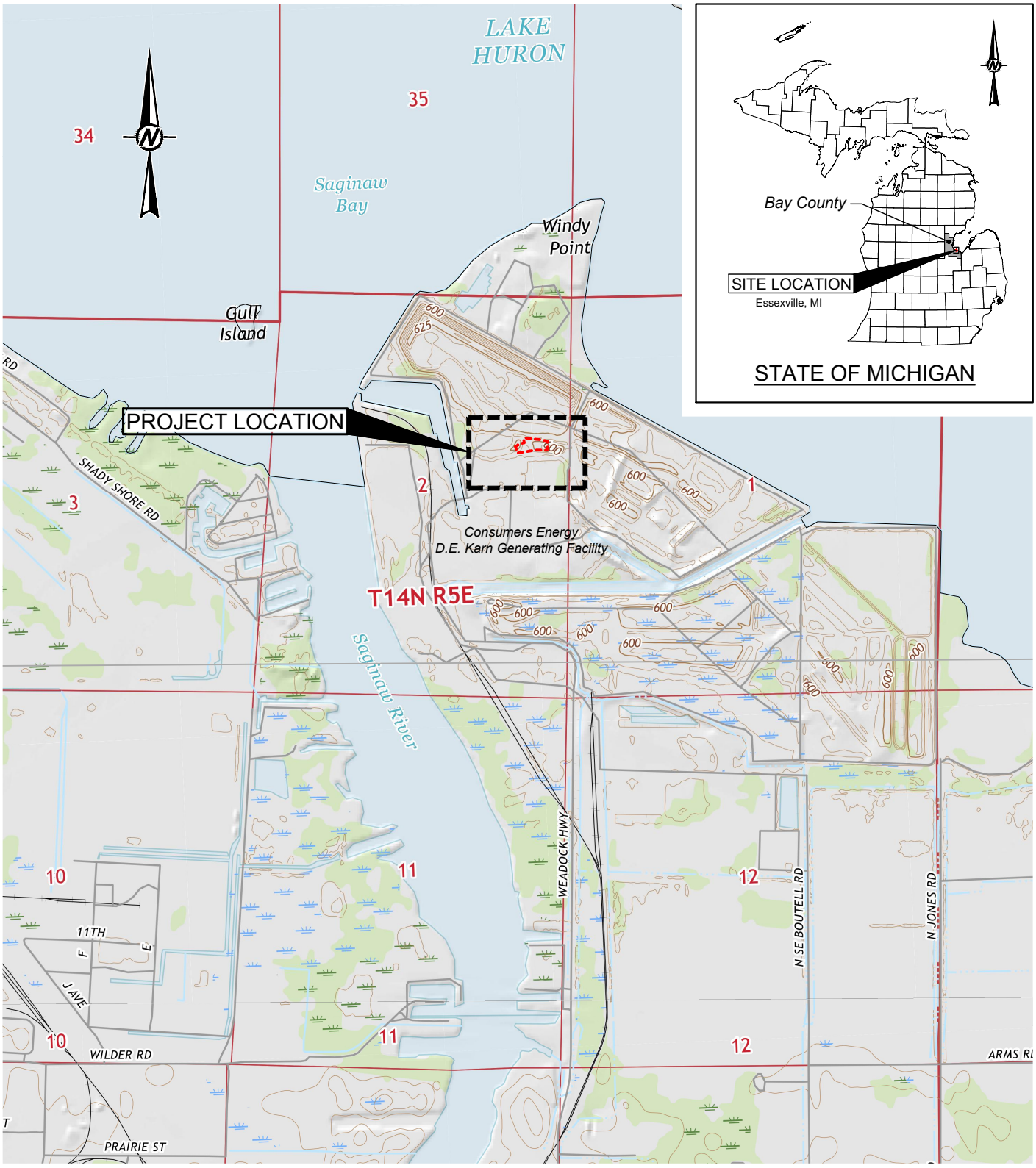
Per 40 CFR 257.82(c)(4); “The owner or operator must prepare periodic inflow design flood control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first periodic plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed an inflow design flood control system plan when the plan has been placed in the facility's operating record as required by Section 257.105(g)(4).”

4.0 REFERENCES

FEMA (Federal Emergency Management Agency). 2010. Flood Insurance Study, Bay County, Michigan. Effective September 17, 2010. Flood Insurance Study Number 26017CV000A.

USEPA (US Environmental Protection Agency). 2015. Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule. 40 CFR Part 257. Effective Date October 19, 2015.

FIGURES



REFERENCE

BASE MAP IMAGERY DERIVED FROM U.S. DEPARTMENT OF INTERIOR, UNITED STATES GEOLOGICAL SURVEY (USGS), MICHIGAN-BAY COUNTY, 7.5-MINUTE SERIES QUADRANGLE MAPS "BAY CITY NE" AND "ESSEXVILLE", BOTH DATED 2017.

0 1000 2000
1" = 2000' FEET

CLIENT
CONSUMERS ENERGY COMPANY
2742 NORTH WEADOCK HIGHWAY
ESSEXVILLE, MICHIGAN 48732

CONSULTANT
Golder Associates

YYYY-MM-DD	2018-05-24
DESIGNED	MMJ
PREPARED	SDA
REVIEWED	JDP
APPROVED	MAB

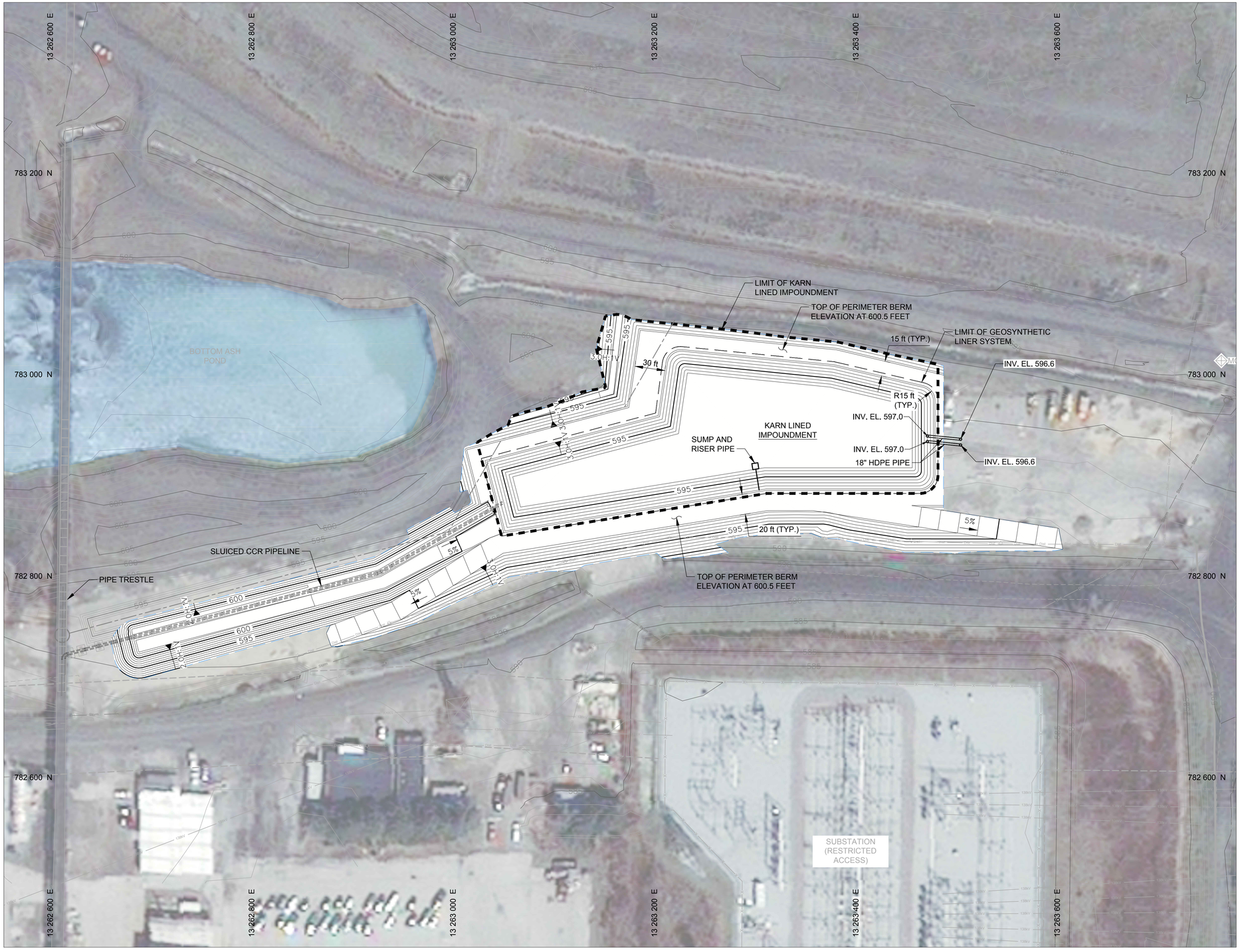
PROJECT
D.E. KARN GENERATING FACILITY
KARN LINED IMPOUNDMENT
RCRA FLOOD CONTROL PLAN

TITLE
SITE LOCATION MAP

PROJECT NO. 1781451.0003
REV. 0
FIGURE 1

P:\0 projects\Consumers Energy\1781451 DE Karn New BAL RCRA Compliance\950 CAD\02_FIGURES\A – Bottom Ash Lined Impoundment RCRA Closure Plan\1781451_BAL_RCRA_CP_USGS-Site-Location-Map.dwg Apr 06, 2018 – 9:03am By: STAnderson

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI A



LEGEND

- 6240 — EXISTING GROUND TOPOGRAPHY
- 6240 — PROPOSED GRADE (TOP OF EMBANKMENT FILL)
- EXISTING PROCESS WATER PIPE
- Storm Storm — EXISTING CULVERT
- EDGE EXISTING OF GRAVEL ROAD
- LIMIT OF GEOSYNTHETICS
- EXISTING ASH TRESTLE

NOTES

1. EXISTING FEATURES OUTSIDE OF THE PROJECT AREA MAY NOT BE SHOWN FOR CLARITY.
2. EXISTING CONDITIONS IN THE BOTTOM ASH POND AND ASH LANDFILL MAY VARY FROM THOSE SHOWN DUE TO ONGOING ASH DISPOSAL OPERATIONS.

REFERENCES

1. AERIAL IMAGE: © CNES 2016, DISTRIBUTION AIRBUS DS GEO SA/AIRBUS DS GEO INC.
2. HORIZONTAL COORDINATE SYSTEM: MICHIGAN STATE PLANE, SOUTH ZONE, NORTH AMERICAN DATUM 1983 (1994 ADJUSTMENT), INTERNATIONAL SURVEY FOOT.
3. VERTICAL BASIS OF ELEVATION: NORTH AMERICAN VERTICAL DATUM 1988.
4. EXISTING SITE TOPOGRAPHY PROVIDED IN APRIL 2016 BY ENGINEERING & ENVIRONMENTAL SOLUTIONS, L.L.C. AUGMENTED WITH DESIGN GRADES FOR PROCESS WATER MODIFICATIONS IMPLEMENTED IN FALL 2017.

KEY MAP N.T.S.

0 50 100
1" = 50' FEET

REV	DATE	DESCRIPTION	DR	BY	CK	APP	CO
1	2018-06-04	SUBMITTED TO POST ON OWNER'S WEBSITE	MMJ	SDA	JDP	MAB	
0	2018-05-24	SUBMITTED FOR OWNER'S REVIEW	MMJ	SDA	JDP	MAB	

REFERENCE DRAWINGS

SIGNATURE

NAME

MICHIGAN P.E. No.

Consumers Energy

D.E. KARN GENERATING FACILITY
ESSEXVILLE, MI

SITE PLAN

KARN LINED IMPOUNDMENT RCRA FLOOD CONTROL PLAN

SCALE: AS SHOWN
JOB: 1781451.0007
DRAWING NO.
FIGURE 2
REV. 1

P:\0 projects\Consumers Energy\178451 DE Karn New BAU RCRA Compliance\950 CAD\02_FIGURES\A – Bottom Ash Lined Impoundment RCRA Closure Plan\178451_BAU_RCRA_CP_Proposed-BAU-Closure-Grades-PLAN.dwg Jun 04, 2018 – 11:11am By: STAnderson

APPENDIX A
FEMA FLOOD ELEVATION AND LAKE HURON NORMAL ELEVATION

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) Report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole-foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS Report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study Report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study Report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures**. Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study Report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 16. The **horizontal datum** was NAD 83, GRS 1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum**. For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301) 713-3242

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713- 3242**, or visit its website at http://www.ngs.noaa.gov.

Base Map information shown on this FIRM was provided in digital format by Bay County, Michigan. This information was photogrammetrically compiled at a scale of 1200 from aerial photography dated 2005.

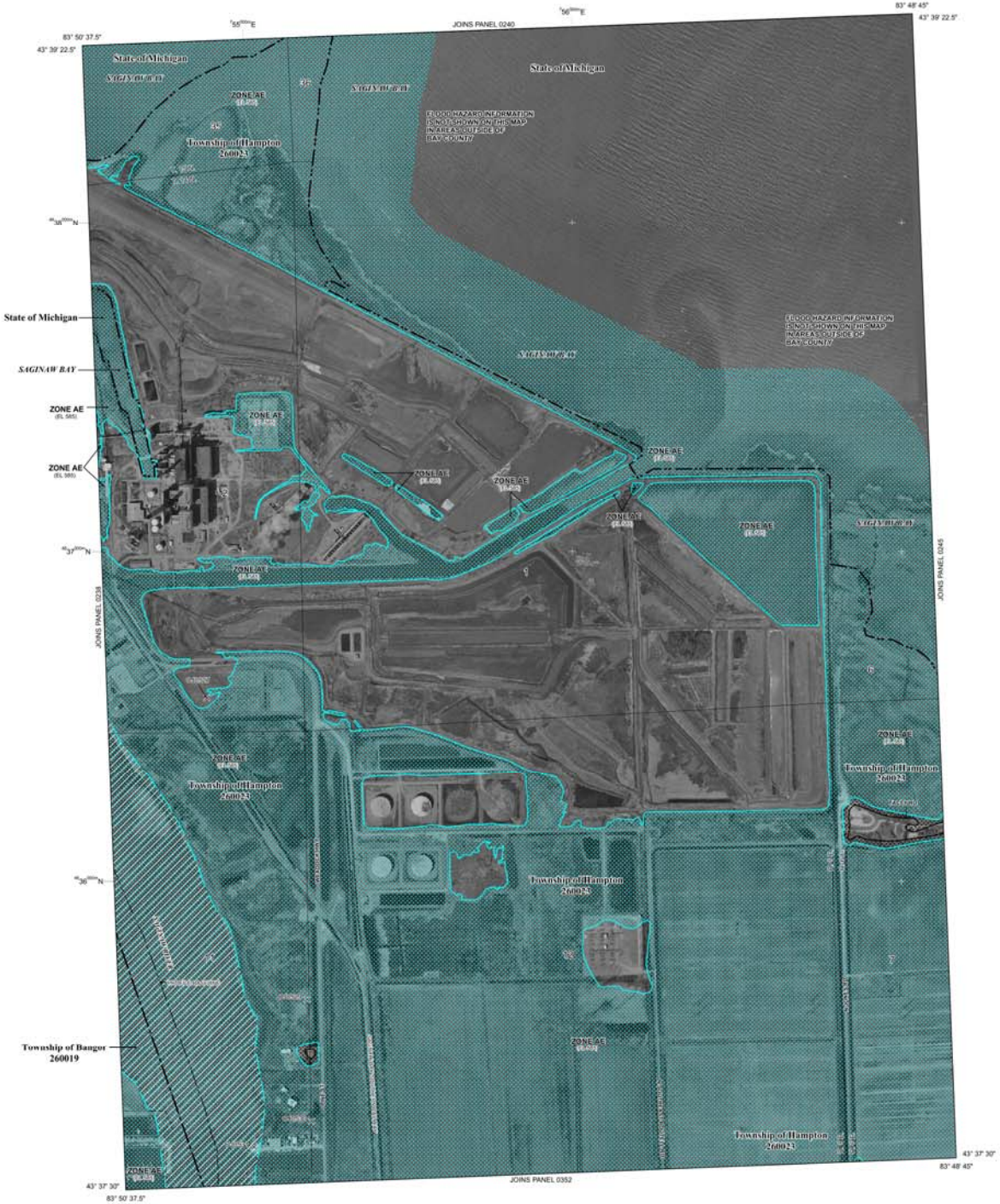
The **profile baselines** depicted on this map represent the hydraulic modeling baselines that match the flood profiles in the FIS report. As a result of improved topographic data, the **profile baseline**, in some cases, may deviate significantly from the channel centerline or appear outside the SFHA.

Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de-annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1-800-358-9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study Report, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1-800-358-9620 and its website at http://msc.fema.gov.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1- 877- FEMA MAP** (1-877-336-2627) or visit the FEMA website at http://www.fema.gov/business/nfip/.



LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Areas formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

OTHER AREAS

ZONE X Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D Areas in which flood hazards are undetermined, but possible.

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

1% Annual Chance Floodplain Boundary

0.2% Annual Chance Floodplain Boundary

Floodway boundary

Zone D boundary

CBRS and OPA boundary

Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.

513 (EL 987) Base Flood Elevation line and value; elevation in feet* / Base Flood Elevation value where uniform within zone; elevation in feet*

*Referenced to the North American Vertical Datum of 1988

A — A Cross section line

23 — 23 Transect line

45° 02' 08", 93° 02' 12" Geographic coordinates referenced to the North American Datum of 1983 (NAD 83) Western Hemisphere

4852000 N 1000-meter Universal Transverse Mercator grid values, zone 16N

DX5510 × Bench mark (see explanation in Notes to Users section of this FIRM panel)

M1.5 River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
June 16, 1986

EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

September 17, 2010 - to add Special Flood Hazard Areas and roads and road names; to change Special Flood Hazard Areas, to update corporate limits and map format; to incorporate previously issued Letters of Map Revision; and to reflect updated topographic information.

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1-800-638-6620.

MAP SCALE 1" = 500'

250 0 500 1000 FEET

150 0 150 300 METERS

NFIP NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0239E

FIRM

FLOOD INSURANCE RATE MAP

BAY COUNTY, MICHIGAN
ALL JURISDICTIONS

PANEL 239 OF 450
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
BANGOR, TOWNSHIP OF	260019	0239	E
HAMPTON, TOWNSHIP OF	260023	0239	E

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
26017C0239E
MAP REVISED
SEPTEMBER 17, 2010

Federal Emergency Management Agency

APPENDIX B
RAINFALL DATA

NOAA Atlas 14, Volume 8, Version 2
Location name: Essexville, Michigan, US*
Latitude: 43.6433°, Longitude: -83.8376°
Elevation: 585 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.281 (0.221–0.364)	0.333 (0.262–0.432)	0.421 (0.331–0.548)	0.497 (0.388–0.651)	0.606 (0.458–0.829)	0.693 (0.510–0.963)	0.783 (0.556–1.12)	0.877 (0.595–1.30)	1.01 (0.655–1.54)	1.11 (0.700–1.72)
10-min	0.411 (0.324–0.533)	0.487 (0.384–0.632)	0.617 (0.484–0.803)	0.728 (0.568–0.953)	0.887 (0.670–1.21)	1.02 (0.747–1.41)	1.15 (0.814–1.64)	1.28 (0.872–1.90)	1.47 (0.959–2.25)	1.62 (1.03–2.52)
15-min	0.501 (0.396–0.649)	0.594 (0.469–0.771)	0.752 (0.591–0.979)	0.888 (0.693–1.16)	1.08 (0.817–1.48)	1.24 (0.911–1.72)	1.40 (0.992–2.00)	1.57 (1.06–2.32)	1.80 (1.17–2.75)	1.98 (1.25–3.07)
30-min	0.722 (0.570–0.936)	0.859 (0.678–1.12)	1.09 (0.856–1.42)	1.29 (1.01–1.69)	1.57 (1.19–2.15)	1.80 (1.32–2.49)	2.03 (1.44–2.90)	2.27 (1.54–3.35)	2.60 (1.69–3.97)	2.86 (1.81–4.44)
60-min	0.940 (0.742–1.22)	1.11 (0.877–1.44)	1.41 (1.11–1.84)	1.67 (1.31–2.19)	2.05 (1.56–2.82)	2.37 (1.74–3.30)	2.69 (1.91–3.87)	3.04 (2.07–4.51)	3.52 (2.30–5.40)	3.91 (2.47–6.07)
2-hr	1.16 (0.925–1.48)	1.36 (1.09–1.75)	1.73 (1.38–2.22)	2.05 (1.62–2.65)	2.54 (1.95–3.45)	2.94 (2.19–4.05)	3.36 (2.42–4.78)	3.81 (2.62–5.60)	4.45 (2.94–6.76)	4.96 (3.17–7.63)
3-hr	1.29 (1.04–1.63)	1.51 (1.21–1.91)	1.90 (1.52–2.42)	2.26 (1.80–2.90)	2.81 (2.18–3.81)	3.28 (2.47–4.51)	3.78 (2.74–5.36)	4.33 (3.00–6.33)	5.10 (3.39–7.72)	5.73 (3.69–8.77)
6-hr	1.52 (1.24–1.90)	1.75 (1.43–2.20)	2.19 (1.78–2.75)	2.61 (2.11–3.30)	3.28 (2.59–4.42)	3.86 (2.95–5.27)	4.50 (3.31–6.33)	5.21 (3.66–7.57)	6.24 (4.20–9.37)	7.09 (4.61–10.7)
12-hr	1.78 (1.47–2.20)	2.02 (1.67–2.50)	2.50 (2.06–3.10)	2.98 (2.43–3.71)	3.75 (3.01–5.02)	4.44 (3.45–6.02)	5.22 (3.89–7.28)	6.09 (4.34–8.78)	7.36 (5.02–11.0)	8.43 (5.54–12.6)
24-hr	2.05 (1.71–2.49)	2.31 (1.93–2.81)	2.85 (2.37–3.48)	3.40 (2.81–4.17)	4.29 (3.49–5.67)	5.09 (4.00–6.81)	5.99 (4.53–8.27)	7.01 (5.05–10.0)	8.51 (5.87–12.6)	9.77 (6.49–14.5)
2-day	2.33 (1.97–2.78)	2.64 (2.23–3.16)	3.25 (2.74–3.91)	3.87 (3.25–4.69)	4.88 (4.02–6.37)	5.79 (4.61–7.64)	6.80 (5.20–9.26)	7.94 (5.79–11.2)	9.62 (6.70–14.0)	11.0 (7.39–16.2)
3-day	2.55 (2.17–3.02)	2.86 (2.44–3.40)	3.50 (2.97–4.17)	4.14 (3.49–4.96)	5.18 (4.29–6.69)	6.11 (4.90–7.99)	7.15 (5.50–9.66)	8.32 (6.11–11.7)	10.1 (7.05–14.6)	11.5 (7.76–16.8)
4-day	2.74 (2.35–3.23)	3.06 (2.63–3.61)	3.70 (3.16–4.39)	4.35 (3.69–5.18)	5.39 (4.49–6.91)	6.33 (5.10–8.22)	7.37 (5.70–9.90)	8.55 (6.30–11.9)	10.3 (7.24–14.8)	11.7 (7.95–17.0)
7-day	3.23 (2.81–3.76)	3.59 (3.11–4.19)	4.28 (3.70–5.01)	4.94 (4.24–5.82)	6.00 (5.03–7.55)	6.93 (5.62–8.86)	7.95 (6.20–10.5)	9.09 (6.75–12.5)	10.7 (7.63–15.3)	12.1 (8.29–17.4)
10-day	3.67 (3.20–4.23)	4.07 (3.56–4.71)	4.83 (4.20–5.60)	5.54 (4.79–6.47)	6.64 (5.59–8.26)	7.59 (6.19–9.60)	8.63 (6.76–11.3)	9.77 (7.29–13.3)	11.4 (8.14–16.1)	12.8 (8.78–18.2)
20-day	4.91 (4.35–5.58)	5.49 (4.86–6.25)	6.50 (5.73–7.43)	7.40 (6.48–8.52)	8.75 (7.42–10.6)	9.86 (8.12–12.2)	11.0 (8.73–14.2)	12.3 (9.27–16.5)	14.1 (10.1–19.6)	15.5 (10.8–22.0)
30-day	6.02 (5.37–6.78)	6.73 (6.01–7.59)	7.95 (7.07–9.00)	9.01 (7.95–10.3)	10.5 (8.97–12.6)	11.8 (9.75–14.4)	13.0 (10.4–16.6)	14.4 (10.9–19.0)	16.2 (11.8–22.4)	17.7 (12.4–24.9)
45-day	7.49 (6.75–8.36)	8.38 (7.54–9.36)	9.84 (8.82–11.0)	11.1 (9.84–12.5)	12.7 (10.9–15.1)	14.1 (11.7–17.0)	15.4 (12.3–19.3)	16.7 (12.7–21.9)	18.5 (13.5–25.3)	19.9 (14.0–27.8)
60-day	8.81 (7.99–9.77)	9.84 (8.90–10.9)	11.5 (10.3–12.8)	12.8 (11.5–14.4)	14.6 (12.5–17.0)	15.9 (13.3–19.0)	17.2 (13.8–21.4)	18.5 (14.1–24.0)	20.1 (14.7–27.2)	21.3 (15.1–29.7)

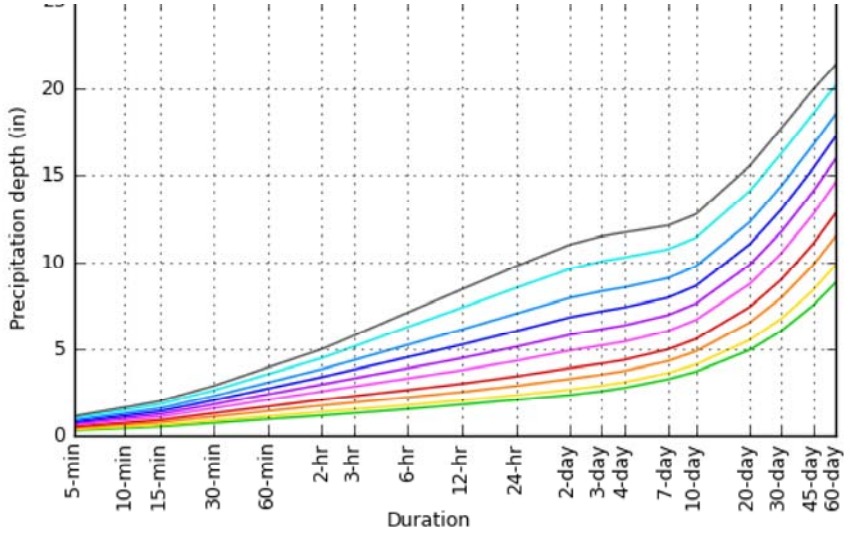
[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

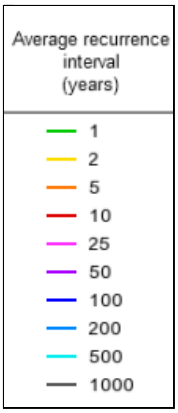
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

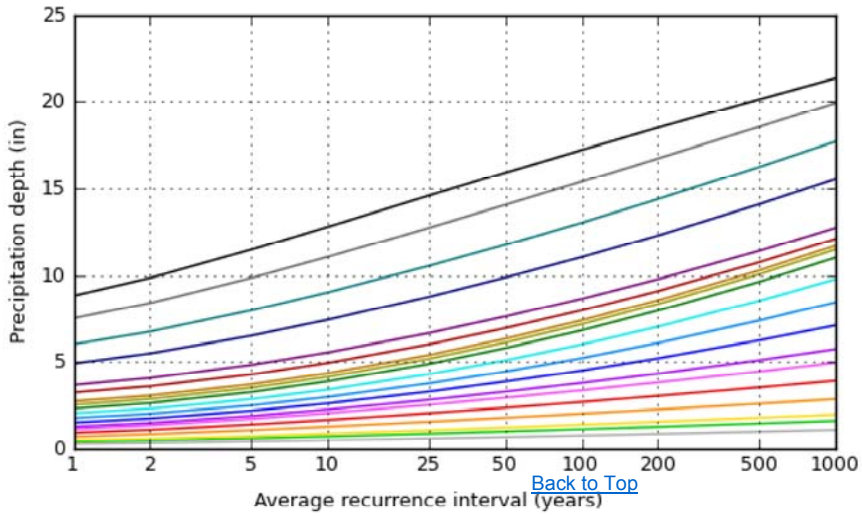
Please refer to NOAA Atlas 14 document for more information.

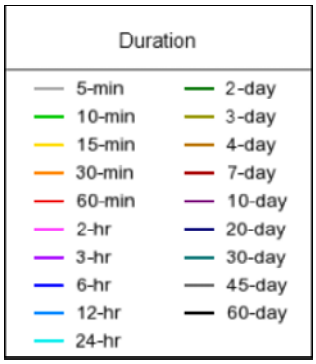
Back to Top

PF graphical









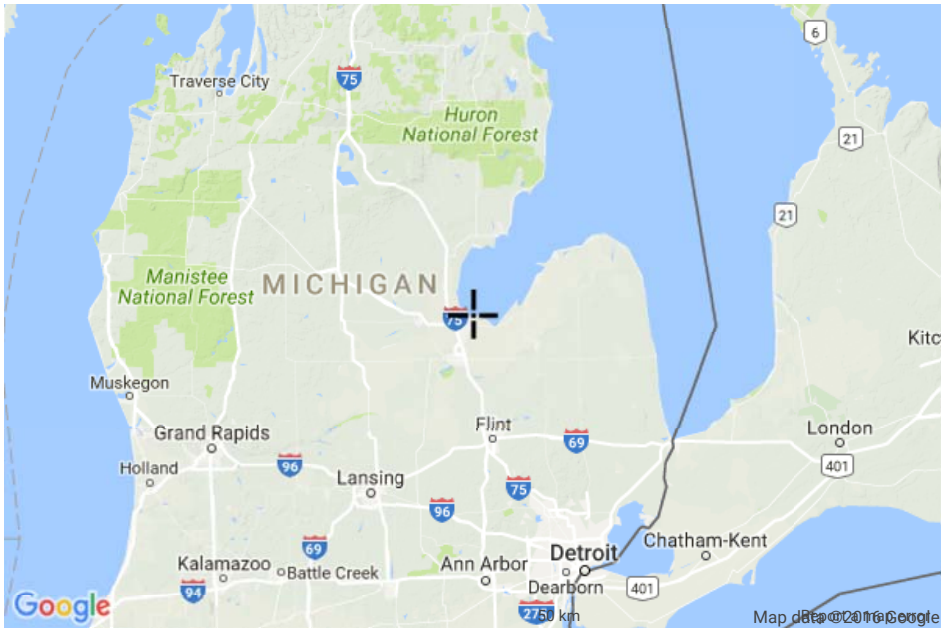
Back to Top

Maps & aerials

NOAA Atlas 14, Volume 8, Version 2

Created (GMT): Thu Aug 18 12:43:50 2016

Small scale terrain



Large scale terrain

Large scale map

Large scale aerial

Back to Top

US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910

Questions?: HDSC.Questions@noaa.gov

Disclaimer

APPENDIX C
HYDROLOGIC AND HYDRAULIC MODEL OUTPUT

```
[TITLE]

[OPTIONS]
 FLOW_UNITS            GPM
 SUBBASIN_HYDROGRAPH   EPA SWMM
 INFILTRATION          SCS Curve Number
 LINK_ROUTING          Hydrodynamic
 START_TIME            00:00:00
 REPORT_START_DATE     07/25/2016
 REPORT_START_TIME     00:00:00
 END_DATE              07/28/2016
 END_TIME              00:00:00
 SWEEP_START           01/01
 SWEEP_END             12/31
 DRY_DAYS              0
 REPORT_STEP           00:05:00
 WET_STEP              00:05:00
 DRY_STEP              01:00:00
 ROUTING_STEP          0:00:30
 ALLOW_PONDING         YES
 INERTIAL_DAMPING      PARTIAL
 VARIABLE_STEP         0.75
 LENGTHENING_STEP      0
 MIN_SURFAREA          0
 NORMAL_FLOW_LIMITED   BOTH
 SKIP_STEADY_STATE     NO
 FORCE_MAIN_EQUATION   H-W
 LINK_OFFSETS          DEPTH
 MIN_SLOPE             0

[RAINGAGES]
;;                Rain      Recd.  Snow   Data       Source           Station    Rain
;;Name            Type      Freq.  Catch  Source     Name             ID         Units
;;--------------------------------------------------------------------------------------
  Rain Gage-01    CUMULATIVE 0:06   1.0    TIMESERIES TS-02

[SUBCATCHMENTS]
;;                                                  Total    Pcnt.             Pcnt.    Curb
Snow
;;Name            Raingage         Outlet           Area     Imperv   Width    Slope    Length
Pack
;;--------------------------------------------------------------------------------------------------
----
  Sub-01          Rain Gage-01     SettlingBasin    1.778000 100      500      0.5      0


[SUBAREAS]
;;Subcatchment    N-Imperv   N-Perv     S-Imperv   S-Perv     PctZero    RouteTo    PctRouted
;;-----------------------------------------------------------------------------------------
  Sub-01          0.015      0.1        0.08       0.20       0          OUTLET

[INFILTRATION]
;;Subcatchment    CurveNum   HydCon     DryTime
;;-----------------------------------------------
  Sub-01          98.00      0.15       7

[OUTFALLS]
;;                Invert     Outfall    Stage/Table      Tide
;;Name            Elev.      Type       Time Series      Gate
;;-------------------------------------------------------------
  Outfall         596.6      FIXED      596.6 NO

[STORAGE]
;;                Invert   Max.     Init.    Shape      Shape      Ponded   Evap.
;;Name            Elev.    Depth    Depth    Curve      Parameters Area     Frac.
;;--------------------------------------------------------------------------------------------------
  SettlingBasin   592      8.5        5          TABULAR    SettlingBasin_Storage      41831
```

```
0

[CONDUITS]
;;               Inlet            Outlet                      Manning    Inlet      Outlet
Init.      Maximum
;;Name            Node             Node             Length     N          Height     Height
Flow       Flow
;;--------------------------------------------------------------------------------------------------
------------------------
  Cross-OverPipes  SettlingBasin    Outfall          40         0.015      5          0
0          0

[XSECTIONS]
;;Link             Type         Geom1      Geom2      Geom3      Geom4      Barrels
CulvertCode
;;--------------------------------------------------------------------------------------------------
------
  Cross-OverPipes  CIRCULAR     1.211      0          1          1          2          3

[LOSSES]
;;Link             Inlet      Outlet     Average    Flap Gate
;;-----------------------------------------------------------
  Cross-OverPipes  0.5        1.0        0          NO

[INFLOWS]
;;                                                 Param    Units    Scale    Baseline Baseline
;;Node           Parameter        Time Series      Type     Factor   Factor   Value    Pattern
;;-------------- ---------------- ---------------- -------- -------- -------- -------- --------
SettlingBasin    FLOW             SlugEvent        FLOW     1.0      2370

[CURVES]
;;Name             Type       X-Value    Y-Value
;;-----------------------------------------------
  PolishingBasin_Storage Storage    0          3745.17
  PolishingBasin_Storage            1          4600.55
  PolishingBasin_Storage            2          5528.6
  PolishingBasin_Storage            3          6529.31
  PolishingBasin_Storage            4          7602.69
  PolishingBasin_Storage            5          8748.73
  PolishingBasin_Storage            6          9967.44
  PolishingBasin_Storage            7          11258.82

  SettlingBasin_Storage Storage    0          26735.11
  SettlingBasin_Storage            1          29611.25
  SettlingBasin_Storage            2          32558.97
  SettlingBasin_Storage            3          35578.28
  SettlingBasin_Storage            4          38669.18
  SettlingBasin_Storage            5          41831.66
  SettlingBasin_Storage            6          45065.74
  SettlingBasin_Storage            7          48371.4

[TIMESERIES]
;;Name             Date       Time       Value
;;-----------------------------------------------
;;,
  SlugEvent        7/25/2016  0:00       0
  SlugEvent        7/25/2016  2:14       0
  SlugEvent        7/25/2016  2:15       1
  SlugEvent        7/25/2016  4:45       1
  SlugEvent        7/25/2016  4:46       0
  SlugEvent        7/25/2016  10:14      0
  SlugEvent        7/25/2016  10:15      1
  SlugEvent        7/25/2016  12:45      1
  SlugEvent        7/25/2016  12:46      0
  SlugEvent        7/25/2016  18:14      0
  SlugEvent        7/25/2016  18:15      1
  SlugEvent        7/25/2016  20:45      1
```

```
  SlugEvent        7/25/2016  20:46      0
  SlugEvent        7/26/2016  2:14       0
  SlugEvent        7/26/2016  2:15       1
  SlugEvent        7/26/2016  4:45       1
  SlugEvent        7/26/2016  4:46       0
  SlugEvent        7/26/2016  10:14      0
  SlugEvent        7/26/2016  10:15      1
  SlugEvent        7/26/2016  12:45      1
  SlugEvent        7/26/2016  12:46      0
  SlugEvent        7/26/2016  18:14      0
  SlugEvent        7/26/2016  18:15      1
  SlugEvent        7/26/2016  20:45      1
  SlugEvent        7/26/2016  20:46      0
  SlugEvent        7/27/2016  2:14       0
  SlugEvent        7/27/2016  2:15       1
  SlugEvent        7/27/2016  4:45       1
  SlugEvent        7/27/2016  4:46       0
  SlugEvent        7/27/2016  10:14      0
  SlugEvent        7/27/2016  10:15      1
  SlugEvent        7/27/2016  12:45      1
  SlugEvent        7/27/2016  12:46      0
  SlugEvent        7/28/2016  0:00       0

;100-year cumulative storm for Bay County, Michigan, with a total rainfall amount of 5.99 in
using a SCS Type II 24-hr storm distribution.
  TS-02                       0:00       0.00000
  TS-02                       0:06       0.00602
  TS-02                       0:12       0.01210
  TS-02                       0:18       0.01824
  TS-02                       0:24       0.02444
  TS-02                       0:30       0.03070
  TS-02                       0:36       0.03702
  TS-02                       0:42       0.04340
  TS-02                       0:48       0.04984
  TS-02                       0:54       0.05634
  TS-02                       1:00       0.06290
  TS-02                       1:06       0.06951
  TS-02                       1:12       0.07619
  TS-02                       1:18       0.08293
  TS-02                       1:24       0.08973
  TS-02                       1:30       0.09659
  TS-02                       1:36       0.10351
  TS-02                       1:42       0.11049
  TS-02                       1:48       0.11752
  TS-02                       1:54       0.12462
  TS-02                       2:00       0.13178
  TS-02                       2:06       0.13900
  TS-02                       2:12       0.14628
  TS-02                       2:18       0.15361
  TS-02                       2:24       0.16101
  TS-02                       2:30       0.16847
  TS-02                       2:36       0.17599
  TS-02                       2:42       0.18356
  TS-02                       2:48       0.19120
  TS-02                       2:54       0.19890
  TS-02                       3:00       0.20666
  TS-02                       3:06       0.21447
  TS-02                       3:12       0.22235
  TS-02                       3:18       0.23029
  TS-02                       3:24       0.23828
  TS-02                       3:30       0.24634
  TS-02                       3:36       0.25446
  TS-02                       3:42       0.26263
  TS-02                       3:48       0.27087
  TS-02                       3:54       0.27916
  TS-02                       4:00       0.28752
  TS-02                       4:06       0.29597
```

TS-02	4:12	0.30453
TS-02	4:18	0.31322
TS-02	4:24	0.32202
TS-02	4:30	0.33095
TS-02	4:36	0.33999
TS-02	4:42	0.34916
TS-02	4:48	0.35844
TS-02	4:54	0.36785
TS-02	5:00	0.37737
TS-02	5:06	0.38701
TS-02	5:12	0.39678
TS-02	5:18	0.40666
TS-02	5:24	0.41666
TS-02	5:30	0.42679
TS-02	5:36	0.43703
TS-02	5:42	0.44739
TS-02	5:48	0.45788
TS-02	5:54	0.46848
TS-02	6:00	0.47920
TS-02	6:06	0.49004
TS-02	6:12	0.50100
TS-02	6:18	0.51209
TS-02	6:24	0.52329
TS-02	6:30	0.53461
TS-02	6:36	0.54605
TS-02	6:42	0.55761
TS-02	6:48	0.56929
TS-02	6:54	0.58109
TS-02	7:00	0.59301
TS-02	7:06	0.60505
TS-02	7:12	0.61721
TS-02	7:18	0.62949
TS-02	7:24	0.64189
TS-02	7:30	0.65441
TS-02	7:36	0.66705
TS-02	7:42	0.67981
TS-02	7:48	0.69268
TS-02	7:54	0.70568
TS-02	8:00	0.71880
TS-02	8:06	0.73228
TS-02	8:12	0.74635
TS-02	8:18	0.76103
TS-02	8:24	0.77630
TS-02	8:30	0.79218
TS-02	8:36	0.80865
TS-02	8:42	0.82572
TS-02	8:48	0.84339
TS-02	8:54	0.86166
TS-02	9:00	0.88053
TS-02	9:06	0.89970
TS-02	9:12	0.91887
TS-02	9:18	0.93803
TS-02	9:24	0.95720
TS-02	9:30	0.97637
TS-02	9:36	0.99602
TS-02	9:42	1.01662
TS-02	9:48	1.03819
TS-02	9:54	1.06071
TS-02	10:00	1.08419
TS-02	10:06	1.10887
TS-02	10:12	1.13499
TS-02	10:18	1.16254
TS-02	10:24	1.19153
TS-02	10:30	1.22196
TS-02	10:36	1.25431
TS-02	10:42	1.28905
TS-02	10:48	1.32619

TS-02	10:54	1.36572
TS-02	11:00	1.40765
TS-02	11:06	1.45365
TS-02	11:12	1.50541
TS-02	11:18	1.56291
TS-02	11:24	1.62617
TS-02	11:30	1.69517
TS-02	11:36	1.83797
TS-02	11:42	2.12262
TS-02	11:48	2.58045
TS-02	11:54	3.40148
TS-02	12:00	3.97137
TS-02	12:06	4.08494
TS-02	12:12	4.18485
TS-02	12:18	4.27111
TS-02	12:24	4.34371
TS-02	12:30	4.40265
TS-02	12:36	4.45321
TS-02	12:42	4.50065
TS-02	12:48	4.54497
TS-02	12:54	4.58618
TS-02	13:00	4.62428
TS-02	13:06	4.65998
TS-02	13:12	4.69400
TS-02	13:18	4.72635
TS-02	13:24	4.75702
TS-02	13:30	4.78601
TS-02	13:36	4.81356
TS-02	13:42	4.83992
TS-02	13:48	4.86508
TS-02	13:54	4.88904
TS-02	14:00	4.91180
TS-02	14:06	4.93375
TS-02	14:12	4.95529
TS-02	14:18	4.97640
TS-02	14:24	4.99710
TS-02	14:30	5.01737
TS-02	14:36	5.03723
TS-02	14:42	5.05667
TS-02	14:48	5.07569
TS-02	14:54	5.09429
TS-02	15:00	5.11247
TS-02	15:06	5.13023
TS-02	15:12	5.14757
TS-02	15:18	5.16449
TS-02	15:24	5.18099
TS-02	15:30	5.19707
TS-02	15:36	5.21274
TS-02	15:42	5.22798
TS-02	15:48	5.24281
TS-02	15:54	5.25721
TS-02	16:00	5.27120
TS-02	16:06	5.28491
TS-02	16:12	5.29845
TS-02	16:18	5.31185
TS-02	16:24	5.32511
TS-02	16:30	5.33822
TS-02	16:36	5.35117
TS-02	16:42	5.36397
TS-02	16:48	5.37662
TS-02	16:54	5.38913
TS-02	17:00	5.40148
TS-02	17:06	5.41368
TS-02	17:12	5.42574
TS-02	17:18	5.43764
TS-02	17:24	5.44940
TS-02	17:30	5.46101

```
TS-02                    17:36      5.47246
TS-02                    17:42      5.48377
TS-02                    17:48      5.49493
TS-02                    17:54      5.50594
TS-02                    18:00      5.51679
TS-02                    18:06      5.52749
TS-02                    18:12      5.53805
TS-02                    18:18      5.54847
TS-02                    18:24      5.55872
TS-02                    18:30      5.56883
TS-02                    18:36      5.57879
TS-02                    18:42      5.58859
TS-02                    18:48      5.59825
TS-02                    18:54      5.60776
TS-02                    19:00      5.61712
TS-02                    19:06      5.62634
TS-02                    19:12      5.63539
TS-02                    19:18      5.64431
TS-02                    19:24      5.65306
TS-02                    19:30      5.66167
TS-02                    19:36      5.67013
TS-02                    19:42      5.67844
TS-02                    19:48      5.68661
TS-02                    19:54      5.69462
TS-02                    20:00      5.70248
TS-02                    20:06      5.71025
TS-02                    20:12      5.71799
TS-02                    20:18      5.72570
TS-02                    20:24      5.73339
TS-02                    20:30      5.74104
TS-02                    20:36      5.74866
TS-02                    20:42      5.75625
TS-02                    20:48      5.76382
TS-02                    20:54      5.77135
TS-02                    21:00      5.77885
TS-02                    21:06      5.78632
TS-02                    21:12      5.79377
TS-02                    21:18      5.80118
TS-02                    21:24      5.80856
TS-02                    21:30      5.81592
TS-02                    21:36      5.82324
TS-02                    21:42      5.83053
TS-02                    21:48      5.83779
TS-02                    21:54      5.84502
TS-02                    22:00      5.85223
TS-02                    22:06      5.85940
TS-02                    22:12      5.86655
TS-02                    22:18      5.87366
TS-02                    22:24      5.88074
TS-02                    22:30      5.88779
TS-02                    22:36      5.89482
TS-02                    22:42      5.90181
TS-02                    22:48      5.90878
TS-02                    22:54      5.91571
TS-02                    23:00      5.92261
TS-02                    23:06      5.92948
TS-02                    23:12      5.93633
TS-02                    23:18      5.94314
TS-02                    23:24      5.94993
TS-02                    23:30      5.95668
TS-02                    23:36      5.96340
TS-02                    23:42      5.97010
TS-02                    23:48      5.97676
TS-02                    23:54      5.98339
TS-02                    24:00      5.99000

;1000-year cumulative storm for Bay County, Michigan, with a total rainfall amount of 9.77 in
```

using a SCS Type II 24-hr storm distribution.

TS-03		0:00	0.00000
TS-03		0:06	0.00982
TS-03		0:12	0.01974
TS-03		0:18	0.02975
TS-03		0:24	0.03986
TS-03		0:30	0.05007
TS-03		0:36	0.06038
TS-03		0:42	0.07078
TS-03		0:48	0.08129
TS-03		0:54	0.09189
TS-03		1:00	0.10259
TS-03		1:06	0.11338
TS-03		1:12	0.12427
TS-03		1:18	0.13527
TS-03		1:24	0.14635
TS-03		1:30	0.15754
TS-03		1:36	0.16883
TS-03		1:42	0.18021
TS-03		1:48	0.19169
TS-03		1:54	0.20326
TS-03		2:00	0.21494
TS-03		2:06	0.22671
TS-03		2:12	0.23858
TS-03		2:18	0.25055
TS-03		2:24	0.26262
TS-03		2:30	0.27478
TS-03		2:36	0.28704
TS-03		2:42	0.29940
TS-03		2:48	0.31186
TS-03		2:54	0.32441
TS-03		3:00	0.33707
TS-03		3:06	0.34981
TS-03		3:12	0.36266
TS-03		3:18	0.37561
TS-03		3:24	0.38865
TS-03		3:30	0.40179
TS-03		3:36	0.41503
TS-03		3:42	0.42837
TS-03		3:48	0.44180
TS-03		3:54	0.45533
TS-03		4:00	0.46896
TS-03		4:06	0.48274
TS-03		4:12	0.49671
TS-03		4:18	0.51087
TS-03		4:24	0.52524
TS-03		4:30	0.53979
TS-03		4:36	0.55455
TS-03		4:42	0.56949
TS-03		4:48	0.58464
TS-03		4:54	0.59998
TS-03		5:00	0.61551
TS-03		5:06	0.63124
TS-03		5:12	0.64716
TS-03		5:18	0.66329
TS-03		5:24	0.67960
TS-03		5:30	0.69611
TS-03		5:36	0.71282
TS-03		5:42	0.72972
TS-03		5:48	0.74682
TS-03		5:54	0.76411
TS-03		6:00	0.78160
TS-03		6:06	0.79928
TS-03		6:12	0.81716
TS-03		6:18	0.83524
TS-03		6:24	0.85351
TS-03		6:30	0.87197

TS-03	6:36	0.89063
TS-03	6:42	0.90949
TS-03	6:48	0.92854
TS-03	6:54	0.94779
TS-03	7:00	0.96723
TS-03	7:06	0.98687
TS-03	7:12	1.00670
TS-03	7:18	1.02673
TS-03	7:24	1.04695
TS-03	7:30	1.06737
TS-03	7:36	1.08799
TS-03	7:42	1.10880
TS-03	7:48	1.12980
TS-03	7:54	1.15100
TS-03	8:00	1.17240
TS-03	8:06	1.19438
TS-03	8:12	1.21734
TS-03	8:18	1.24128
TS-03	8:24	1.26619
TS-03	8:30	1.29208
TS-03	8:36	1.31895
TS-03	8:42	1.34679
TS-03	8:48	1.37562
TS-03	8:54	1.40541
TS-03	9:00	1.43619
TS-03	9:06	1.46745
TS-03	9:12	1.49872
TS-03	9:18	1.52998
TS-03	9:24	1.56125
TS-03	9:30	1.59251
TS-03	9:36	1.62456
TS-03	9:42	1.65816
TS-03	9:48	1.69334
TS-03	9:54	1.73007
TS-03	10:00	1.76837
TS-03	10:06	1.80862
TS-03	10:12	1.85122
TS-03	10:18	1.89616
TS-03	10:24	1.94345
TS-03	10:30	1.99308
TS-03	10:36	2.04584
TS-03	10:42	2.10250
TS-03	10:48	2.16308
TS-03	10:54	2.22756
TS-03	11:00	2.29595
TS-03	11:06	2.37098
TS-03	11:12	2.45540
TS-03	11:18	2.54919
TS-03	11:24	2.65236
TS-03	11:30	2.76491
TS-03	11:36	2.99783
TS-03	11:42	3.46210
TS-03	11:48	4.20885
TS-03	11:54	5.54798
TS-03	12:00	6.47751
TS-03	12:06	6.66275
TS-03	12:12	6.82571
TS-03	12:18	6.96640
TS-03	12:24	7.08481
TS-03	12:30	7.18095
TS-03	12:36	7.26341
TS-03	12:42	7.34079
TS-03	12:48	7.41309
TS-03	12:54	7.48030
TS-03	13:00	7.54244
TS-03	13:06	7.60067
TS-03	13:12	7.65616

TS-03	13:18	7.70892
TS-03	13:24	7.75894
TS-03	13:30	7.80623
TS-03	13:36	7.85117
TS-03	13:42	7.89416
TS-03	13:48	7.93519
TS-03	13:54	7.97427
TS-03	14:00	8.01140
TS-03	14:06	8.04721
TS-03	14:12	8.08233
TS-03	14:18	8.11677
TS-03	14:24	8.15052
TS-03	14:30	8.18360
TS-03	14:36	8.21598
TS-03	14:42	8.24769
TS-03	14:48	8.27871
TS-03	14:54	8.30904
TS-03	15:00	8.33870
TS-03	15:06	8.36766
TS-03	15:12	8.39595
TS-03	15:18	8.42355
TS-03	15:24	8.45046
TS-03	15:30	8.47670
TS-03	15:36	8.50224
TS-03	15:42	8.52711
TS-03	15:48	8.55129
TS-03	15:54	8.57479
TS-03	16:00	8.59760
TS-03	16:06	8.61995
TS-03	16:12	8.64205
TS-03	16:18	8.66391
TS-03	16:24	8.68553
TS-03	16:30	8.70691
TS-03	16:36	8.72803
TS-03	16:42	8.74891
TS-03	16:48	8.76955
TS-03	16:54	8.78994
TS-03	17:00	8.81010
TS-03	17:06	8.83000
TS-03	17:12	8.84967
TS-03	17:18	8.86908
TS-03	17:24	8.88826
TS-03	17:30	8.90718
TS-03	17:36	8.92587
TS-03	17:42	8.94432
TS-03	17:48	8.96251
TS-03	17:54	8.98047
TS-03	18:00	8.99817
TS-03	18:06	9.01563
TS-03	18:12	9.03285
TS-03	18:18	9.04983
TS-03	18:24	9.06656
TS-03	18:30	9.08305
TS-03	18:36	9.09929
TS-03	18:42	9.11528
TS-03	18:48	9.13104
TS-03	18:54	9.14655
TS-03	19:00	9.16182
TS-03	19:06	9.17684
TS-03	19:12	9.19162
TS-03	19:18	9.20615
TS-03	19:24	9.22044
TS-03	19:30	9.23448
TS-03	19:36	9.24828
TS-03	19:42	9.26183
TS-03	19:48	9.27515
TS-03	19:54	9.28822

```
  TS-03                        20:00      9.30104
  TS-03                        20:06      9.31371
  TS-03                        20:12      9.32634
  TS-03                        20:18      9.33892
  TS-03                        20:24      9.35145
  TS-03                        20:30      9.36393
  TS-03                        20:36      9.37637
  TS-03                        20:42      9.38875
  TS-03                        20:48      9.40108
  TS-03                        20:54      9.41338
  TS-03                        21:00      9.42561
  TS-03                        21:06      9.43779
  TS-03                        21:12      9.44993
  TS-03                        21:18      9.46202
  TS-03                        21:24      9.47407
  TS-03                        21:30      9.48606
  TS-03                        21:36      9.49800
  TS-03                        21:42      9.50990
  TS-03                        21:48      9.52174
  TS-03                        21:54      9.53354
  TS-03                        22:00      9.54529
  TS-03                        22:06      9.55698
  TS-03                        22:12      9.56864
  TS-03                        22:18      9.58024
  TS-03                        22:24      9.59180
  TS-03                        22:30      9.60329
  TS-03                        22:36      9.61475
  TS-03                        22:42      9.62616
  TS-03                        22:48      9.63752
  TS-03                        22:54      9.64882
  TS-03                        23:00      9.66009
  TS-03                        23:06      9.67129
  TS-03                        23:12      9.68246
  TS-03                        23:18      9.69357
  TS-03                        23:24      9.70464
  TS-03                        23:30      9.71565
  TS-03                        23:36      9.72662
  TS-03                        23:42      9.73753
  TS-03                        23:48      9.74841
  TS-03                        23:54      9.75922
  TS-03                        24:00      9.77000

[REPORT]
 INPUT     YES
 CONTROLS  YES

[OPTIONS]
 TEMPDIR   "C:\Users\jhansel\AppData\Local\Temp\"
```

Autodesk® Storm and Sanitary Analysis 2016 - Version 11.1.55 (Build 1)

****
Project Description
****
File Name ..... Flood Control Plan.SPF

****
Analysis Options
****
Flow Units ..... GPM
Subbasin Hydrograph Method. EPA SWMM
Infiltration Method ..... SCS Curve Number
Link Routing Method ..... Hydrodynamic
Storage Node Exfiltration.. None
Starting Date JUL-25-2016 00:00:00
Ending Date JUL-28-2016 00:00:00
Antecedent Dry Days 0.0
Report Time Step 00:05:00
Wet Time Step 00:05:00
Dry Time Step 01:00:00
Routing Time Step ..... 30.00 sec

****
Element Count
****
Number of rain gages 1
Number of subbasins 1
Number of nodes 2
Number of links 1
Number of pollutants 0
Number of land uses 0

****
Raingage Summary
****

Gage ID	Data Source	Data Type	Recording Interval min
Rain Gage-01	TS-02	CUMULATIVE	6.00

****
Subbasin Summary
****

Subbasin ID	Total Area acres	Equiv. Width ft	Imperv. Area %	Average Slope %	Raingage
Sub-01	1.78	500.00	100.00	0.5000	Rain Gage-01

****
Node Summary
****

Node ID	Element Type	Invert Elevation ft	Maximum Elev. ft	Ponded Area ft²	External Inflow
Outfall	OUTFALL	596.60	597.81	0.00	
SettlingBasin	STORAGE	592.00	600.50	41831.00	Yes

****
Link Summary
****

Link ID	From Node	To Node	Element Type	Length ft	Slope %	Manning's Roughness
Cross-OverPipes	SettlingBasin	Outfall	CONDUIT	40.0	1.0000	0.0150

****
Cross Section Summary
****

Link ID	Shape	Depth/ Diameter ft	Width ft	No. of Barrels	Cross Sectional Area ft²	Full Flow Hydraulic Radius ft	Design Flow Capacity GPM
Cross-OverPipes	CIRCULAR	1.21	1.21	2	1.15	0.30	2309.11

Runoff Quantity Continuity **********	Volume acre-ft	Depth inches
Total Precipitation	0.888	5.990
Evaporation Loss	0.000	0.000
Infiltration Loss	0.000	0.000
Surface Runoff	0.878	5.928
Final Surface Storage	0.012	0.080
Continuity Error (%)	-0.297	

Flow Routing Continuity **********	Volume acre-ft	Volume Mgallons
Dry Weather Inflow	0.000	0.000
Wet Weather Inflow	0.879	0.286
Groundwater Inflow	0.000	0.000
RDII Inflow	0.000	0.000
External Inflow	8.786	2.863
External Outflow	9.525	3.104
Surface Flooding	0.000	0.000
Evaporation Loss	0.000	0.000
Initial Stored Volume	3.919	1.277
Final Stored Volume	4.058	1.322
Continuity Error (%)	-0.001	

****
Composite Curve Number Computations Report
****

Subbasin Sub-01

Soil/Surface Description	Area (acres)	Soil Group	CN
-	1.41	-	98.00

Composite Area & Weighted CN 1.41 98.00

****
EPA SWMM Time of Concentration Computations Report
****

Tc = (0.94 * (L^0.6) * (n^0.6)) / ((i^0.4) * (S^0.3))

Where:

Tc = Time of Concentration (min)
L = Flow Length (ft)
n = Manning's Roughness
i = Rainfall Intensity (in/hr)
S = Slope (ft/ft)

Subbasin Sub-01

Flow length (ft):	154.91
Pervious Manning's Roughness:	0.10000
Impervious Manning's Roughness:	0.01500
Pervious Rainfall Intensity (in/hr):	0.24958
Impervious Rainfall Intensity (in/hr):	0.24958
Slope (%):	0.50000
Computed TOC (minutes):	13.32

****
Subbasin Runoff Summary
****

Subbasin ID	Total Rainfall in	Total Runon in	Total Evap. in	Total Infil. in	Total Runoff in	Peak Runoff GPM	Runoff Coefficient	Time of Concentration days hh:mm:ss
Sub-01	5.99	0.00	0.00	0.00	5.93	6423.29	0.990	0 00:13:18

****
Node Depth Summary
****

Node ID	Average Depth Attained ft	Maximum Depth Attained ft	Maximum HGL Attained ft	Time of Max Occurrence days	Time of Max Occurrence hh:mm	Total Flooded Volume acre-in	Total Flooded Time minutes	Retention Time hh:mm:ss
Outfall	0.38	0.71	597.31	0	12:31	0	0	0:00:00
SettlingBasin	5.55	6.10	598.10	0	12:31	0	0	0:00:00

****
Node Flow Summary
****

Node ID	Element Type	Maximum Lateral Inflow GPM	Peak Inflow GPM	Time of Peak Inflow Occurrence days	Time of Peak Inflow Occurrence hh:mm	Maximum Flooding Overflow GPM	Time of Flooding Occurrence days	Time of Flooding Occurrence hh:mm
Outfall	OUTFALL	0.00	2970.65	0	12:31	0.00		
SettlingBasin	STORAGE	8788.81	8788.81	0	12:00	0.00		

****
Storage Node Summary
****

Storage Node ID	Maximum Ponded Volume 1000 ft³	Maximum Ponded Volume (%)	Time of Max Ponded Volume days hh:mm	Average Ponded Volume 1000 ft³	Average Ponded Volume (%)	Maximum Storage Node Outflow GPM	Maximum Exfiltration Rate cfm	Time of Max. Exfiltration Rate hh:mm:ss	Total Exfiltrated Volume 1000 ft³
SettlingBasin	218.476	65	0 12:31	194.107	58	2970.65	0.00	0:00:00	0.000

****
Outfall Loading Summary
****

Outfall Node ID	Flow Frequency (%)	Average Flow GPM	Peak Inflow GPM
Outfall	99.24	1074.05	2970.65
System	99.24	1074.05	2970.65

****
Link Flow Summary
****

Link ID	Element Type	Time of Peak Flow Occurrence days hh:mm	Maximum Velocity Attained ft/sec	Length Factor	Peak Flow during Analysis GPM	Design Flow Capacity GPM	Ratio of Maximum /Design Flow	Ratio of Maximum Depth	Total Time minutes	Reported Condition

```
------------------------------
  Cross-OverPipes      CONDUIT      0  12:31      3.62    1.00     2970.65     4618.22      0.64
0.74           0  Calculated


  ***************************
  Flow Classification Summary
  ***************************

  -------------------------------------------------------------------------------
                     --- Fraction of Time in Flow Class ----   Avg.     Avg.
                          Up    Down  Sub   Sup   Up    Down   Froude   Flow
  Link               Dry  Dry   Dry   Crit  Crit  Crit  Crit   Number   Change
  -------------------------------------------------------------------------------
  Cross-OverPipes   0.01  0.00  0.00  0.99  0.00  0.00  0.00     0.80   0.0009


  ***************************
  Time-Step Critical Elements
  ***************************
  Link Cross-OverPipes (90.99%)


  *******************************
  Highest Flow Instability Indexes
  *******************************
  All links are stable.


  ************************
  Routing Time Step Summary
  ************************
  Minimum Time Step           :     3.29 sec
  Average Time Step           :     7.23 sec
  Maximum Time Step           :    30.00 sec
  Percent in Steady State     :     0.00
  Average Iterations per Step :     2.00


  Analysis began on:  Tue May 29 15:45:20 2018
  Analysis ended on:  Tue May 29 15:45:21 2018
  Total elapsed time: 00:00:01
```

Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Inc.
15851 South U.S. 27, Suite 50
Lansing, MI 48906 USA
Tel: (517) 482-2262
Fax: (517) 482-2460

Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity