**NTH Consultants, Ltd.**

Infrastructure Engineering
and Environmental Services

41780 Six Mile Road, Suite 200
Northville, MI 48168
248.553.6300
248.324.5179 Fax

Mr. Christopher Scieszka
DTE Electric Company.
One Energy Plaza
Detroit, Michigan 48226

October 14, 2021
NTH Project No. 62-210081-02

**RE: Inflow Design Flood Control System Plan 5-Year Periodic Assessment
River Rouge Power Plant Former Bottom Ash Basin
River Rouge, Michigan**

Dear Mr. Scieszka:

NTH Consultants, Ltd. (NTH) has completed a periodic update to the initial inflow design flood control (IDFC) system plan for the bottom ash basins at River Rouge Power Plant (RRPP) in accordance with the Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals (CCR) from Electric Utilities 40 CFR Part 257.82. Specifically, this inflow design flood control system plan constitutes the 5-year periodic assessment of the initial plan (dated October 14, 2016) for this impoundment, as required by 40 CFR Part 257.82(c)(4). NTH performed this assessment using information provided by personnel from DTE Electric Company (DTE), observations we made during a site visit by our personnel, and an updated topographic survey. In general, the analysis methods and development of information are presented in the initial inflow design flood control system plan and are not reiterated herein. This letter identifies changes to the conditions documented in the initial plan and stipulates any new information made available to NTH as part of the periodic assessment that may alter or re-affirm the findings from the initial 2016 evaluation, which is attached to the end of the report for reference.

## BACKGROUND

The RRPP bottom ash basin is a physical sedimentation basin that previously received bottom ash and other process flow effluent from the power plant. RRPP ceased power generation operations and terminated coal burning and ash generation on June 1, 2020. The basin was cleaned of ash residuals, which was completed on September 21, 2020. Following the CCR removal, the basin was restored as a non-CCR process water basin on October 27, 2020. As of the date of this evaluation, the former CCR surface impoundment has not achieved certified clean closure as defined by 40 CFR 257.

Discharge water from the basin flows over an overflow weir and into the weir box structure before going to a below-grade pump station. However, previously there were two sets of pumps in the pump station, one set that recirculated the sluice water back into the plant for operational process use and one set that pumped to an outfall in the overflow canal. The recirculation pumps have been taken out of service and the basin now only pumps to the outfall in the overflow canal, which is authorized via a National Pollution Discharge Eliminations Systems (NPDES) permit. The basin is an incised surface impoundment, per the definition in 40 CFR 257.53 and therefore, a 25-year storm event was used for the assessment.

NTH prepared an inflow design flood control system plan in 2016 to document and demonstrate the hydrologic and hydraulic capacity and performance conditions of the CCR surface impoundment, including the basin, intake structures, and downstream hydraulic structures in accordance with 40 CFR 257.82. We previously determined that there were no deficiencies for the bottom ash CCR surface impoundment or downstream conveyance structures that warranted upgrades or improvements. In addition, the discharge from the basin meets the regulatory NPDES permit requirements for total suspended solids (TSS) and fats, oils, and grease (FOG).

**ASSESSMENT**

For this periodic evaluation, NTH performed the following to analyze the condition of the surface impoundment and verify the information presented in the initial IDFC report:

- Performed a site visit on August 10, 2021 to meet DTE personnel, learn about any changes in the DTE assets, and observe the current system conditions. A photo log from the site visit is included as an attachment to this letter;
- Reviewed the initial report;
- Procured supplemental topographic and bathymetric surveying of the surface impoundment. The supplemental survey was performed on May 11, 2021 by BMJ Engineers & Surveyors, Inc. to update previous bathymetric information from 2016 and to facilitate accurate capacity calculations for the system. The supplemental survey information is included as an attachment to this letter;
- Obtained updated information on each of the inflows into the basin;
- Updated the model input parameters including new peak flow information, system removals and reconfigurations, and updated capacity of the basin according to the bathymetric survey. The updated site plan is included as an attachment to this letter; and
- Re-ran the Autodesk Storm and Sanitary Analysis (SSA) modeling software with the updated data inputs. The updated model output is included as an attachment to this letter.

Based on information from the above actions, NTH summarizes the following for this IDFC periodic assessment:

- The current configuration and condition of the basin (as shown in the attached photographs) is consistent with those presented in the initial IDFC report, except to several of the inflow and outflow processes as summarized below. Also, as stated before, CCR material was removed from the basin and it was restored as a process water basin.
- The approximate capacity of the basin is not significantly different from that presented in the initial report but has increased as a result of the CCR material removal.
    - 2.7 million gallons (2.3 million gallons in 2016).

  As a point of clarification, the capacity of the basins at any given time is a function of the active dredging state and is not necessarily indicative of changes to the basin geometry. The overflow weir and basin blowdown pumps control the basin water levels and flow and NTH staff observed no indication that the basin or weir geometries or basin blowdown pumps have been altered since the initial IDFC report.
- Analysis of the inflow data provided by DTE showed that many of the previous flows were removed and abandoned after the plant ceased power generation activities. However, flow was added from the groundwater extraction system that was installed in 2018.

- Overall, the total flows into the basin dropped from 1.5 cfs to 1.45 cfs. As stated previously, the recirculation system was removed from service, removing another approximately 4.26 cfs of flow when that system was in operation.

**SURFACE IMPOUNDMENT INFLOW SUMMARY**

| No. | Pipe | Diameter (inches) | Invert | Flow Rate (cfs) | Frequency | Changes Since 2016 IDFC Report |
|---|---|---|---|---|---|---|
| 1 | Sand Filter Discharge | 6 | 578.63 | Abandoned, stormwater flow included in basin watershed | Storm events | No changes |
| 2 | Fire Booster Drain | 10 | 578.84 | *5.6 | Once a month for an hour | No changes |
| 3 | Truck Bay Silo #1 Drain (?) | 12 | 579.38 | *Abandoned, stormwater flow included in basin watershed | Storm events | No changes |
| 4 | Transfer House Wash Down | 6 | 578.31 | 0.1 | Sporadically | No changes |
| 5 | Ash Settling Bins Drain | 12 | 579.05 | (a) 4.26 from the bottom ash basin recirculation pumps (b) 1.07 from Sump 2 in plan (c) 0.04 from RO/UF Sump | Twice Daily | (a) System no longer in use since June 2020 (b) No changes (c) No changes |
| 6 | Truck Bay Silo #2 Drain | 12 | 579.19 | 0.1 | During washdowns | Area capped June 2020. Does not discharge to basin |

| No. | Pipe | Diameter (inches) | Invert | Flow Rate (cfs) | Frequency | Changes Since 2016 IDFC Report |
|---|---|---|---|---|---|---|
| 7 | BFG Condensate Drain | 4 | 578.74 | 0.1 | Unknown | No changes |
| 8 | BFG House Storm Drain | 12 | 578.15 | Gravity-fed Stormwater flow already included in basin watershed | Storm events | No changes |
| 9 | Pump House Sump Pump | 3 | Unknown | 0.1 | Storm events | No changes |
| 10 | Groundwater Extraction System | 4** | 580.3** | 0.05 | Continuously | 11 Groundwater Extraction Wells collect surrounding groundwater and discharge into basin at a single point. Installed June 2018. Of the 11 wells, 10 operate continuously. |

**NTH assumed the fire booster flow is not present during the analysis because it is highly unlikely that DTE will test the fire booster pump during a 25-year storm event in addition to the peak process flows occurring simultaneously.*
***Values are approximate and are based off visual confirmation during the site visit.*

**SURFACE IMPOUNDMENT PUMP OUTFLOW SUMMARY**

| | Number of Pumps | Flow Rate (gpm) | Total Dynamic Head (Ft) | Changes Since 2016 IDFC Report |
|---|---|---|---|---|
| **Recirculation Pumps** | 3 | 958 | 660 | No longer in use |
| **Blowdown Pumps** | 2 | 220 | 50 | No changes* |

**Pumps still run manually by DTE staff one at a time when basin water level reaches an elevation of 577'-8"(one foot below top of sheet pile at 579'-8") and discharge to overflow canal*

- The dimensions, capacities, and operations of the receiving stormwater system, which consists of the blowdown pumps and piping to the outfall in the overflow canal, remains unchanged from that presented in the initial report; however, the recirculation system is no longer in use.
- Information from the supplemental survey indicates basin water surface elevations are consistent with that documented in the initial IDFC report.

The inflow design flood control system plan presented in the initial report is still applicable to the current condition of the RRPP bottom ash basin because the basin, overflow weir, basin blowdown pumps, and outfall are unchanged; however, there have been some operational changes due to the plant closure in 2020, causing the removal of the recirculation system and changing the basin to a non-CCR process water basin. Since the basin has not received certified clean closure as the date of this evaluation, and despite the changes to the operational inflows and outflows, the basin still meets the hydrologic and hydraulic capacity and performance requirements for bottom ash CCR surface impoundments in accordance with 40 CFR 257.82.

**CONCLUSIONS**

Based on the findings summarized herein and the hydrologic and hydraulic capacity requirements for CCR surface impoundments presented in 40 CFR 257.82, NTH has determined that the surface impoundment for RRPP meets the criteria of this section. In accordance with 40 CFR 257.82(c)(5), a statement of Certification for the RRPP surface impoundment is included with this letter as an attachment. A copy of this letter should be kept in the facility's operating record for future reference.

Please contact NTH if you have any questions.

Sincerely,

NTH Consultants, Ltd.

DocuSigned by:
David R. Lutz
2BF41F0D0F4749B...

David R. Lutz, P.E.
Vice President

DocuSigned by:
Samantha L. Grant
A1E1683045E447D...

Samantha L. Grant, P.E.
Project Engineer

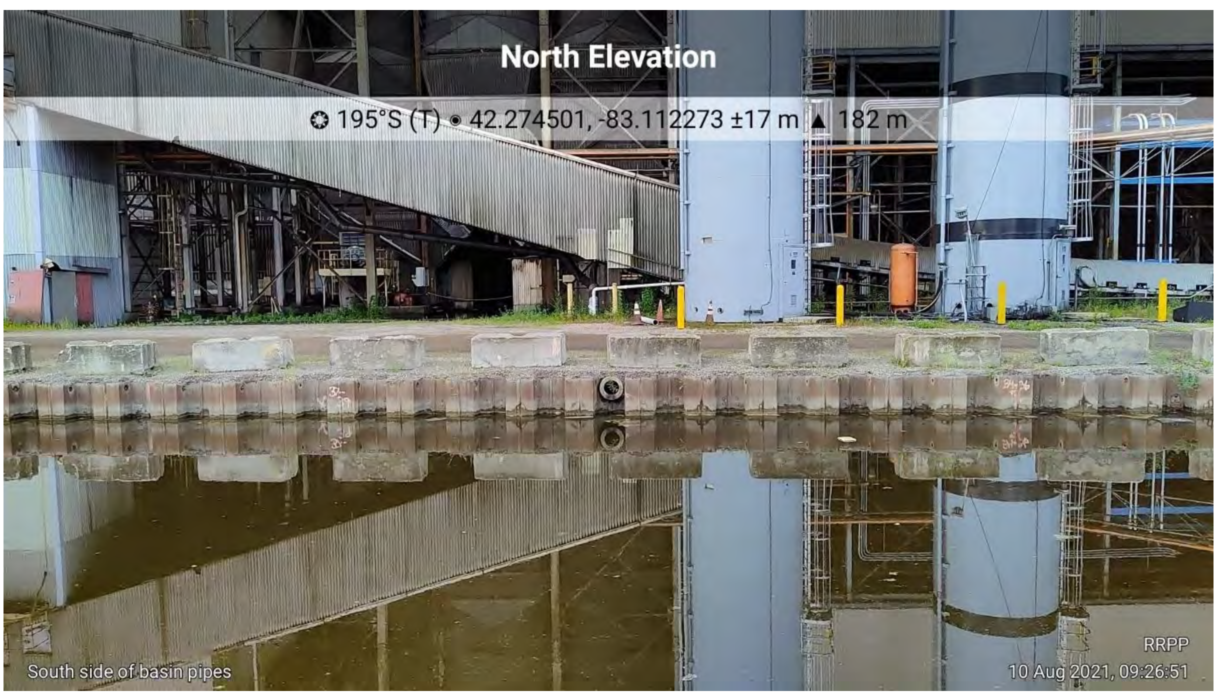
DRL/SLG/mam

Attachments

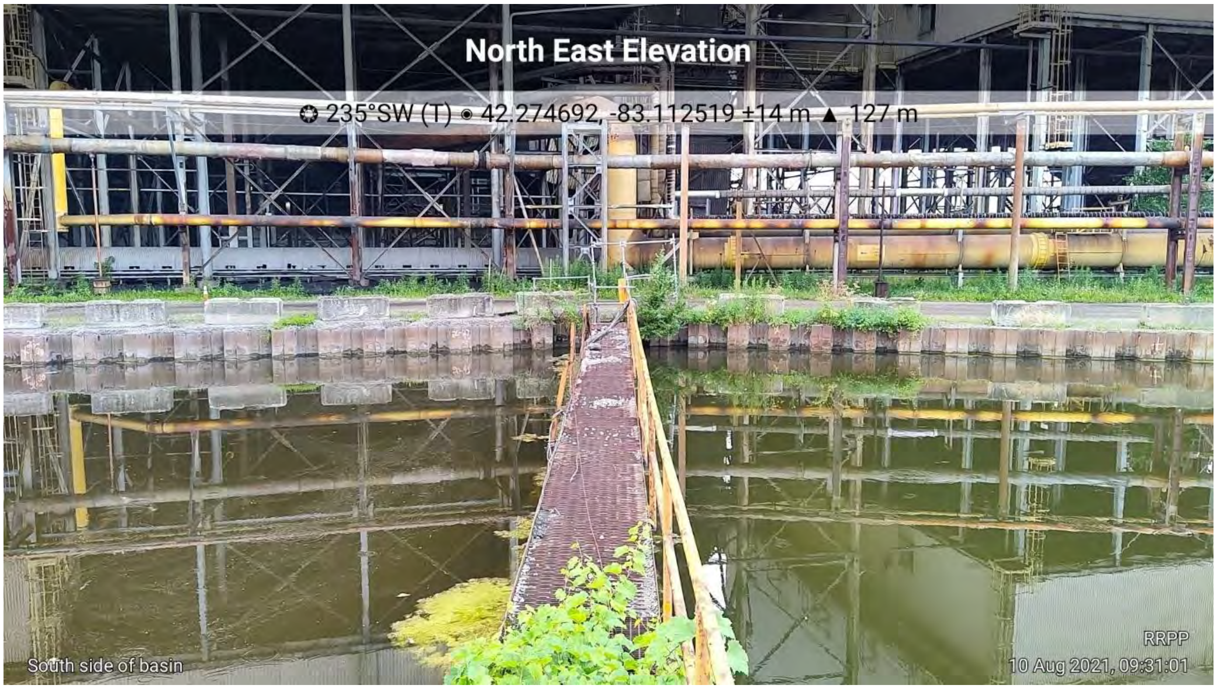

***Photograph 1: Inlet Pipes at East End of Basin from Southeast Corner of Basin Looking Northeast***


***Photograph 2: New Groundwater Extraction Well Discharge from Southeast Corner of Basin Looking Northeast***

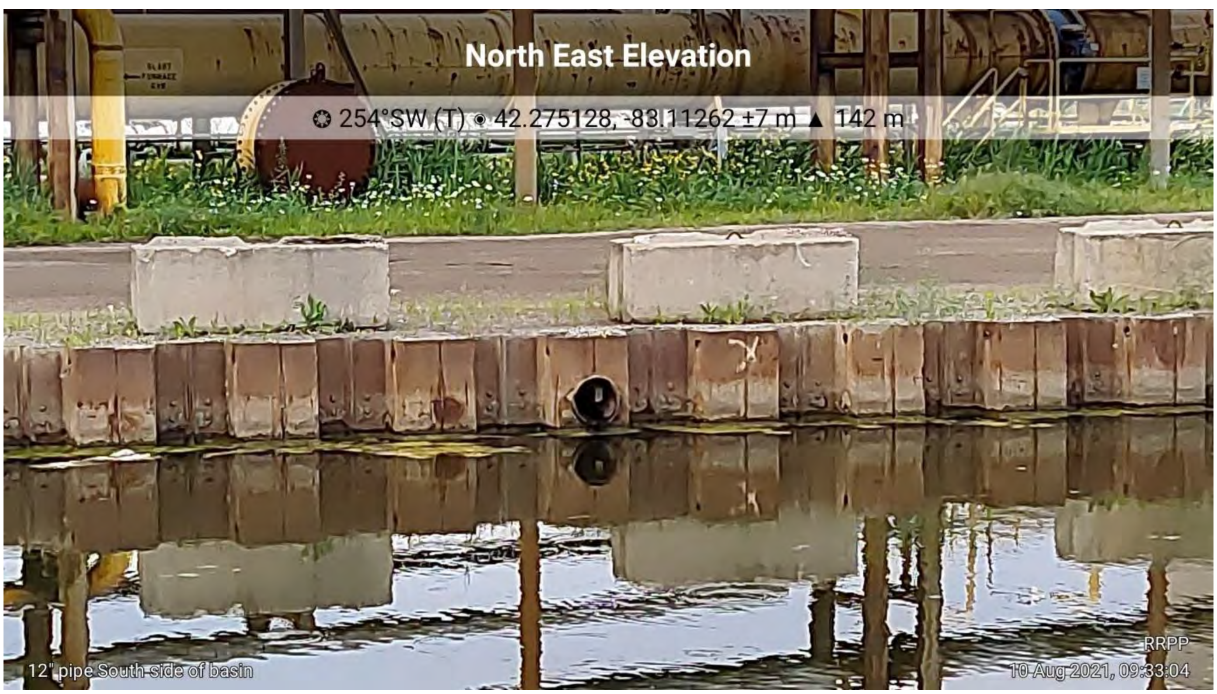

*Photograph 3: Transfer House Wash Down Inlet from Northeast Corner of Basin Looking Southwest*




*Photograph 4: Ash Settling Bins Drain from North Side of Basin Looking South*




*Photograph 5: Underflow Weir and BFG Condensate Drain from North Side of Basin Looking South*

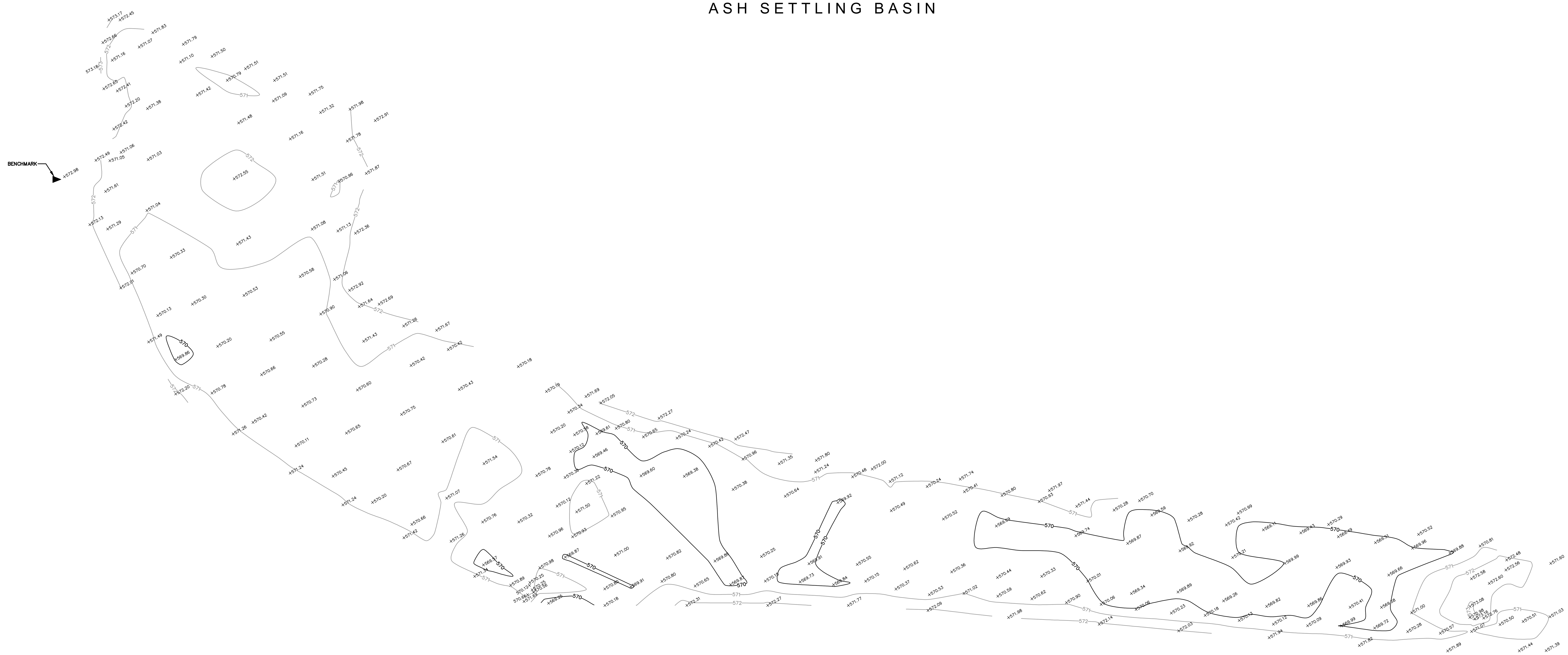



*Photograph 6: BFG House Storm Drain from North Side of Basin Looking Southwest*


***Photograph 7: Pump House and Overflow Weir Looking West from North Side of Basin***


***Photograph 8: Pump House Sump Pump Looking West from North Side of Basin***

# RIVER ROUGE POWER PLANT
## ASH SETTLING BASIN




NOTES:
VERTICAL DATUM: DTE PLANT DATUM (ORIGIN UNKNOWN)

HORIZONTAL DATUM: DTE PLANT DATUM (ORIGIN UNKNOWN)

BENCHMARK:
DESCRIPTION: ATOP CUT "X" IN STEEL SEAWALL NEAREST TO THE SOUTHEASTERLY MOST CORNER OF CONCRETE WALL OF ASH BASIN PUMP HOUSE AT THE WEST END OF ASH SETTLING BASINS ±0.5' FROM WALL & ±1' FROM END OF SEAWALL.
ELEVATION = 580.22 (PLANT DATUM)

WATER LEVEL
ELEVATION = 577.93 (PLANT DATUM)

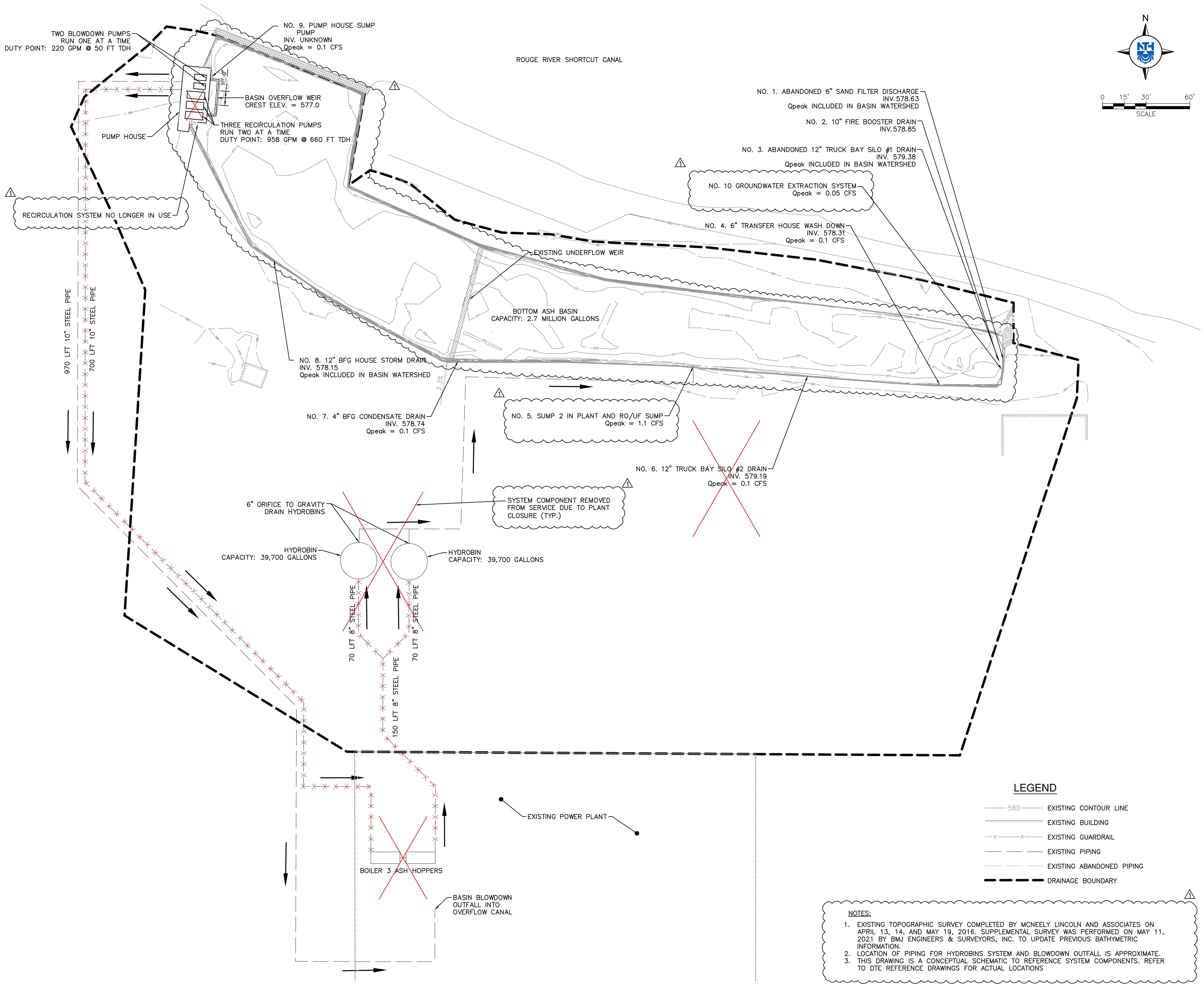
GRAPHIC SCALE
20 0 10 20 40
( IN FEET )
1 inch = 20 ft.


BMJ ENGINEERS & SURVEYORS, INC.
CIVIL ENGINEERS & LAND SURVEYORS
519 HURON AVE. PORT HURON, MI 48060
TEL: 810-984-5596 FAX: 810-984-8760
Web Page: www.bmjinc.com Email: mail@bmjinc.com


BATHYMETRIC SURVEY OF ASH SETTLING BASIN AT DTE RIVER ROUGE POWER PLANT
BELANGER PARK DRIVE, CITY OF RIVER ROUGE, WAYNE COUNTY, MICHIGAN
FOR: NTH CONSULTANTS, LTD

| NO | REVISIONS | DATE |
|---|---|---|

SCALE: 1" = 20'
DATE: 5-11-21
SURVEYED: AMB
DRAWN: SWS
CHK'D: RJA
JOB NO. 2104.15
SHT 1 OF 1




## LEGEND

- 580 EXISTING CONTOUR LINE
- EXISTING BUILDING
- EXISTING GUARDRAIL
- EXISTING PIPING
- EXISTING ABANDONED PIPING
- DRAINAGE BOUNDARY

NOTES:

1. EXISTING TOPOGRAPHIC SURVEY COMPLETED BY MCNEELY LINCOLN AND ASSOCIATES ON APRIL 13, 14, AND MAY 19, 2016. SUPPLEMENTAL SURVEY WAS PERFORMED ON MAY 11, 2021 BY BMJ ENGINEERS & SURVEYORS, INC. TO UPDATE PREVIOUS BATHYMETRIC INFORMATION.
2. LOCATION OF PIPING FOR HYDROBINS SYSTEM AND BLOWDOWN OUTFALL IS APPROXIMATE.
3. THIS DRAWING IS A CONCEPTUAL SCHEMATIC TO REFERENCE SYSTEM COMPONENTS. REFER TO DTE REFERENCE DRAWINGS FOR ACTUAL LOCATIONS


NTH Consultants, Ltd.
Infrastructure Engineering and Environmental Services

| | |
|---|---|
| Northville, MI | 248.553.6300 |
| Detroit, MI | 313.237.3900 |
| Lansing, MI | 517.484.6900 |
| Grand Rapids, MI | 616.451.6270 |
| Cleveland, OH | 216.334.4040 |


SUBMITTAL

| REV | DESCRIPTION | DATE | BY |
|---|---|---|---|
| 1 | 5-YR PERIODIC ASSESSMENT | 9/7/2021 | DGD |

PROJECT NAME:
DTE RIVER ROUGE POWER PLANT - BOTTOM ASH BASIN HYDRAULIC ANALYSIS

PROJECT LOCATION:
RIVER ROUGE POWER PLANT
DETROIT, MICHIGAN

| | |
|---|---|
| NTH PROJECT NO.: 62-210081 | CAD FILE NAME: 210081-RR-SP |
| DESIGNED BY: SLG | INCEP DATE: 9/7/2016 |
| DRAWN BY: SLG | DRAWING SCALE: 1" = 30' |
| CHECKED BY: DRL | SUBMITTED DATE: 9/7/2021 |

SHEET TITLE:
RIVER ROUGE POWER PLANT FORMER BOTTOM ASH BASIN

EXISTING SYSTEM COMPONENT PLAN

SHEET REFERENCE NUMBER:
3

c:\users\ddolowy\desktop\j drive local\210081\production sets\rrpp\210081-rr-sp.dwg Plotted: 9/14/2021 4:39 PM by ddolowy

```
Autodesk® Storm and Sanitary Analysis 2016 - Version 13.2.202 (Build 0)
-----------------------------------------------------------------------------------------

*******************
Project Description
*******************
File Name ................. River Rouge.SPF


****************
Analysis Options
****************
Flow Units ................ cfs
Subbasin Hydrograph Method. Rational
Time of Concentration...... SCS TR-55
Return Period.............. 25 years
Link Routing Method ....... Hydrodynamic
Storage Node Exfiltration.. None
Starting Date ............. JUL-29-2016 00:00:00
Ending Date ............... JUL-29-2016 02:00:00
Report Time Step .......... 00:00:10


*************
Element Count
*************
Number of subbasins ....... 1
Number of nodes ........... 4
Number of links ........... 3


****************
Subbasin Summary
****************
Subbasin                 Total
                          Area
ID                         ft²
------------------------------
Sub-01               229940.29


************
Node Summary
************
Node                Element             Invert   Maximum    Ponded    External
```

| ID | Type | Elevation ft | Elev. ft | Area ft² | Inflow |
|---|---|---|---|---|---|
| Jun-06 | JUNCTION | 575.83 | 576.33 | 0.00 | |
| Out-01 | OUTFALL | 590.67 | 591.17 | 0.00 | |
| Ash-Basin | STORAGE | 564.83 | 579.80 | 0.00 | Yes |
| Weir-Structure | STORAGE | 573.33 | 579.50 | 0.00 | |

************
Link Summary
************

| Link ID | From Node | To Node | Element Type | Length ft | Slope % | Manning's Roughness |
|---|---|---|---|---|---|---|
| Blowdown-Outfall | Out-01 | Jun-06 | CONDUIT | 970.0 | 1.5299 | 0.0130 |
| Blowdown-1 | Weir-Structure | Jun-06 | TYPE3 PUMP | | | |
| Ash-Basin-Weir | Ash-Basin | Weir-Structure | WEIR | | | |

*********************
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 cfs |
|---|---|---|---|---|---|---|---|
| Blowdown-Outfall | CIRCULAR | 0.50 | 0.50 | 1 | 0.20 | 0.13 | 0.69 |

| Runoff Quantity Continuity | Volume acre-ft | Depth inches |
|---|---|---|
| Total Precipitation ...... | 0.504 | 1.145 |
| Continuity Error (%) ..... | 0.147 | |

| Flow Routing Continuity | Volume acre-ft | Volume Mgallons |
|---|---|---|
| External Inflow .......... | 0.240 | 0.078 |
| External Outflow ......... | 0.078 | 0.026 |
| Initial Stored Volume .... | 22.239 | 7.247 |
| Final Stored Volume ...... | 22.830 | 7.440 |
| Continuity Error (%) ..... | -0.000 | |

```
*************************************
Runoff Coefficient Computations Report
*************************************

------------------
Subbasin Sub-01
------------------
                                                          Area          Soil       Runoff
Soil/Surface Description                                  (ft²)         Group      Coeff.
-------------------------------------------------------------------------------------------
-                                                      189049.25          -          0.85
-                                                       40890.83          -          0.90
Composite Area & Weighted Runoff Coeff.                229940.07                     0.86


***************************************************
SCS TR-55 Time of Concentration Computations Report
***************************************************

Sheet Flow Equation
-------------------

        Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

        Where:

        Tc = Time of Concentration (hrs)
        n  = Manning's Roughness
        Lf = Flow Length (ft)
        P  = 2 yr, 24 hr Rainfall (inches)
        Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation
----------------------------------

        V  = 16.1345 * (Sf^0.5) (unpaved surface)
        V  = 20.3282 * (Sf^0.5) (paved surface)
        V  = 15.0 * (Sf^0.5) (grassed waterway surface)
        V  = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
        V  = 9.0 * (Sf^0.5) (cultivated straight rows surface)
        V  = 7.0 * (Sf^0.5) (short grass pasture surface)
        V  = 5.0 * (Sf^0.5) (woodland surface)
        V  = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
        Tc = (Lf / V) / (3600 sec/hr)
```

Where:

Tc = Time of Concentration (hrs)
Lf = Flow Length (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)

Channel Flow Equation
--------------------

V = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
R = Aq / Wp
Tc = (Lf / V) / (3600 sec/hr)

Where:

Tc = Time of Concentration (hrs)
Lf = Flow Length (ft)
R = Hydraulic Radius (ft)
Aq = Flow Area ($ft^2$)
Wp = Wetted Perimeter (ft)
V = Velocity (ft/sec)
Sf = Slope (ft/ft)
n = Manning's Roughness

------------------
Subbasin Sub-01
------------------

User-Defined TOC override (minutes): 10.00

**********************
Subbasin Runoff Summary
**********************

| Subbasin ID | Accumulated Precip in | Rainfall Intensity in/hr | Total Runoff in | Peak Runoff cfs | Weighted Runoff Coeff | Time of Concentration days | Time of Concentration hh:mm:ss |
|---|---|---|---|---|---|---|---|
| Sub-01 | 1.14 | 4.58 | 0.98 | 20.79 | 0.860 | 0 | 00:15:00 |

*****************

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 Time Flooded minutes | Retention Time hh:mm:ss |
|---|---|---|---|---|---|---|---|---|
| Jun-06 | 22.17 | 73.56 | 649.39 | 0 | 00:03 | 0 | 0 | 0:00:00 |
| Out-01 | 0.30 | 0.32 | 590.99 | 0 | 00:03 | 0 | 0 | 0:00:00 |
| Ash-Basin | 13.61 | 13.72 | 578.55 | 0 | 02:00 | 0 | 0 | 0:00:00 |
| Weir-Structure | 5.10 | 5.21 | 578.54 | 0 | 02:00 | 0 | 0 | 0:00:00 |

*****************
Node Flow Summary
*****************

| Node ID | Element Type | Maximum Lateral Inflow cfs | Peak Inflow cfs | Time of Peak Inflow Occurrence days | Time of Peak Inflow Occurrence hh:mm | Maximum Flooding Overflow cfs | Time of Peak Flooding Occurrence days | Time of Peak Flooding Occurrence hh:mm |
|---|---|---|---|---|---|---|---|---|
| Jun-06 | JUNCTION | 0.00 | 0.49 | 0 | 00:00 | 0.00 | | |
| Out-01 | OUTFALL | 0.00 | 0.51 | 0 | 00:03 | 0.00 | | |
| Ash-Basin | STORAGE | 22.23 | 22.77 | 0 | 00:15 | 0.00 | | |
| Weir-Structure | STORAGE | 0.00 | 41.71 | 0 | 00:00 | 0.00 | | |

********************
Storage Node Summary
********************

| Storage Node ID | Maximum Ponded Volume 1000 ft³ | Maximum Ponded Volume (%) | Time of Max Ponded Volume days | Time of Max Ponded Volume hh:mm | Average Ponded Volume 1000 ft³ | Average Ponded Volume (%) | Maximum Storage Node Outflow cfs | Maximum Exfiltration Rate cfm | Time of Max. Exfiltration Rate hh:mm:ss | Total Exfiltrated Volume 1000 ft³ |
|---|---|---|---|---|---|---|---|---|---|---|
| Ash-Basin | 993.265 | 94 | 0 | 02:00 | 987.471 | 93 | 41.71 | 0.00 | 0:00:00 | 0.000 |
| Weir-Structure | 1.107 | 83 | 0 | 02:00 | 1.080 | 81 | 5.42 | 0.00 | 0:00:00 | 0.000 |

**********************

Outfall Loading Summary
***********************

| Outfall Node ID | Flow Frequency (%) | Average Flow cfs | Peak Inflow cfs |
|---|---|---|---|
| Out-01 | 96.74 | 0.49 | 0.51 |
| System | 96.74 | 0.49 | 0.51 |

*****************
Link Flow Summary
*****************

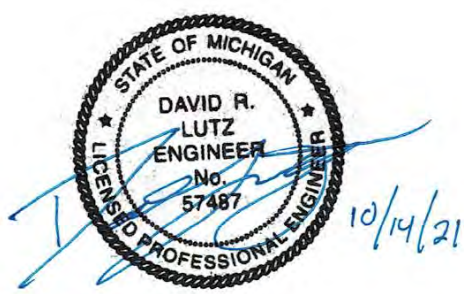
| Link ID | Element Type | Time of Peak Flow Occurrence days hh:mm | Maximum Velocity Attained ft/sec | Length Factor | Peak Flow during Analysis cfs | Design Flow Capacity cfs | Ratio of Maximum /Design Flow | Ratio of Maximum Flow Depth | Total Time Surcharged minutes | Reported Condition |
|---|---|---|---|---|---|---|---|---|---|---|
| Blowdown-Outfall | CONDUIT | 0 00:03 | 2.98 | 1.00 | 0.51 | 0.69 | 0.73 | 0.81 | 0 | Calculated |
| Blowdown-1 | PUMP | 0 00:00 | | | 0.49 | | 1.00 | | 120 | |
| Ash-Basin-Weir | WEIR | 0 00:00 | | | 41.71 | | | 0.62 | | |

********************************
Highest Flow Instability Indexes
********************************
Link Ash-Basin-Weir (11)

Analysis began on: Tue Sep 14 16:55:56 2021
Analysis ended on: Tue Sep 14 16:55:56 2021
Total elapsed time: < 1 sec

**STATEMENT OF CERTIFICATION**

I, David R. Lutz, a Professional Engineer licensed in the State of Michigan, certify[1] that NTH Consultants, Ltd. have reviewed available historical information, conducted a field visit, performed engineering and hydraulic/hydrologic analysis, modeling, and calculations on the inflow design flood control system for the former bottom ash CCR surface impoundment at the DTE River Rouge Power Plant, located in River Rouge, Michigan. To the best of my knowledge and belief, the analysis and documentation presented in this report for the former bottom ash basin at the aforementioned facility is accurate and has been developed in substantial conformance with the requirements stipulated in 40 CFR Part 257.82.




David R. Lutz, P.E.
State of Michigan Professional Engineer
Registration No. 57487

([1]) I am rendering my professional opinion based on the information available to me at the time of this report's writing. This certification does not comprise a guarantee or warranty that certain conditions exist, nor does it relieve any other party of their requirements to abide by all applicable local, state, and federal regulations, and to honor all express or customary guarantees and warranties associated with their work.

# Report

## *Inflow Design Flood Control System Plan*
## *River Rouge Power Plant*
## *River Rouge, Michigan*

**DTE Energy Company**
**One Energy Plaza, Detroit, MI**

**October 14, 2016**
**NTH Project No. 62-160047-04**


**NTH Consultants, Ltd.**
41780 Six Mile Road
Northville, MI 48168

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## INTRODUCTION

NTH Consultants, Ltd. (NTH), in conjunction with personnel from DTE Energy Company (DTE), has completed an inflow design flood control system plan for the bottom ash basin at River Rouge Power Plant (RRPP) in accordance with the Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals (CCR) from Electric Utilities 40 CFR Part 257.82. This plan details the hydraulic and hydrologic capacity of the CCR impoundment system, including the basin, intake structures, and downstream hydraulic structures. The intent of the plan is to ensure that the CCR impoundment has the capacity to manage the discharge from the process flows along with a specified design rainfall event "inflow design flood", based on the hazard potential classification of the basin.

The RRPP was constructed in the 1950's on the southern shore of the Rouge Short Cut Canal, along the west bank of the Detroit River. The bottom ash basin is a physical sedimentation basin, located north of RRPP near the Rouge Short Cut Canal and receives bottom ash and other process flow effluent pumped from the power plant. Prior to entering the bottom ash basin, the sluiced ash is pumped to two decanting hydrobin structures. The sluiced ash then gravity drains from the hydrobins to the bottom ash basin. Discharge water from the basin flows over an overflow weir and into a weir box structure before going to a below-grade pump station on the west side of the basin. There are two sets of centrifugal pumps in the pump station; one set recirculates the sluice water back into the plant and the other set pumps it to the outfall in the overflow canal with other site storm and process water effluent authorized via a National Pollution Discharge Elimination System (NPDES) permit. An overall site plan is included as Figure 1, in the attachments.

*Regulatory Basis*

In accordance with 40 CFR Part 257.82, NTH has prepared this inflow design flood control system plan to demonstrate and document the hydrologic and hydraulic capacity and performance requirements for the bottom ash CCR surface impoundment. Specifically, this plan details how the bottom ash CCR surface impoundment collects and controls the peak discharge from the inflow design flood, in addition to the peak discharge into the impoundment from plant process flow. The inflow design flood requirements for the capacity evaluation depend on the hazard potential classification of the basin in accordance with 40 CFR 257.82(a)(3). The basin at RRPP is not required to be classified in accordance with 40 CFR 257.73(a)(2), since it is an incised CCR impoundment based on the definition prescribed in 40 CFR 257.53. Because of this, the RRPP bottom ash CCR surface impoundment system is being analyzed to handle a 25-year flood event in addition to the plant process flows. As stipulated in Section VI (H)(3) of the rule preamble, the plan also includes a:

- Characterization of the design storm, catchment area, run-on and run-off routing models;
- Characterization of the intake, decant, and spillway structures and their capacity;
- Characterization of the downstream hydraulic structures which receive the discharge from the CCR surface impoundment; and
- Supporting engineering calculations and analysis results.

## MODELING OF CCR IMPOUNDMENT SYSTEM

NTH evaluated the bottom ash CCR surface impoundment system using the Autodesk ® Storm and Sanitary Analysis 2017 computer modeling software. This software was used to develop runoff hydrographs, or temporal flow distribution models, for the watersheds contributing to the system as well as to route the inflow hydrographs through the bottom ash CCR impoundment and conveyance structures.

*Model Input*

In order to compile the data necessary for input into the model, NTH conducted several steps including:

- Performed a site visit to meet DTE personnel, learn about the DTE assets, and field review the existing system conditions;

- Reviewed historic site drawings and flow data provided by DTE plant staff; and
- Procured ground surface topographical elevations by McNeely & Lincoln Associates (MLA), a registered land surveyor, on April 13, 14, and May 19, 2016. MLA also sounded the bottom of the basin to allow for accurate capacity calculations and surveyed components of the system, including the basin, the weir and box structure, and pipe inverts (see Figure 2 for the detailed survey information).

NTH performed the analysis using design precipitation data adopted from the National Oceanic Atmospheric Administration (NOAA) Atlas 14, Volume 8, Version 2 (2013). We evaluated the bottom ash CCR surface impoundment system for a 25-year storm event and utilized the rational method to calculate the storm water runoff generated from each of the sub-watersheds. The rational method determines the peak discharge rate from each sub-watershed based on the following equation:

$$\mathbf{Q = CiA}$$

Where:
Q = Peak discharge rate (cubic feet per second (CFS))
C = Runoff coefficient (presented in table below)
i = Rainfall intensity from IDF curves based on design storm return period and Tc (in/hr)
A = Sub-watershed drainage area (Acres)

We determined the contributing runoff amount for the basin through review of the existing ground topography and historical drawings, and through site visits performed at the RRPP. We assumed the CCR bottom ash basin system collects all stormwater in the vicinity of the basin on the north side of the plant. The contributing area, time of concentration, and runoff coefficient were determined for the watershed area. These input parameters are used to determine both the amount and intensity of runoff generated in the watershed during the design storm and the overall amount of runoff collected and conveyed by the storm water system (see Figure 3 for depiction of drainage area).

The time of concentration, Tc, is the time required for the entire watershed to contribute runoff to the system and is dependent on flow path, slope and ground type. Based on state-of-the-practice engineering standards, we utilized a minimum Tc of 15 minutes for the watershed, which is the minimum amount of time used in a typical analysis, even though the actual flow time may be much less. The model was allowed to run for a 2-hour duration to allow enough time for all of the storm water runoff from the design storm to contribute to the CCR impoundment and the downstream structures.

The runoff coefficient is a function of land use and ground condition. We adopted runoff coefficients from our past experience and generally-acceptable industry standards. The runoff coefficients used for this study are summarized in the following table:

| Ground Type | Runoff Coefficient (C) |
|---|---|
| **Grass** | **0.30** |
| **Pavements/Parking Lots** | **0.90** |
| **Compacted Gravel Covered Areas** | **0.85** |

We selected the hydrodynamic routing method in Storm and Sanitary Analysis software program because it is the most sophisticated method and produces the most theoretically accurate results. It solves the one-dimensional Saint-Venant flow equations which consists of continuity and momentum equations for pipes and ditches and a volume continuity equation at the storage nodes and junctions. This routing method can represent pressurized flows when the piping becomes full and can model the amount of flooding in storage nodes and junctions.

See Figure 3 in the attachments, which depicts the CCR system and contributing drainage areas based on the results of our field survey and investigation, and review of historical site drawings. Refer to the model output results in the attachments for additional input information.

*Model Input Assumptions*

NTH utilized information obtained from topographic surveys, historical information, and field investigations to build the model of the CCR impoundment and conveyance network. When available, items such as pipe diameter, inverts, and material of construction were utilized to accurately model the conveyance network.

Additionally, NTH obtained one year of historical flow data for the blowdown pumps from DTE plant staff to characterize a portion of the process flow out of the bottom ash CCR surface impoundment system. This included daily flow readings from an electronic integrator to measure process flows going to the outfall. NTH, working with DTE staff at RRPP attempted to determine appropriate parameters for the peak inflows for the current inlets into the bottom ash basin shown in Table 1 and depicted in Figure 3.

Reasonable assumptions for some of the input parameters were made to develop a complete system model due to absence of detailed information from DTE plant staff and historical documents for some flows and components of the system. In general, these assumptions related to some inlet flow rates, piping lengths within the plant, and watershed topographic information that was not confirmed by DTE staff, the field investigation, or review of historical information provided by DTE.

While every attempt was made to accurately model the existing system, assumptions introduce unknown parameters into the model. If any of these assumptions are incorrect, the results of the model will be impacted. Should actual conditions vary from the assumptions utilized in the model, the predicted model results, and subsequent recommendations to correct any deficiencies identified, may be impacted. We have relatively high confidence that the model for the CCR impoundment and conveyance structures depicts the most conservative anticipated conditions during the modeled flood event.

**Table 1: Flow Rates of Existing Inlets into the RRPP Bottom Ash Basin**

| No. | Pipe | Diameter (inches) | Invert | Flow Rate (cfs) | Frequency |
|---|---|---|---|---|---|
| 1 | Sand Filter Discharge | 6 | 578.63 | *Abandoned, stormwater flow included in basin watershed | Storm events |
| 2 | Fire Booster Drain | 10 | 578.84 | **5.6 | Once a month for an hour |
| 3 | Truck Bay Silo #1 Drain (?) | 12 | 579.38 | *Abandoned, stormwater flow included in basin watershed | Storm events |
| 4 | Transfer House Wash Down | 6 | 578.31 | 0.1 | Sporadically |
| 5 | Ash Settling Bins Drain | 12 | 579.05 | (a) 4.26 from the bottom ash basin recirculation pumps<br>(b) 1.07 from Sump 2 in plant<br>(c) 0.04 from RO/UF Sump | Twice daily |
| 6 | Truck Bay Silo #2 Drain | 12 | 579.19 | 0.1 | During washdowns |
| 7 | BFG Condensate Drain | 4 | 578.74 | 0.1 | Unknown |
| 8 | BFG House Storm Drain | 12 | 578.15 | Gravity-fed Stormwater flow already included in basin watershed | Storm events |
| 9 | Pump House Sump Pump | 3 | Unknown | 0.1 | Storm events |

**DTE staff provided information that the lines were abandoned, but during the site visit NTH observed visible flow coming out of the pipes. It is assumed that the pipes are collecting stormwater even though they are not receiving process flows anymore and the flow amount is included in the watershed area for the basin.*

*** NTH assumed the fire booster flow is not present during the analysis because it is highly unlikely that DTE will test the fire booster pump during a 25-year storm event in addition to the peak process flows occurring simultaneously.*

*Existing System Components*

The bottom ash basin at RRPP was originally an open excavation with 2H:1V inclination side slopes, but the basin was reconstructed in place in 1998 with tied-back steel sheet pile walls. Sluice water containing bottom ash enters on the south side of the basin through a 12-inch underground pipe, which is gravity fed from the bottom ash hydrobins. There are eight other pipes along the south and east sides of the basin contributing stormwater and process water from various places in and around the plant, as described in Table 1 and shown in Figure 3. DTE staff-provided flow data for the blowdown pumps for the past year, which indicated a peak outfall rate from these pumps of 0.93 cubic feet per second (cfs). The basin has a capacity of 2.3 million gallons.

The basin discharges over an overflow weir into a box structure on the west side of the basin. The weir spans ten feet and the box structure flows into two separate intakes for the recirculation and blowdown pumps. The three recirculation pumps are Goulds model 3735-3736 with an operating duty point of 958 GPM flow rate at a total dynamic head (TDH) of 660 feet. The pumps are run manually by DTE staff two at a time when the ash needs to be sluiced from the ash hoppers (generally twice per day). The two basin blowdown pumps are Goulds model 3196 MT with an operating duty point of 220 GPM at 50 feet TDH. The pumps are run manually by DTE staff one at a time when the basin gets to an elevation of 577’-8” (one foot below top of sheet pile at 579’-8”) and discharge to the overflow canal within the plant.

The recirculation pumps send the water overflow to the bottom ash hoppers in the plant where the recirculation water is used to clean the bottom ash out of the hoppers. The sluiced bottom ash is then sent to two hydrobin decanting structures for primary treatment, where the bottom ash settles out and the water is drained through 6-inch orifices back to the bottom ash basin through the 12-inch gravity drain line for secondary treatment in the basin. Each hydrobin has a capacity of 39,750 gallons per historical drawings provided by DTE. Refer to Figure 3 for a schematic of the bottom ash CCR impoundment and conveyance system at the RRPP.

*Model Output*

The model produces output from the basin watershed that includes inflow, outflow, peak outflow rate, and total runoff inflow/outflow volumes. The model also provides output from the CCR impoundment and conveyance structures including peak flow rates / velocities, maximum hydraulic grade lines, flow depths, and flooding/surcharged structures. To determine where system deficiencies exist, the results were analyzed for:

1. Locations where the modeled water surface elevation exceeded the rim/ground surface elevation at the basin and manholes (i.e. Flooding);

2. Locations were the modeled water surface exceeded the crown of the pipes within the manholes (i.e. Surcharging); or

3. Locations where the anticipated flow in a conveyance structure was greater than its design capacity (i.e. flow is > capacity).

While items noted as surcharging or below capacity identify a system deficiency, this does not necessarily warrant upgrades or improvements. These system deficiencies show that the system is still operating, but as a pressure flow system, instead of a gravity flow system. If no flooding is observed, the flow is still contained within the conveyance system, and the modeling software calculates theoretically accurate downstream and upstream system results based on the operating condition of these components.

*Analysis of Design Flood Event –Existing Conditions*

The modeled results show that the bottom ash CCR surface impoundment and conveyance system at the RRPP are operating as a pressure flow system. During the design flood event, the depth of the water within the basin rises 1.64 feet above the crest elevation of the weir (elevation 577.0 feet), which still provides approximately 1.16 feet of freeboard in the basin to the top elevation of the basin, slightly above the industry standard freeboard. The weirs can manage the peak flow produced by the design flood and peak process flow of 26.5 cfs from the process water and stormwater runoff contributing to each basin, with a maximum calculated capacity of 131.6 cfs (see Weir Capacity Calculation for details).

We note that the operating water level of the basin (and subsequent freeboard available) is critically dependent on the operation and functionality of the blowdown pumps, which are manually pumped at a rate of 0.5 cfs/pump, generally one pump at a time. The model depicts the pumps running in a continuous operation to maintain the operating level in the basin during the 2-hour analysis duration. Based on information provided by DTE staff, the blowdown pumps are manually turned on or off by DTE personnel when they observe the basin level at a high level. The flow capacity of the blowdown pump is only approximately 2% of the modeled inflow into the basin from the contributory watershed and nine inlets.

Historically, the basins have performed well and, according to DTE personnel, have never flooded in adverse conditions. There is some freeboard in the basins to account for a reasonable level of unforeseen incidents in the event additional flow into or restricted flow downstream of the basins occurs. DTE staff also inspects the bottom ash CCR impoundment system weekly and after significant rain or storm events to remediate any observed issues as soon as practical.

The model output result file provides additional information regarding the output and results. Refer to Figure 3 for additional information on the existing bottom ash CCR surface impoundment components.

## CONCLUSIONS

NTH has prepared this inflow design flood control system plan to demonstrate and document the hydrologic and hydraulic capacity and performance requirements for the bottom ash CCR surface impoundment of the RRPP in accordance with 40 CFR 257.82.

The existing bottom ash CCR impoundment system at RRPP currently conveys both bottom ash and other plant process water and on-site stormwater. The overall hydraulic system comprises the hydrobins, the bottom ash basin, overflow outfall weir, pumps and downstream piping. Our analysis indicates that there are no current deficiencies for the bottom ash CCR surface impoundment or downstream conveyance structures, as modeled, at the RRPP that warrant upgrades or improvements to the CCR surface impoundment or downstream conveyance structures.

## STATEMENT OF CERTIFICATION

I, David R. Lutz, a Professional Engineer licensed in the State of Michigan, certify[1] that NTH Consultants, Ltd. have reviewed available historical information, conducted a field visit, performed engineering and hydraulic/hydrologic analysis, modeling, and calculations on the inflow design flood control system for the bottom ash CCR surface impoundment at the DTE River Rouge Power Plant, located in River Rouge, Michigan. To the best of my knowledge and belief, the analysis and documentation presented in this report for the bottom ash basin at the aforementioned facility is accurate and has been developed in substantial conformance with the requirements stipulated in 40 CFR Part 257.82.

STATE OF MICHIGAN DAVID R. LUTZ ENGINEER No. 57487 LICENSED PROFESSIONAL ENGINEER

10/14/16

David R. Lutz, P.E.
State of Michigan Professional Engineer
Registration No. 57487

([1]) I am rendering my professional opinion based on the information available to me at the time of this report writing. This certification does not comprise a guarantee or warranty that certain conditions exist, nor does it relieve any other party of their requirements to abide by all applicable local, state, and federal regulations, and to honor all express or customary guarantees and warranties associated with their work.

## ATTACHMENTS

- Figure 1: Overall Site Plan
- Figure 2: Topographic Survey
- Figure 3: Existing System Component Plan
- Weir Capacity Calculation
- Time of Concentration Calculation
- Autodesk Storm and Sanitary Analysis Model Outputs

## REFERENCE DOCUMENTS

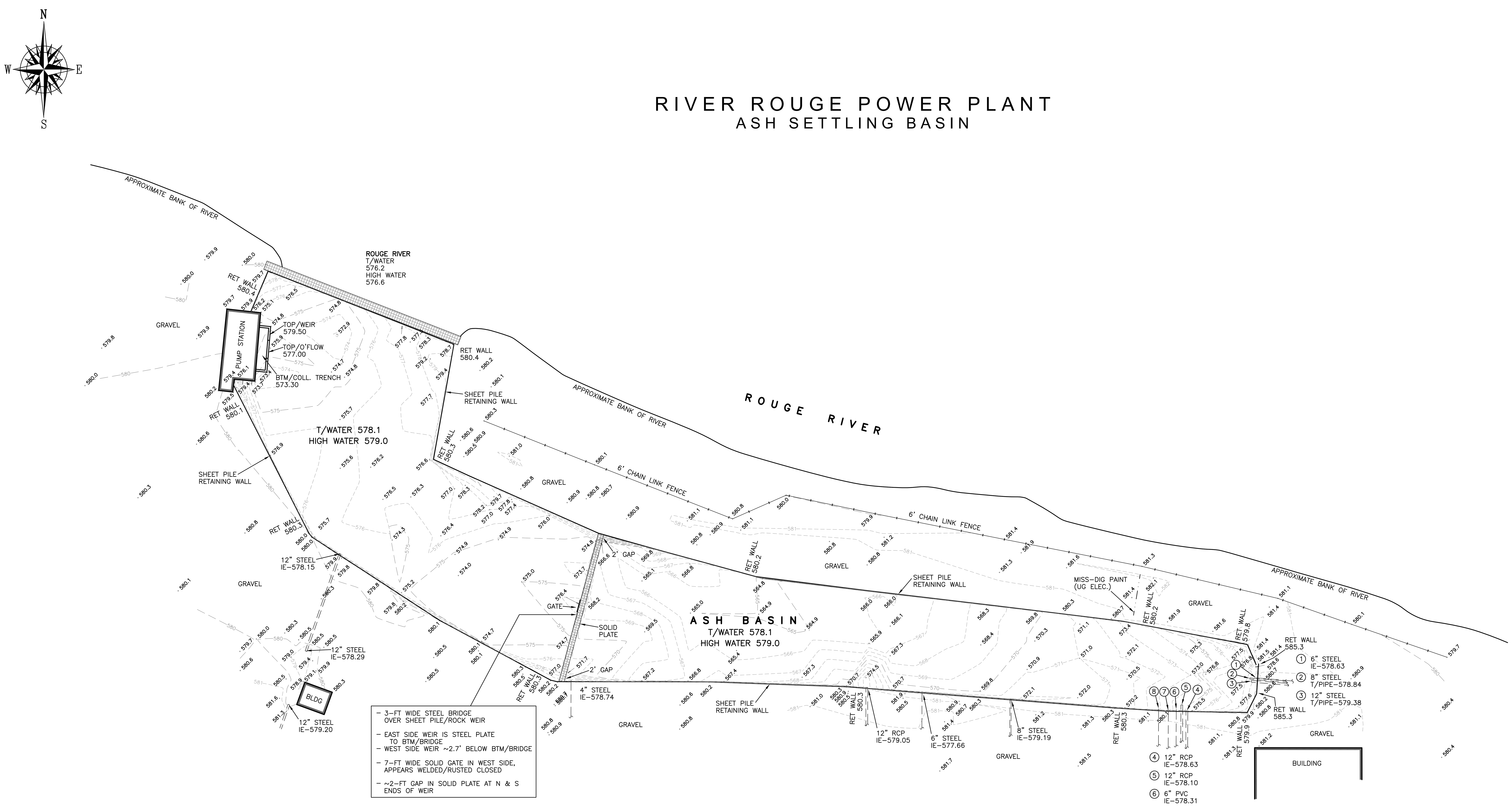
- 6MS515-55 "GENERAL YARD MAP"
- 6C515C-33 "LAYOUT OF ASH SETTLING BINS FOR THE BOTTOM ASH OF BOILER NO. 3"
- 7P515-491 "PIPING-ASSEMBLY-LAYOUT OF LINES BELOW EL. 609'-0" BETWEEN "C" & "G" ROW OF COLUMNS, BOILER NO. 3"
- 6M515-406 "LAYOUT OF BOILER ASH HOPPER FOR FOSTER WHEELER BOILER NO. 3"
- 6M515-408 "LAYOUT OF THE BOTTOM ASH SLUICE LINES FOR FOSTER WHEELER CORP. BOILER NO. 3"
- 6M515-261 "GENERAL LAYOUT OF BOILER ASH HOPPER FOR BOILDER NO. TWO"
- 6M515W-15 "REROUTING OF BOILER HOUSE FLOOD DRAINS INTO OILY AND ASH WASTE SYSTEM"
- 6M515W-18 "DETAILS OF DRAIN PIPING IN BOILERHOUSE FOR SGREGATION OF FLOOR DRAINS"
- 6S515Q-2001-003 "SITE UNDERGROUND RELOCATION"
- BLOWDOWN PUMP FLOW YEAR 2015

# ATTACHMENTS

- FIGURE 1: OVERALL SITE PLAN
- FIGURE 2: TOPOGRAPHIC SURVEY
- FIGURE 3: EXISTING SYSTEM COMPONENT PLAN
- WEIR CAPACITY CALCULATION
- TIME OF CONCENTRATION CALCULATION
- AUTODESK STORM AND SANITARY ANALYSIS MODEL OUTPUT


| | | | | |
|---|---|---|---|---|
| NTH PROJECT No.: 62–160047 | CAD FILE NAME: 160047–RRPP | NTH Consultants, Ltd. Infrastructure Engineering and Environmental Services | SITE LOCATION PLAN | FIGURE: 1 |
| DESIGNED BY: SLG | PLOT DATE: 9/30/2016 | | RIVER ROUGE POWER PLANT RIVER ROUGE, MICHIGAN | |
| DRAWN BY: SLG | DRAWING SCALE: 1" = 200' | | | |
| CHECKED BY: DRL | INCEPTION DATE: 9/7/2016 | | | |

# RIVER ROUGE POWER PLANT
## ASH SETTLING BASIN




- 3-FT WIDE STEEL BRIDGE OVER SHEET PILE/ROCK WEIR
- EAST SIDE WEIR IS STEEL PLATE TO BTM/BRIDGE
- WEST SIDE WEIR ~2.7' BELOW BTM/BRIDGE
- 7-FT WIDE SOLID GATE IN WEST SIDE, APPEARS WELDED/RUSTED CLOSED
- ~2-FT GAP IN SOLID PLATE AT N & S ENDS OF WEIR

NTH FIGURE 2

UTILITY WARNING

UNDERGROUND UTILITY LOCATIONS, AS SHOWN ON THE PLAN, WERE OBTAINED FROM UTILITY OWNERS, AND FIELD LOCATION WHERE POSSIBLE. MCNEELY & LINCOLN CAN NOT GUARANTEE THE ACCURACY AND COMPLETENESS OF THE UTILITY INFORMATION.

A MINIMUM OF 3 WORKING DAYS PRIOR TO BEGINNING CONSTRUCTION, THE CONTRACTOR SHALL NOTIFY "MISS DIG" AND HAVE ALL UNDERGROUND UTILITIES STAKED BEFORE ANY WORK MAY BEGIN.

THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE PROTECTION OF ALL UTILITIES THAT MAY INTERFERE WITH CONSTRUCTION.

811 Know what's below. Call before you dig.

DATUM INFORMATION:
HORIZONTAL DATUM = DTE PLANT DATUM ORIGIN UNKNOWN
VERTICAL DATUM = DTE PLANT DATUM ORIGIN UNKNOWN

0 7.5 30 60 90
SCALE: 1 INCH = 30 FEET

STATE OF MICHIGAN — DAVID P. WHITE — PROFESSIONAL SURVEYOR — NO. 50458 — LICENSED PROFESSIONAL SURVEYOR



| | |
|---|---|
| DATE: | 06/27/16 |
| SUR BY: | TFS/GW |
| DRWN BY: | DPW |
| CHKD BY: | MRD |
| FIELD BK: | 840 |

CLIENT: NTH CONSULTANTS, LTD. 41780 SIX MILE RD NORTHVILLE, MI 48168

McNEELY & LINCOLN ASSOCIATES, INC.
CIVIL ENGINEERING & LAND SURVEYING
PH. (734) 432-9777 FAX (734) 432-9786
37741 PEMBROKE, LIVONIA, MICHIGAN 48152

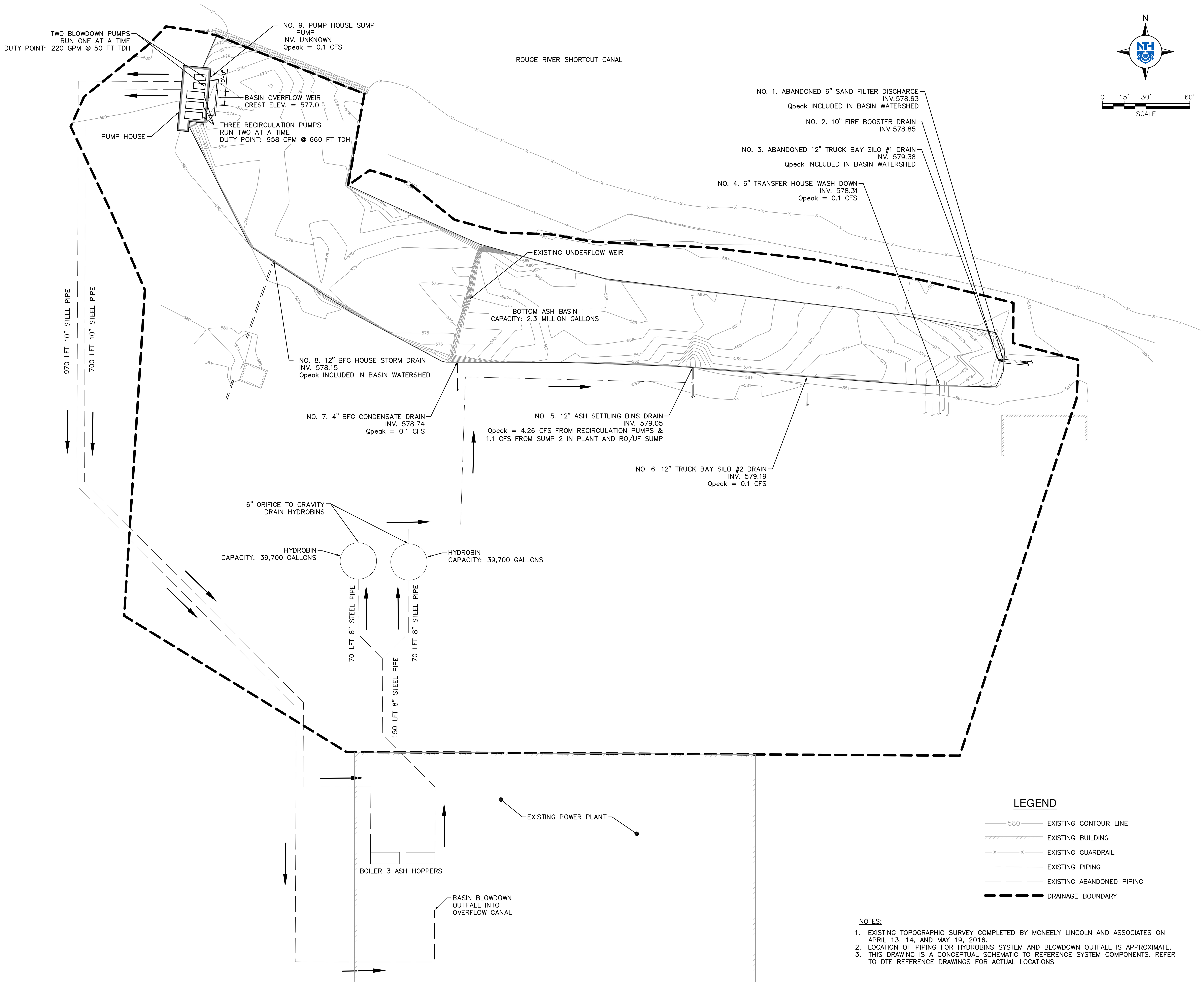
REVISIONS: A B C D E

REV.

TOPOGRAPHIC SURVEY - ASH BASIN
RIVER ROUGE POWER PLANT
PART OF PRIVATE CLAIM 45
CITY OF RIVER ROUGE, WAYNE CO., MICH.

1

SCALE: 1" = 30'
PROJECT NO.: 8243.02
FILE NAME: 8243.02 TOPO.DWG
SHEET 1 OF 1




## LEGEND

| | |
|---|---|
| 580 | EXISTING CONTOUR LINE |
| | EXISTING BUILDING |
| —x—x— | EXISTING GUARDRAIL |
| | EXISTING PIPING |
| | EXISTING ABANDONED PIPING |
| | DRAINAGE BOUNDARY |

NOTES:

1. EXISTING TOPOGRAPHIC SURVEY COMPLETED BY MCNEELY LINCOLN AND ASSOCIATES ON APRIL 13, 14, AND MAY 19, 2016.
2. LOCATION OF PIPING FOR HYDROBINS SYSTEM AND BLOWDOWN OUTFALL IS APPROXIMATE.
3. THIS DRAWING IS A CONCEPTUAL SCHEMATIC TO REFERENCE SYSTEM COMPONENTS. REFER TO DTE REFERENCE DRAWINGS FOR ACTUAL LOCATIONS

**NTH Consultants, Ltd.**
Infrastructure Engineering and Environmental Services

| | |
|---|---|
| Northville, MI | 248.553.6300 |
| Detroit, MI | 313.237.3900 |
| Lansing, MI | 517.484.6900 |
| Grand Rapids, MI | 616.451.6270 |
| Cleveland, OH | 216.334.4040 |


SUBMITTAL

| REV | DESCRIPTION | DATE | BY |
|---|---|---|---|

PROJECT NAME:

DTE RIVER ROUGE POWER PLANT - BOTTOM ASH BASIN HYDRAULIC ANALYSIS

PROJECT LOCATION:

RIVER ROUGE POWER PLANT
DETROIT, MICHIGAN

| | |
|---|---|
| NTH PROJECT NO.: 62-160047 | CAD FILE NAME: 160047-RR-SP |
| DESIGNED BY: SLG | INCEP DATE: 9/7/2016 |
| DRAWN BY: SLG | DRAWING SCALE: 1" = 30' |
| CHECKED BY: DRL | SUBMITTED DATE: 9/30/2016 |

SHEET TITLE:

RIVER ROUGE POWER PLANT BOTTOM ASH BASIN

EXISTING SYSTEM COMPONENT PLAN

SHEET REFERENCE NUMBER:

3

**NTH Consultants, Ltd.**
Infrastructure Engineering
and Environmental Services

| | | | | | |
|---|---|---|---|---|---|
| Job | DTE Hydro Analysis | Project No. | 62-160047 | Sheet No. | 1 |
| Subject | RRPP Weir | By | SLG | Date | 9/21/2016 |
| Capacity Calculation | | Checked By | KBD | Date | 9/28/2016 |

Calculate capacity of weir for RRPP bottom ash basin

Use broad-crested weir equation

$$Q = C_s b H^{3/2}$$

$C_s = 3.33\ ft^{0.5}/sec$

$b = 10\ ft$

$H = 25\ ft$

$$Q = 3.33\ ft^{0.5}/sec \cdot 10\ ft\ (2.5\ ft)^{3/2} = \boxed{131.6\ cfs}$$

Height of water at maximum flow rate

$Q_{max} = 27.3\ cfs$

$$Q = C_s b H^{3/2} \rightarrow H = \left(\frac{Q}{C_s b}\right)^{2/3} = \left(\frac{27.3\ cfs}{3.33\ ft^{0.5}/sec \cdot 10 ft}\right)^{2/3}$$

$$\boxed{H = 0.89\ ft}$$

**DTE River Rouge Power Plant**
**Drainage Areas**
**62-130590**

| Area # | Overland Flow | | Channel Flow | Tc (hrs.) | **Tc (min.)** |
|---|---|---|---|---|---|
| RR Basin | L (ft) | 30 | | | |
| | S (%) | 2.30 | | | |
| | V (ft/s) | 0.73 | | | |
| | T (hrs) | 0.011 | | 0.011 | **0.7** |
| | L (ft) | 248 | | | |
| | S (%) | 0.50 | | | |
| | V (ft/s) | 0.34 | | | |
| | T (hrs) | 0.203 | | 0.203 | **12.2** |
| Tc | | | | | **12.9** |

L = distance in feet
S = slope in %
T = time of travel in hours = L / ( V * 3600 )
V=0.48*sqrt(S)-Sheet Flow<300'
V=2.1*sqrt(S)-Channel Flow

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

*******************
Project Description
*******************
File Name ................. River Rouge-with fewer pumps-no operational controls.SPF


****************
Analysis Options
****************
Flow Units ................ cfs
Subbasin Hydrograph Method. Rational
Time of Concentration...... SCS TR-55
Return Period.............. 25 years
Link Routing Method ....... Hydrodynamic
Storage Node Exfiltration.. None
Starting Date ............. JUL-29-2016 00:00:00
Ending Date ............... JUL-29-2016 02:00:00
Report Time Step .......... 00:00:10


*************
Element Count
*************
Number of subbasins ....... 1
Number of nodes ........... 9
Number of links ........... 11


****************
Subbasin Summary
****************
Subbasin                 Total
                          Area
ID                         ft²
------------------------------
Sub-01               229940.29


************
Node Summary
************
Node                Element            Invert   Maximum     Ponded     External
```

| ID | Type | Elevation ft | Elev. ft | Area ft² | Inflow |
|---|---|---|---|---|---|
| Jun-06 | JUNCTION | 575.83 | 576.33 | 0.00 | |
| Jun-1 | JUNCTION | 574.00 | 574.84 | 0.00 | |
| Jun-2 | JUNCTION | 604.42 | 605.26 | 0.00 | |
| Jun-3 | JUNCTION | 575.83 | 577.33 | 0.00 | |
| Out-01 | OUTFALL | 590.67 | 591.17 | 0.00 | |
| Ash-Basin | STORAGE | 564.83 | 579.80 | 0.00 | Yes |
| Hydrobin-3 | STORAGE | 607.59 | 635.17 | 0.00 | |
| Hydrobin-4 | STORAGE | 607.59 | 635.17 | 0.00 | |
| Weir-Structure | STORAGE | 573.33 | 579.50 | 0.00 | |

************
Link Summary
************

| Link ID | From Node | To Node | Element Type | Length ft | Slope % | Manning's Roughness |
|---|---|---|---|---|---|---|
| Blowdown-Outfall | Out-01 | Jun-06 | CONDUIT | 970.0 | 1.5299 | 0.0130 |
| Recirc-1 | Jun-2 | Jun-1 | CONDUIT | 960.0 | 3.1687 | 0.0130 |
| Recirc-2 | Hydrobin-3 | Jun-2 | CONDUIT | 70.0 | 47.0143 | 0.0130 |
| Recirc-3 | Hydrobin-4 | Jun-2 | CONDUIT | 70.0 | 47.0143 | 0.0130 |
| Recirc-4 | Ash-Basin | Jun-3 | CONDUIT | 341.6 | 0.9426 | 0.0130 |
| Blowdown-1 | Weir-Structure | Jun-06 | TYPE3 PUMP | | | |
| Recirculation-1 | Weir-Structure | Jun-1 | TYPE3 PUMP | | | |
| Recirculation-2 | Weir-Structure | Jun-1 | TYPE3 PUMP | | | |
| Hydrobin-3-Orifice | Hydrobin-3 | Jun-3 | ORIFICE | | | |
| Hydrobin-4-Orifice | Hydrobin-4 | Jun-3 | ORIFICE | | | |
| Ash-Basin-Weir | Ash-Basin | Weir-Structure | WEIR | | | |

*********************
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 cfs |
|---|---|---|---|---|---|---|---|
| Blowdown-Outfall | CIRCULAR | 0.50 | 0.50 | 1 | 0.20 | 0.13 | 0.69 |
| Recirc-1 | CIRCULAR | 0.83 | 0.83 | 1 | 0.55 | 0.21 | 3.90 |
| Recirc-2 | CIRCULAR | 0.50 | 0.50 | 1 | 0.20 | 0.13 | 3.85 |
| Recirc-3 | CIRCULAR | 0.50 | 0.50 | 1 | 0.20 | 0.13 | 3.85 |
| Recirc-4 | CIRCULAR | 1.00 | 1.00 | 1 | 0.79 | 0.25 | 3.46 |

```
**************************        Volume         Depth
Runoff Quantity Continuity       acre-ft        inches
**************************     ---------       -------
Total Precipitation ......         0.504         1.145
Continuity Error (%) .....         0.147

**************************        Volume        Volume
Flow Routing Continuity          acre-ft      Mgallons
**************************     ---------     ---------
External Inflow ..........         0.248         0.081
External Outflow .........         0.078         0.026
Initial Stored Volume ....        18.754         6.111
Final Stored Volume ......        19.352         6.306
Continuity Error (%) .....         0.000

***************************************
Runoff Coefficient Computations Report
***************************************

------------------
Subbasin Sub-01
------------------
                                                        Area            Soil       Runoff
Soil/Surface Description                                (ft²)           Group      Coeff.
-----------------------------------------------------------------------------------------
-                                                   189049.25              -         0.85
-                                                    40890.83              -         0.90
Composite Area & Weighted Runoff Coeff.             229940.07                        0.86

****************************************************
SCS TR-55 Time of Concentration Computations Report
****************************************************

Sheet Flow Equation
-------------------

        Tc = (0.007 * ((n * Lf)^0.8)) / ((P^0.5) * (Sf^0.4))

        Where:

        Tc = Time of Concentration (hrs)
```

```
        n  = Manning's Roughness
        Lf = Flow Length (ft)
        P  = 2 yr, 24 hr Rainfall (inches)
        Sf = Slope (ft/ft)

Shallow Concentrated Flow Equation
----------------------------------

        V  = 16.1345 * (Sf^0.5) (unpaved surface)
        V  = 20.3282 * (Sf^0.5) (paved surface)
        V  = 15.0 * (Sf^0.5) (grassed waterway surface)
        V  = 10.0 * (Sf^0.5) (nearly bare & untilled surface)
        V  = 9.0 * (Sf^0.5) (cultivated straight rows surface)
        V  = 7.0 * (Sf^0.5) (short grass pasture surface)
        V  = 5.0 * (Sf^0.5) (woodland surface)
        V  = 2.5 * (Sf^0.5) (forest w/heavy litter surface)
        Tc = (Lf / V) / (3600 sec/hr)

        Where:

        Tc = Time of Concentration (hrs)
        Lf = Flow Length (ft)
        V  = Velocity (ft/sec)
        Sf = Slope (ft/ft)

Channel Flow Equation
---------------------

        V  = (1.49 * (R^(2/3)) * (Sf^0.5)) / n
        R  = Aq / Wp
        Tc = (Lf / V) / (3600 sec/hr)

        Where:

        Tc = Time of Concentration (hrs)
        Lf = Flow Length (ft)
        R  = Hydraulic Radius (ft)
        Aq = Flow Area (ft²)
        Wp = Wetted Perimeter (ft)
        V  = Velocity (ft/sec)
        Sf = Slope (ft/ft)
        n  = Manning's Roughness

------------------
Subbasin Sub-01
------------------
```

User-Defined TOC override (minutes): 10.00

**********************
Subbasin Runoff Summary
**********************

| Subbasin ID | Accumulated Precip in | Rainfall Intensity in/hr | Total Runoff in | Peak Runoff cfs | Weighted Runoff Coeff | Time of Concentration days | Time of Concentration hh:mm:ss |
|---|---|---|---|---|---|---|---|
| Sub-01 | 1.14 | 4.58 | 0.98 | 20.79 | 0.860 | 0 | 00:15:00 |

******************
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 Time Flooded minutes | Retention Time hh:mm:ss |
|---|---|---|---|---|---|---|---|---|
| Jun-06 | 22.15 | 73.56 | 649.39 | 0 | 00:03 | 0 | 0 | 0:00:00 |
| Jun-1 | 114.49 | 714.21 | 1288.21 | 0 | 00:01 | 0 | 0 | 0:00:00 |
| Jun-2 | 47.03 | 87.28 | 691.70 | 0 | 00:02 | 0 | 0 | 0:00:00 |
| Jun-3 | 8.56 | 33.81 | 609.64 | 0 | 00:03 | 0 | 0 | 0:00:00 |
| Out-01 | 0.30 | 0.32 | 590.99 | 0 | 00:04 | 0 | 0 | 0:00:00 |
| Ash-Basin | 13.68 | 13.81 | 578.64 | 0 | 02:00 | 0 | 0 | 0:00:00 |
| Hydrobin-3 | 5.93 | 6.10 | 613.69 | 0 | 01:20 | 0 | 0 | 0:00:00 |
| Hydrobin-4 | 5.93 | 6.10 | 613.69 | 0 | 01:20 | 0 | 0 | 0:00:00 |
| Weir-Structure | 5.16 | 5.31 | 578.64 | 0 | 02:00 | 0 | 0 | 0:00:00 |

*****************
Node Flow Summary
*****************

| Node ID | Element Type | Maximum Lateral Inflow cfs | Peak Inflow cfs | Time of Peak Inflow Occurrence days | Time of Peak Inflow Occurrence hh:mm | Maximum Flooding Overflow cfs | Time of Peak Flooding Occurrence days | Time of Peak Flooding Occurrence hh:mm |
|---|---|---|---|---|---|---|---|---|

| | | | | | | |
|---|---|---|---|---|---|---|
| Jun-06 | JUNCTION | 0.00 | 0.49 | 0 | 00:00 | 0.00 |
| Jun-1 | JUNCTION | 0.00 | 4.26 | 0 | 00:00 | 0.00 |
| Jun-2 | JUNCTION | 0.00 | 4.26 | 0 | 00:02 | 0.00 |
| Jun-3 | JUNCTION | 0.00 | 4.26 | 0 | 01:20 | 0.00 |
| Out-01 | OUTFALL | 0.00 | 0.51 | 0 | 00:04 | 0.00 |
| Ash-Basin | STORAGE | 22.28 | 26.54 | 0 | 00:15 | 0.00 |
| Hydrobin-3 | STORAGE | 0.00 | 2.16 | 0 | 00:02 | 0.00 |
| Hydrobin-4 | STORAGE | 0.00 | 2.16 | 0 | 00:02 | 0.00 |
| Weir-Structure | STORAGE | 0.00 | 41.70 | 0 | 00:00 | 0.00 |

********************
Storage Node Summary
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| 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 cfs | Maximum Exfiltration Rate cfm | Time of Max. Exfiltration Rate hh:mm:ss | Total Exfiltrated Volume 1000 ft³ |
|---|---|---|---|---|---|---|---|---|---|
| Ash-Basin | 840.797 | 95 | 0 02:00 | 834.847 | 94 | 41.70 | 0.00 | 0:00:00 | 0.000 |
| Hydrobin-3 | 0.069 | 1 | 0 01:20 | 0.067 | 1 | 2.13 | 0.00 | 0:00:00 | 0.000 |
| Hydrobin-4 | 0.069 | 1 | 0 01:20 | 0.067 | 1 | 2.13 | 0.00 | 0:00:00 | 0.000 |
| Weir-Structure | 1.130 | 85 | 0 02:00 | 1.096 | 82 | 4.75 | 0.00 | 0:00:00 | 0.000 |

**********************
Outfall Loading Summary
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| Outfall Node ID | Flow Frequency (%) | Average Flow cfs | Peak Inflow cfs |
|---|---|---|---|
| Out-01 | 96.68 | 0.49 | 0.51 |
| System | 96.68 | 0.49 | 0.51 |

*****************
Link Flow Summary
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| Link ID | Element Type | Time of Peak Flow Occurrence days hh:mm | Maximum Velocity Attained ft/sec | Length Factor | Peak Flow during Analysis cfs | Design Flow Capacity cfs | Ratio of Maximum /Design Flow | Ratio of Maximum Flow Depth | Total Time Surcharged minutes | Reported Condition |
|---|---|---|---|---|---|---|---|---|---|---|
| Blowdown-Outfall | CONDUIT | 0 00:04 | 2.98 | 1.00 | 0.51 | 0.69 | 0.73 | 0.81 | 0 | Calculated |
| Recirc-1 | CONDUIT | 0 00:02 | 14.96 | 1.00 | 4.26 | 3.90 | 1.09 | 1.00 | 118 | SURCHARGED |
| Recirc-2 | CONDUIT | 0 00:02 | 13.33 | 1.00 | 2.16 | 3.85 | 0.56 | 0.77 | 0 | Calculated |
| Recirc-3 | CONDUIT | 0 00:02 | 13.33 | 1.00 | 2.16 | 3.85 | 0.56 | 0.77 | 0 | Calculated |
| Recirc-4 | CONDUIT | 0 00:03 | 5.67 | 1.00 | 4.34 | 3.46 | 1.26 | 0.94 | 0 | > CAPACITY |
| Blowdown-1 | PUMP | 0 00:00 | | | 0.49 | | 1.00 | | 120 | |
| Recirculation-1 | PUMP | 0 00:00 | | | 2.13 | | 1.00 | | 120 | |
| Recirculation-2 | PUMP | 0 00:00 | | | 2.13 | | 1.00 | | 120 | |
| Hydrobin-3-Orifice | ORIFICE | 0 01:20 | | | 2.13 | | | 1.00 | | |
| Hydrobin-4-Orifice | ORIFICE | 0 01:20 | | | 2.13 | | | 1.00 | | |
| Ash-Basin-Weir | WEIR | 0 00:00 | | | 41.70 | | | 0.66 | | |

********************************
Highest Flow Instability Indexes
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Link Ash-Basin-Weir (137)

WARNING 002 : Max/rim elevation (depth) increased to account for connecting conduit height dimensions for Node Jun-3.

Analysis began on: Fri Sep 30 10:26:02 2016
Analysis ended on: Fri Sep 30 10:26:02 2016
Total elapsed time: < 1 sec