Hugo CCR Surface Impoundment Inflow Design Flood Control

Western Farmers Electric Cooperative

Project No. 85009

Revision 0
October 14, 2016

Hugo CCR Surface Impoundment Inflow Design Flood Control

Prepared for

Western Farmers Electric Cooperative
Project No. 85009
Hugo, Oklahoma

Revision 0
October 14, 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

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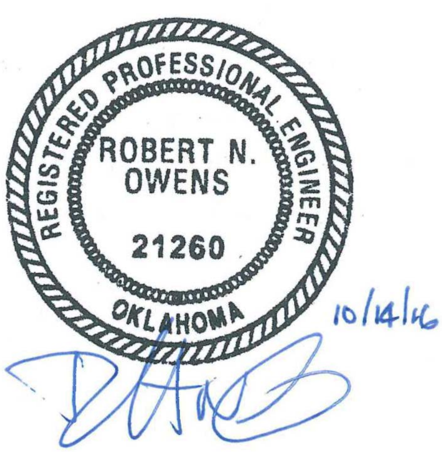
Certification

I hereby certify, as a Professional Engineer in the state of Oklahoma, that the information in this document and Appendix was assembled under my direct personal charge. I am a “Qualified Professional Engineer” as defined by 40 C.F.R. § 257.53 by the fact that I have the technical knowledge and experience to make the specific technical certifications set forth herein. This Plan meets the requirements of 40 C.F.R. § 257.82.This report is not intended or represented to be suitable for reuse by Western Farmers Electric Cooperative or others without specific verification or adaptation by the Engineer.



Robert N. Owens P.E. (No. 21260)

Date:

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LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
ALM	Asset Life Management
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CFR	Code of Federal Regulations
cfs	Cubic feet per second
CMMS	Computerized Maintenance Management System
EPA	Environmental Protection Agency
ESP	Electrostatic Precipitator
FGD	Flue Gas Desulfurization
mgd	Million gallons per day
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
OAC	Oklahoma Administrative Code
ODEQ	Oklahoma Department of Environmental Quality
OPDES	Oklahoma Pollution Discharge Elimination System
RCRA	Resource Conservation and Recovery Act
USC	United States Code
USGS	United States Geological Survey
WFEC	Western Farmers Electric Cooperative

1.0 INTRODUCTION

Burns & McDonnell (BMcD) has compiled information and prepared this Inflow Design Flood Control System Plan (Plan) for the existing CCR Surface Impoundment (Impoundment) at the Western Farmers Electric Cooperative (WFEC) Hugo Power Plant (Plant). The purpose of this Plan is to comply with the United States Environmental Protection Agency's (EPA) Coal Combustion Residual Rule (CCR Rule), and the counterpart rule of the Oklahoma Department of Environmental Quality (ODEQ).

On April 17, 2015, the EPA published the CCR Rule relating to the disposal of coal combustion residual (CCR) materials generated at electric utilities' coal-fired units. The CCR Rule was promulgated pursuant to the Resource Conservation and Recovery Act (RCRA, 42 U.S.C. §§ 6901 *et seq*.), using the Subtitle D approach and is found at 40 C.F.R. § 257.50 *et seq*. Additionally, ODEQ adopted counterpart regulations to the CCR Rule effective September 15, 2016, which are found at Oklahoma Administrative Code (OAC) 252:517.

The owner or operator of a CCR surface impoundment subject to the CCR Rule must prepare an Inflow Design Flood Control System Plan in accordance with 40 C.F.R. § 257.82(c)(1) and OAC 252:517-13-3. This Plan provides the documentation and engineering calculations for the Impoundment at the Plant. Per 40 C.F.R. § 257.82(c)(1), the Plan must contain documentation (including supporting engineering calculations) that the inflow design flood control system has been designed and constructed to:

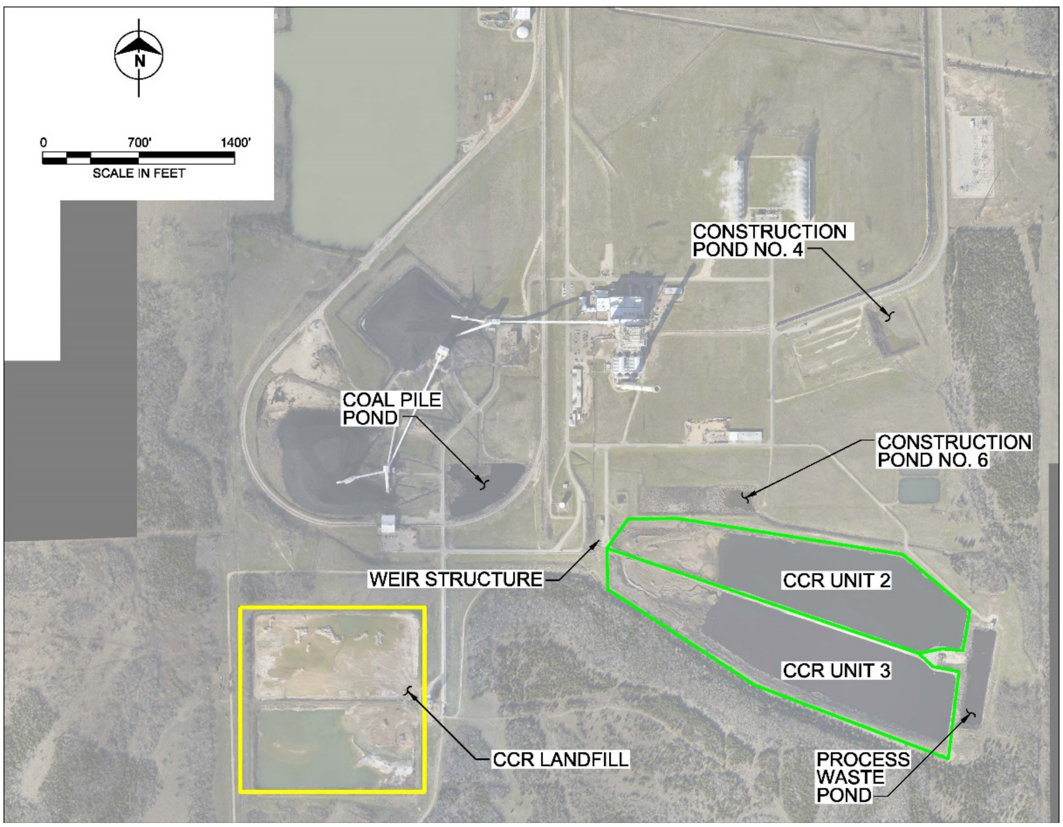
- Adequately manage flow into the Impoundment during and following the peak discharge resulting from the specified inflow design flood;
- Adequately manage flow from the Impoundment to collect and control the peak discharge resulting from the specified inflow design flood; and
- Handle discharge from the Impoundment in accordance with the surface water requirements described in 40 C.F.R. § 257.3-3.

2.0 EXISTING CONDITIONS

The Plant is a single, coal-fired unit rated at 450 MW. The Plant is located south of highway US-70, west of the Town of Fort Towson, Oklahoma, and is owned and operated by WFEC. Fly ash and economizer ash generated by the Plant are beneficially reused or managed in the on-site Landfill. Bottom ash is available for beneficial reuse and managed in two cells of the Impoundment as described below.

Bottom ash is handled wet and sluiced to one or both of two cells of the Impoundment. The northern cell is designated as CCR Unit 2 and the southern cell is designated as CCR Unit 3. Both cells are approximately 30 acres[1] each in size and have a total intended design capacity of approximately 1,640,000 cubic yards of CCR. See Figure 2-1 for general site plan.

Figure 2-1 Hugo Site Plan



[1] Surface area is measured at elevation 446.0 feet, North American Vertical Datum, 1988.

A secondary use of the Impoundment is to receive the following internal Plant flows:

- Cooling tower blowdown
- Water treatment waste discharge
- Coal pile runoff
- Boiler blowdown
- Air heater wash waste water
- Floor and equipment drains
- Cooling towers drains
- Sanitary treatment pond drain
- Stormwater from the Landfill

Plant process water and coal pile runoff overflow is directed to a weir structure which has sluice gates that are used to direct flow to one or both cells of the Impoundment. Coal pile runoff overflow is directed to the weir structure by way of a 24” diameter pipe.

Between CCR Unit 2 and CCR Unit 3, on the east end, there is an ash water recycle structure which allows the Plant to either send water back to the ash water system or gravity drain to the Process Waste Pond. The ash water recycle structure is also used to control the elevation of the water surface in the cells of the Impoundment. The water surface elevation in both cells is maintained at elevation 443’ by two 24” diameter vertical pipes which gravity drain to the Process Waste Pond by way of a 42” pipe, where it is thereafter discharged to the Red River in accordance with an OPDES permit issued by ODEQ.

The Impoundment was designed by Burns & McDonnell in the late 1970’s. Information regarding the history of construction can be found in the History of Construction prepared by BMcD of even date to this Plan.

3.0 DESIGN BASIS / FLOOD CONTROL SYSTEM

3.1 Flood Control System

The flood control system consists of two cells of the Impoundment, the ash water recycle structure, and the piping and valves used to direct water to the Process Waste Pond. As stormwater runoff enters the Impoundment, runoff is temporarily stored in the Impoundment and discharged through the 24" vertical discharge pipes, as described in Section 2.0. To demonstrate the flood control system for the design storm, a model of the stormwater runoff was established and compared to the storage available. The following subsections define the criteria and inputs used to build a model to document the inflow storage capacity.

3.2 Hazard Potential Classification

As set forth in the Combined Initial Hazard Potential Classification, Structural Stability, and Safety Factor Assessment prepared by C.H. Guernsey & Company (October, 2016), the Impoundment is classified as a "low hazard potential CCR surface impoundment." Thus, in accordance with 40 C.F.R. § 257.82(a)(3)(iii), the inflow design flood is the 100-year flood.

3.3 Inflow Design Flood System Criteria

3.3.1 Capacity Criteria

The CCR Rule discusses that surface impoundments must have adequate hydrologic and hydraulic capacity to manage flows for the inflow design flood. Specifically, 40 C.F.R. § 257.82(a) of the CCR Rule requires the following:

> *The owner or operator of an existing or new CCR surface impoundment or any lateral expansion of a CCR surface impoundment must design, construct, operate and maintain an inflow design flood control system as specified in paragraphs (a)(1) and (2) of this section.*
>
> *(1) The inflow design flood control system must adequately manage flow into the CCR unit during and following the peak discharge of the inflow design flood.*
>
> *(2) The inflow design flood control system must adequately manage flow from the CCR unit to collect and control the peak discharge resulting from the inflow design flood.*

For this analysis, the above criteria were interpreted to mean that the top of the Impoundment dike should not be overtopped during the inflow design flood.

3.3.2 Freeboard Criteria

Under the CCR Rule, "freeboard" means the vertical distance between the lowest point on the crest of the impoundment dike and the surface of the waste contained therein 40 C.F.R. § 257.53. The CCR Rule further discusses that operating CCR surface impoundment freeboard must be adequate to meet performance standards, but a specific, quantified freeboard is not defined. As stated previously, the CCR criteria is interpreted to mean that the top of the surface impoundment dike should not be overtopped during the inflow design flood; therefore, it is assumed that to meet the freeboard criteria during the design flood, no additional operating freeboard is required.

The Plant's OPDES Permit includes a freeboard requirement but does not specify a storm for which the freeboard shall be maintained. The permit indicates that the freeboard shall be maintained at three feet. Since the Impoundment water surface elevation is held at elevation 443' by the vertical discharge pipes, and the top of the Impoundment dike is at elevation 446', during a storm event there may be a period where the Impoundment will have less than three feet of freeboard. Stormwater runoff that enters the Impoundment at a rate that is faster than the 24" vertical discharge pipes can send water to the Process Waste Pond will be temporarily stored in the Impoundment. Once the stormwater runoff has subsided, the 24" vertical discharge pipes will return the water surface elevation to elevation 443'.

3.4 Project Mapping

Project mapping consisted of performing an aerial survey and survey of the Impoundment's bottom elevations.

3.4.1 Aerial Survey

An aerial survey was performed in January 2016 by Survey and Aerial Mapping, LLC. The aerial survey included topography, planimetric features, and orthoimagery.

3.4.2 Impoundment Bottom Elevations

A survey of the bottom elevation of the Impoundment's two cells was conducted by C.H. Guernsey & Company. This data, combined with the information from the aerial survey, was used to form area capacity curves that were representative as of the time Impoundment bottom elevations were obtained.

3.4.3 Vertical Datum

Mapping sources referenced were in the North American Vertical Datum of 1988 (NAVD 88).

3.4.4 Horizontal Coordinate System

North American Datum (NAD) 1983 State Plane Oklahoma South 3502 (U.S. feet) coordinate system was utilized as the basis for mapping and modeling efforts.

4.0 HYDROLOGIC AND HYDRAULIC CAPACITY

4.1 Calculation Approach

To simulate the inflow from process flows and stormwater and the outflow from ash water reuse and discharge to the permitted outfall, the computer program Hydrologic Engineering Center-Hydrologic Modeling System (HEC-HMS) was used to generate a model. HEC-HMS is software developed by the U.S. Army Corps of Engineers for the evaluation of watersheds and hydrologic processes. The HEC-HMS model breaks down the hydrologic and hydraulic processes into a precipitation model, a runoff model, and other elements, such as culverts, storage ponds, and pumps. The detailed calculation and model description are contained in Appendix A.

4.2 Hydrology

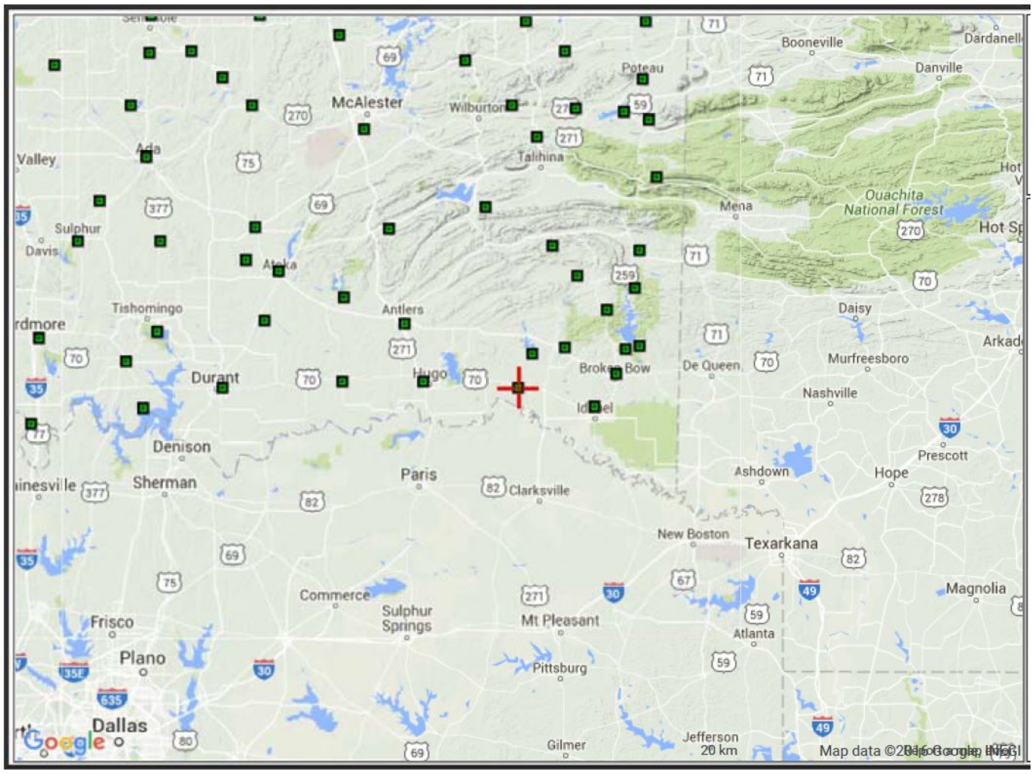
4.2.1 Recurrence Interval and Rainfall Duration

The inflow design flood event for this Plan, as dictated by the hazard potential classification, was a 100-year flood event. Since a storm duration was not specified under 40 C.F.R. § 257.82 or other pertinent inflow design flood sections, a 24-hour storm duration was utilized. This is an industry standard duration and produces a more conservative rainfall depth than shorter duration storm events.

4.2.2 Rainfall Distribution and Depth

The precipitation depth used for the inflow design flood event is 9.66 inches, as required per 40 C.F.R. § 257.82 and the assumed 24-hour storm duration. This precipitation data was acquired from the National Weather Service (NOAA, 2016). The point precipitation location, where the precipitation values are derived for, is shown in Figure 4-1. The table of rainfall depths for various frequencies and durations is presented in Figure 4-2.

Figure 4-1. Point Precipitation Location



4.2.3 Watershed Delineation and Hydrologic Characteristics

The Plant watersheds were delineated using the mapping sources as discussed in Section 3.4 and are shown in Figure 4-3. Watershed F represents CCR Unit 2, and Watershed I represents CCR Unit 3. Precipitation that falls on these watersheds runs off directly into the corresponding CCR Unit. Watershed A is the runoff that comes from the area inside the railroad tracks circling the coal yard. Precipitation that falls on Watershed A runs off into the coal pile runoff pond, through a 24” pipe which drains to the weir overflow structure, and then through one or both of two 24” pipes that drain into CCR Units 2 and 3.

Watersheds G and K drain to Construction Ponds No. 6 and 4 respectively. Watershed B drains south of the coal pile and north of the Landfill, and discharges into Watershed H. A cutoff ditch routes stormwater around the south side of CCR Unit 3.

Properties of the watershed were determined using the topographical and planimetric features from the mapping. These properties were used to build the HEC-HMS model. The engineering calculation utilizing the HEC-HMS Model is included in Appendix A.

Figure 4-2. NOAA Point Precipitation Frequency Estimates

SS 257.82 (a)(3) (iii), 100 year flood

PDS-based 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	0.468 (0.377–0.582)	0.534 (0.430–0.665)	0.644 (0.517–0.803)	0.737 (0.590–0.920)	0.867 (0.680–1.10)	0.969 (0.748–1.24)	1.07 (0.811–1.39)	1.18 (0.868–1.54)	1.32 (0.949–1.75)	1.44 (1.01–1.91)
10-min	0.685 (0.552–0.853)	0.782 (0.629–0.974)	0.943 (0.757–1.18)	1.08 (0.863–1.35)	1.27 (0.996–1.61)	1.42 (1.10–1.81)	1.57 (1.19–2.03)	1.73 (1.27–2.26)	1.94 (1.39–2.57)	2.10 (1.48–2.80)
15-min	0.836 (0.673–1.04)	0.954 (0.767–1.19)	1.15 (0.923–1.43)	1.32 (1.05–1.64)	1.55 (1.21–1.97)	1.73 (1.34–2.21)	1.92 (1.45–2.47)	2.11 (1.55–2.75)	2.37 (1.70–3.13)	2.56 (1.81–3.41)
30-min	1.23 (0.986–1.52)	1.40 (1.13–1.74)	1.69 (1.36–2.11)	1.94 (1.55–2.42)	2.28 (1.79–2.89)	2.55 (1.97–3.25)	2.82 (2.13–3.64)	3.10 (2.28–4.05)	3.48 (2.50–4.61)	3.77 (2.66–5.02)
60-min	1.62 (1.31–2.02)	1.86 (1.49–2.31)	2.25 (1.80–2.80)	2.58 (2.06–3.22)	3.05 (2.39–3.88)	3.42 (2.65–4.37)	3.81 (2.88–4.92)	4.21 (3.10–5.50)	4.75 (3.41–6.29)	5.17 (3.64–6.88)
2-hr	2.02 (1.64–2.49)	2.31 (1.88–2.85)	2.80 (2.27–3.45)	3.22 (2.60–3.98)	3.82 (3.03–4.81)	4.30 (3.35–5.44)	4.79 (3.65–6.14)	5.31 (3.94–6.89)	6.01 (4.34–7.90)	6.56 (4.65–8.67)
3-hr	2.27 (1.86–2.78)	2.60 (2.12–3.18)	3.15 (2.57–3.86)	3.63 (2.95–4.46)	4.32 (3.45–5.43)	4.88 (3.83–6.16)	5.46 (4.19–6.97)	6.08 (4.53–7.85)	6.92 (5.03–9.07)	7.59 (5.40–9.98)
6-hr	2.76 (2.28–3.34)	3.14 (2.60–3.81)	3.81 (3.14–4.62)	4.39 (3.61–5.35)	5.26 (4.25–6.55)	5.96 (4.73–7.47)	6.71 (5.19–8.50)	7.50 (5.64–9.63)	8.60 (6.30–11.2)	9.48 (6.79–12.4)
12-hr	3.31 (2.77–3.97)	3.76 (3.14–4.52)	4.56 (3.80–5.48)	5.26 (4.37–6.34)	6.31 (5.15–7.80)	7.17 (5.75–8.90)	8.08 (6.32–10.2)	9.06 (6.88–11.5)	10.4 (7.69–13.5)	11.5 (8.31–14.9)
24-hr	3.89 (3.26–4.62)	4.45 (3.76–5.29)	5.43 (4.57–6.45)	6.29 (5.27–7.49)	7.55 (6.21–9.22)	8.58 (6.93–10.5)	9.66 (7.61–12.0)	10.8 (8.26–13.6)	12.4 (9.21–15.9)	13.7 (9.93–17.6)
2-day	4.49 (3.83–5.26)	5.20 (4.43–6.11)	6.40 (5.44–7.53)	7.43 (6.29–8.76)	8.91 (7.39–10.8)	10.1 (8.22–12.3)	11.3 (8.99–13.9)	12.6 (9.71–15.8)	14.4 (10.7–18.2)	15.8 (11.5–20.1)
3-day	4.93 (4.23–5.75)	5.68 (4.88–6.63)	6.96 (5.96–8.14)	8.06 (6.86–9.44)	9.62 (8.02–11.5)	10.9 (8.89–13.1)	12.2 (9.69–14.9)	13.5 (10.4–16.8)	15.3 (11.5–19.3)	16.8 (12.3–21.3)
4-day	5.27 (4.54–6.12)	6.05 (5.22–7.03)	7.37 (6.34–8.58)	8.50 (7.28–9.92)	10.1 (8.47–12.1)	11.4 (9.36–13.7)	12.7 (10.2–15.5)	14.1 (10.9–17.4)	16.0 (12.0–20.1)	17.5 (12.8–22.1)
7-day	6.06 (5.27–6.98)	6.91 (6.01–7.96)	8.33 (7.22–9.61)	9.54 (8.24–11.0)	11.3 (9.49–13.3)	12.6 (10.4–15.0)	14.0 (11.3–16.9)	15.5 (12.1–19.0)	17.4 (13.2–21.7)	19.0 (14.0–23.8)
10-day	6.77 (5.92–7.75)	7.66 (6.70–8.78)	9.15 (7.98–10.5)	10.4 (9.04–12.0)	12.2 (10.3–14.3)	13.6 (11.3–16.1)	15.0 (12.1–18.0)	16.5 (12.9–20.1)	18.5 (14.0–22.9)	20.0 (14.9–25.1)
20-day	8.94 (7.92–10.1)	9.95 (8.80–11.3)	11.6 (10.2–13.2)	13.0 (11.4–14.8)	14.9 (12.7–17.2)	16.3 (13.7–19.1)	17.8 (14.5–21.1)	19.3 (15.2–23.3)	21.2 (16.2–26.1)	22.7 (17.0–28.2)
30-day	10.8 (9.61–12.1)	12.0 (10.6–13.5)	13.8 (12.3–15.6)	15.4 (13.6–17.4)	17.4 (14.9–20.0)	19.0 (16.0–22.0)	20.5 (16.8–24.1)	22.0 (17.4–26.3)	23.9 (18.3–29.2)	25.4 (19.0–31.3)
45-day	13.1 (11.8–14.7)	14.6 (13.1–16.3)	16.9 (15.1–18.9)	18.7 (16.6–21.0)	21.1 (18.1–24.0)	22.8 (19.3–26.2)	24.4 (20.1–28.5)	26.0 (20.6–30.9)	28.0 (21.5–33.8)	29.3 (22.1–36.1)
60-day	15.1 (13.6–16.8)	16.9 (15.2–18.8)	19.6 (17.6–21.9)	21.7 (19.4–24.3)	24.5 (21.1–27.6)	26.4 (22.4–30.2)	28.2 (23.2–32.7)	29.9 (23.8–35.3)	31.9 (24.5–38.4)	33.2 (25.1–40.7)

[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.

Estimates from the table in csv format: precipitation frequency estimates Submit

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National Weather Service
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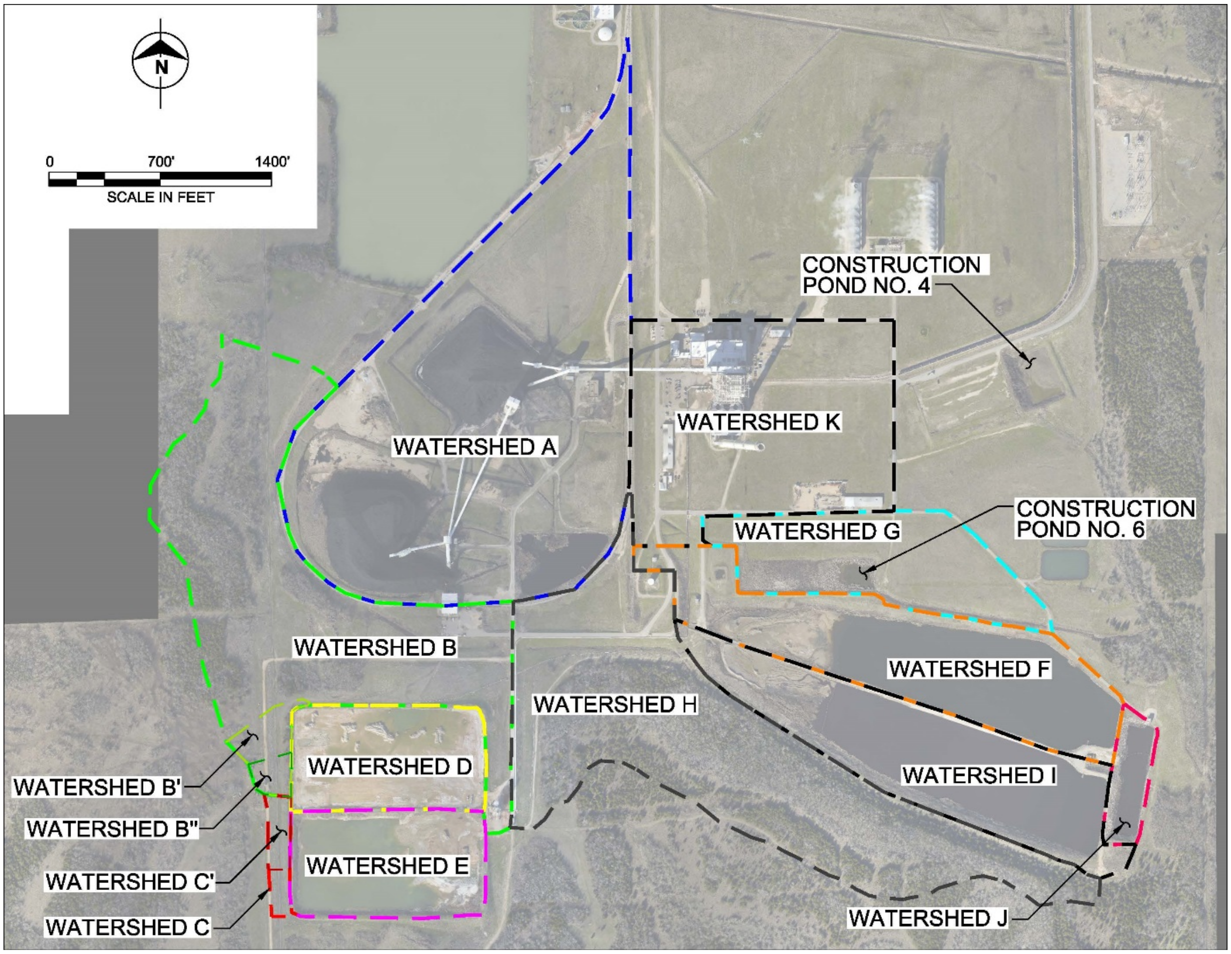
Figure 4-3. Plant Watershed Boundaries



4.2.4 Process Inflows

To accurately evaluate the inflow design flood control system, both stormwater runoff flows and process flows were considered. Stormwater flows were estimated from the model, while process flows were taken from the Plant's water mass balance. The estimated process inflows contributing to the Impoundment are summarized in Table 4-1, below. This information was obtained from a water mass balance provided by WFEC, and is included in Attachment A.

Table 4-1. Surface Impoundment Process Inflows

Source	Flow (mgd)	Flow (cfs)
Demineralizer	0.005	0.0077
Cooling Tower	0.39	0.6034
Boiler Blowdown	0.02	0.0309
Chemical Cleaning Rinse	0	0
Oil Separator	0.32	0.4951
Coal Pond*	0.12	0.1857
Air Heater	1.2	1.8567
Sanitary Treatment	0.060	0.0928
Sum	2.115	3.2724

*Coal Pond Runoff is included in model as a separate watershed.

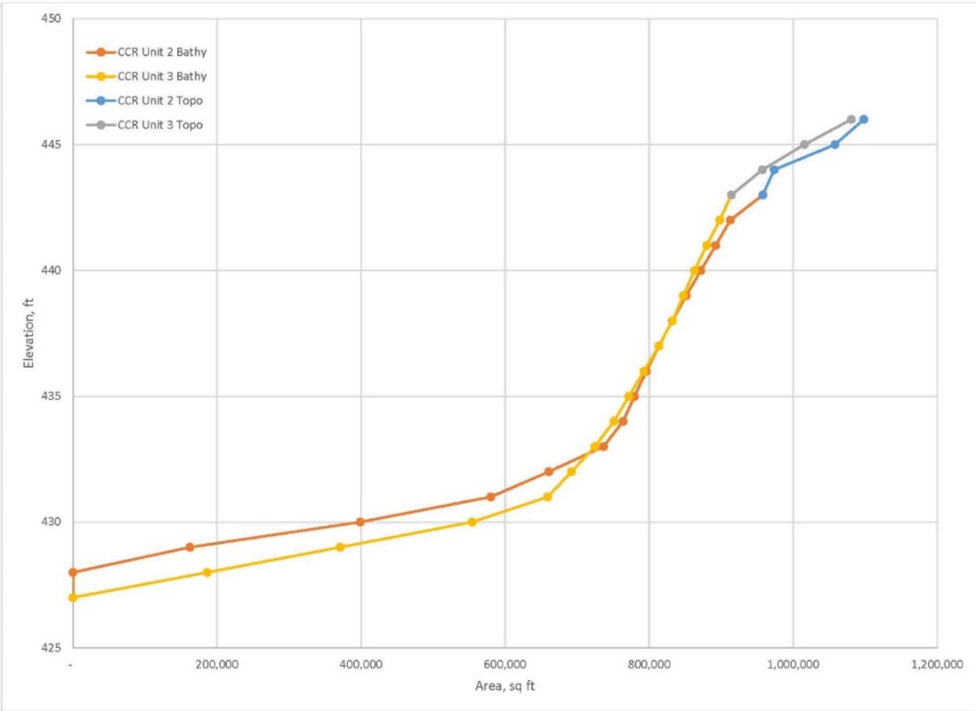
4.2.4.1 Stage / Surface Area Information

Stage and surface area information for CCR Unit 2 and CCR Unit 3 was developed from a combination of the data discussed in Section 3.4. A plot of the stage versus surface area relationship is shown in Figure 4-4.

Table 4-2 Stage Storage Information

	CCR Unit 2			CCR Unit 3		
Elevation	Area	Stage Volume	Cumulative Volume	Area	Stage Volume	Cumulative Volume
ft	sq ft	ft^3/ft	ft^3/ft	sq ft	ft^3/ft	ft^3/ft
427	-	0		0		
428	-	0		186,201	93,101	93,101
429	162,395	81,198	81,198	371,032	92,415	371,032
430	398,759	118,182	398,759	554,293	91,630	831,439
431	580,239	90,740	870,359	659,128	52,417	1,318,256
432	660,774	40,267	1,321,548	692,116	16,494	1,730,289
433	736,703	37,964	1,841,757	724,610	16,247	2,173,831
434	763,851	13,574	2,291,554	751,078	13,234	2,628,773
435	779,605	7,877	2,728,617	771,877	10,399	3,087,508
436	796,083	8,239	3,184,334	792,652	10,387	3,566,933
437	813,572	8,744	3,661,073	813,404	10,376	4,067,018
438	832,035	9,231	4,160,173	832,401	9,499	4,578,206
439	851,447	9,706	4,682,961	847,416	7,507	5,084,493
440	871,823	10,188	5,230,941	863,066	7,825	5,609,927
441	892,445	10,311	5,800,896	879,864	8,399	6,159,048
442	912,855	10,205	6,389,987	897,881	9,008	6,734,105
443	957,761	22,453	7,183,206	914,181	8,150	7,313,449
444	973,650	7,945	7,789,200	957,369	21,594	8,137,633
445	1,058,025	42,188	8,993,214	1,015,600	29,116	9,140,401
446	1,098,045	20,010	9,882,403	1,080,783	32,591	10,267,436

Figure 4-4. Stage and Surface Area Relationship



5.0 RESULTS

5.1 Calculation Inputs

Analysis results described herein were based on the following input which is based on Burns & McDonnell's understanding of the systems and Plant operating procedures:

- Watersheds A, F, and I contribute stormwater to the Impoundment.
- The Impoundment is continually being filled with CCR and sedimentation; therefore, the Impoundment capacity is in constant flux. A survey of the bottom of the Impoundment was performed by Guernsey earlier this year, and is included in Attachment B. This analysis was based on the conditions of the Impoundment at the time the survey was conducted.
- Contributing process flows to the Impoundment were averages established for the Plant's OPDES permit. For this analysis, the inflows were assumed to be constant.

5.2 Design Flood Event

As stated in Section 4.2.2, the depth of 100-year, 24-hour storm is 9.66 inches.

5.3 General Model Construction

The HEC-HMS model was set up to simulate actual conditions as close as possible. The basis of the model input or model configuration for several inputs are listed below.

- Watershed areas and land cover uses were input based on information determined from mapping.
- Precipitation data was retrieved from the National Oceanic and Atmospheric Administration (NOAA).
- The Impoundment was modeled based on survey data and information from Guernsey's bottom survey of the Impoundment (Attachment B).
- Process inflows were modeled based on the Plant Water Balance (Attachment A).

5.4 Summary

Results indicated that the Impoundment was not overtopped during the design flood inflow. Freeboard was estimated to be less than three feet as the 24" vertical discharge pipes sent excess water to the Process Waste Pond. Peak elevation was noted to be EL 445.7'. The water surface elevation in the Impoundment returned to the operating level about 2 days after the peak runoff from the design flood event occurred.

5.5 Operating Plan

To meet the requirements of 40 C.F.R. § 257.82(a)(1) and adequately manage flow into the Impoundment during and following the peak discharge, the Plant should continue to operate as the currently do by monitoring the Impoundment water surface level, using the valves and sluice gates at the weir structure to divert water to either cell to reduce the risk of overtopping. The Plant should continue to avoid pumping stormwater from the Landfill and minimize washdown wastewater while the Impoundment water level is above the operating Elevation of 443'.

To meet the requirements of 40 C.F.R. § 257.82(a)(2) and adequately manage flow from the Impoundment during and following the peak discharge, the Plant should continue to utilize the manual valves and the two 24" vertical pipes at the ash water recycle structure to gravity flow water to the Process Wastewater Pond.

To meet the requirements of 40 C.F.R. § 257.82(b) and discharge in accordance with 40 C.F.R. § 257.3-3, the Plant should continue to utilize the equipment and methods currently used to comply with the OPDES permit.

5.6 Conclusion

The Impoundment's inflow design flood control system is designed, constructed, operated, and maintained to adequately manage: (1) flow into the Impoundment during and following the peak discharge resulting from the specified inflow design flood; and (2) flow from the Impoundment to collect and control the peak discharge resulting from the specified inflow design flood. Additionally, discharges from the Impoundment as a result of the design flood are handled in accordance with 40 C.F.R. § 257.3-3.

6.0 REVIEW AND REVISIONS

The Inflow Report will be placed in the Plant's Operating Record in accordance with the CCR Rule. Pursuant to the CCR Rule, if there is a significant change to any information compiled in the Inflow Report, the relevant information will be updated and the revised document will be placed in the Plant's Operating Record with notice and public accessibility as required by the CCR Rule. A record of revisions made to this document is included in Section 7.0.

7.0 RECORD OF REVISIONS

Revision Number	Date	Revisions Made	By Whom
0	10/14/16	Initial Issue	Burns & McDonnell

APPENDIX A – 85009-C-002

Client : Mr. Stephen Jantzen
Project Name : Hugo CCR Documentation
Project Number : 85009

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-002
ISSUED DATE:	10/14/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	B. Liu

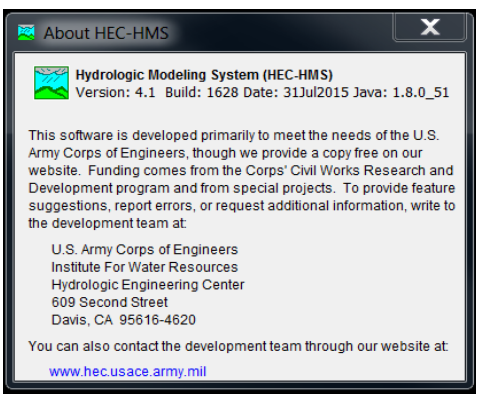
OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

REFERENCES:

1 Lindeburg, M. (2006). *Civil engineering reference manual for the PE exam.* Belmont, CA: Professional Publications, Inc.
2 Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan (2011). NOAA Atlas 14 Volume 6 Version 2.0, Precipitation-Frequency Atlas of the United States, California. NOAA, National Weather Service, Silver Spring, MD.
3 Cox, D., Chu, T., Ruane, R. (February 1979). *Characterization of coal pile drainage* (EPA-600/7-79-051). Washington, DC: US Environment Protection Agency
4 Web soil survey
5 Cronshey, R. et al. (June 1986). *Urban hydrology for small watersheds* (TR-55). Washington, DC: US Department of Agriculture.

SOFTWARE:

1 Hydrologic Modeling System (HEC-HMS)



MODEL:

1 HUGO_INFLOW_HMS_4.1.hms
\Clients\ENR\WFEC\85009_CCRStudy\Studies\Tech_Consult\Reports\INFLOW STUDY\HUGO_INFLOW_HMS_4.1

DESIGN INPUT:

1 Impoundment hazard classification is Low Hazard Potential.
Therefore, per §257.82 (a)(3)(iii), the design flood is the 100 year storm.
2 Site soil classification is D. Reference 4
3 Curve Numbers as follows:

	CN	
Coal Pile	73	Reference 3
CCR	73	Same as Coal Pile
Gravel	91	Reference 5
Pavement, Buildings	98	Reference 5
Meadow - Mowed for Hay	78	Reference 5
Woods	77	Reference 5
Water*	100	

*Water is modeled to have no losses, therefore 100% of rainfall is excess runoff.

4 Weighted curve numbers taking into account impervious area will be calculated for each watershed.

Client : Mr. Stephen Jantzen
Project Name : Hugo CCR Documentation
Project Number : 85009

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-002
ISSUED DATE:	10/14/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

EQUATIONS:

1	Sheet Flow Travel Time		
		tsheet = 0.007*(nL)0.8/√(P2)*Sdecimal0.4	Reference 1, p. 20-3, eq. 20.6
2	Shallow Flow Travel Time		
		tshallow = L/v	Reference 1, p. 20-3, Section 5
3	Velocity of Shallow Flow		
		vshallow =16.1345√(Sdecimal)	Reference 1, p. 20-3, eq. 20.7
4	Channel Flow Travel Time		
		tchannel = L/v	Reference 1, p. 20-3, Section 5
5	Time of Concentration		
		tc = tsheet + tshallow + tchannel	Reference 1, p. 20-3, eq. 20.5
6	Lag Time		
		tlag= 0.6*tc	Reference 1, p.20-11, eq. 20.27
7	Soil Water Storage Capacity		
		S = (1000/CN) -10	Reference 1, p. 20-19, eq. 20.43
8	Initial Abstraction		
		Ia = 0.2*S	Reference 1, p. 20-15, eq. 20.38
9	Weir Equation		
		$Q = 3.33bh^{3/2}$	Reference 1, p. 19-11, eq. 19.51
10	Orifice Equation		
		$v_0=C_v(2gh)^{1/2}$	Reference 1, p. 17-16, eq. 17.69
11		Q = vA	Reference 1, p 19-2, eq. 19.1

VARIABLES:

1	tlag	lag time, min
2	L	hydraulic length of the watershed, ft
3	S	soil water storage capacity, in
4	Sdecimal	slope, ft/ft
5	CN	curve number, unit less
6	Ia	initial abstraction, in
7	Ad	total drainage area, ac or mi2
8	AT	total area, ac
9	Q	peak runoff rate, cfs
10	vchannel	channel velocity, ft/s
11	vshallow	shallow velocity, ft/s
12	tc	time of concentration, min
13	tsheet	sheet flow travel time, min
14	tshallow	shallow concentrated flow travel time, min
15	tchannel	channel flow travel time, min
16	P2	2yr 24hr rainfall, in
17	n	Manning's roughness coefficient
18	b	weir width, ft
19	h	head, ft
20	v_0	orifice velocity, ft/s
21	C_v	discharge coefficient
22	g	acceleration due to gravity, 32.2 ft/s^2
23	A	Area, ft^2

Client : Mr. Stephen Jantzen
Project Name : Hugo CCR Documentation
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WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-002
ISSUED DATE:	10/14/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

ATTACHMENTS:

1 Point Precipitation Data - Ref 2
2 Water Balance

PROCEDURE:

1 Use topographic mapping and planimetric features to establish the watersheds boundaries for the plant.
See Figure 1 for watershed boundaries.
See Table 1 for watershed area.

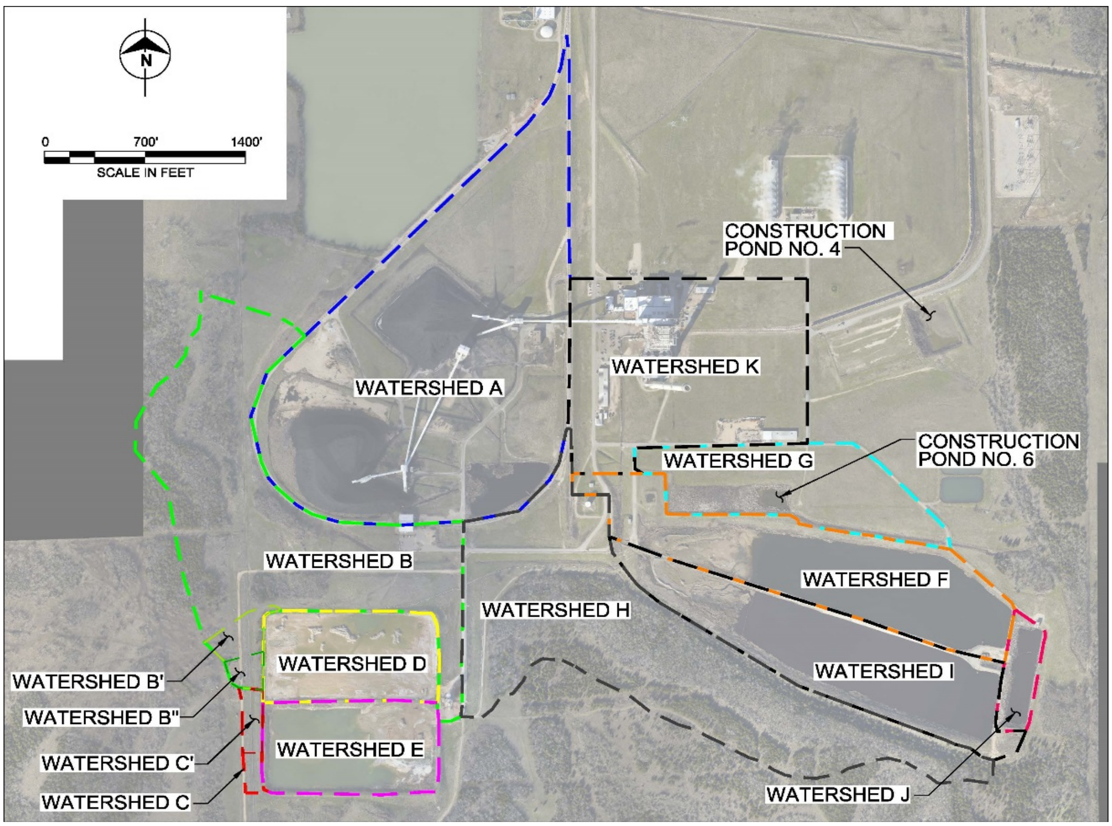

Figure 1 - Watershed Boundaries for Plant

WORKSHEET TITLE: Run-on and run-off **CALCULATION NO.:** 85009-C-002

ISSUED DATE: 10/14/2016 **REVISION:** 0

PERFORMED BY: J. Dowell **REVIEWED BY:** B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

PROCEDURE (continued):

Watershed A drains through the coal pile runoff pond into the impoundments.
Watershed B is diverted south of the Coal Pile and north of the Landfill into a ditch that goes through Watershed H.
Watersheds B' and B'' are sub-watersheds of Watershed B.
Watershed C drains to the south side of the site. Watershed C' is a sub-watershed of Watershed C.
Watershed D is the north half of the CCR Landfill.
Watershed E is the south half of the CCR Landfill.
Watershed F drains through various open ditches and pipes to the impoundments.
Watershed G drains to the north side of the CCR Impoundment.
Watershed H drains to the south side of the CCR Impoundment.
Watershed I consists of the area immediately around the south impoundment.
Watershed J is the Process Waste Pond.
Watershed K drains the plant to Construction Pond 4.
Watersheds B, C, D, E, G, H, J, and K do not runoff to the CCR impoundment, therefore they are excluded from further consideration in this calculation.

Table 1

Watershed	A	F	I
Area, sf	4,416,209	1,610,440	1,509,089
Area, ac	101.4	37.0	34.6
Area, mi^2	0.15841	0.05777	0.05413

2 Use planimetric features and aerial photography to establish the ground surface cover of the watersheds.
See Table 2 for summary of ground surface features and calculation of composite curve number.
See Figures 2 through 4 for the watershed ground surface features.

Table 2

Watershed	A		F		I	
	area, sf	CN	area, sf	CN	area, sf	
Gravel	900,317		71,643		48,828	
CN=91		18.55		4.05		2.94
Bldg/Pvmnt	58,900		25,921		-	
CN=98		1.31		1.58		
Coal/CCR	798,440		237,896		452,747	
CN=73		13.20		10.78		21.90
Grass	2,531,439		363,616		108,529	
CN=78		44.71		17.61		5.61
Water*	127,113		911,364		893,615	
CN=100		2.88		56.59		59.22
Total Area	**4,416,209**	**80.65**	**1,610,440**	**90.61**	**1,509,089**	**89.67**
S		**2.40**		**1.04**		**1.15**
Ia		**0.48**		**0.21**		**0.23**

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-002
ISSUED DATE:	10/14/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	B. Liu
OBJECTIVE:	Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.		

PROCEDURE (continued):

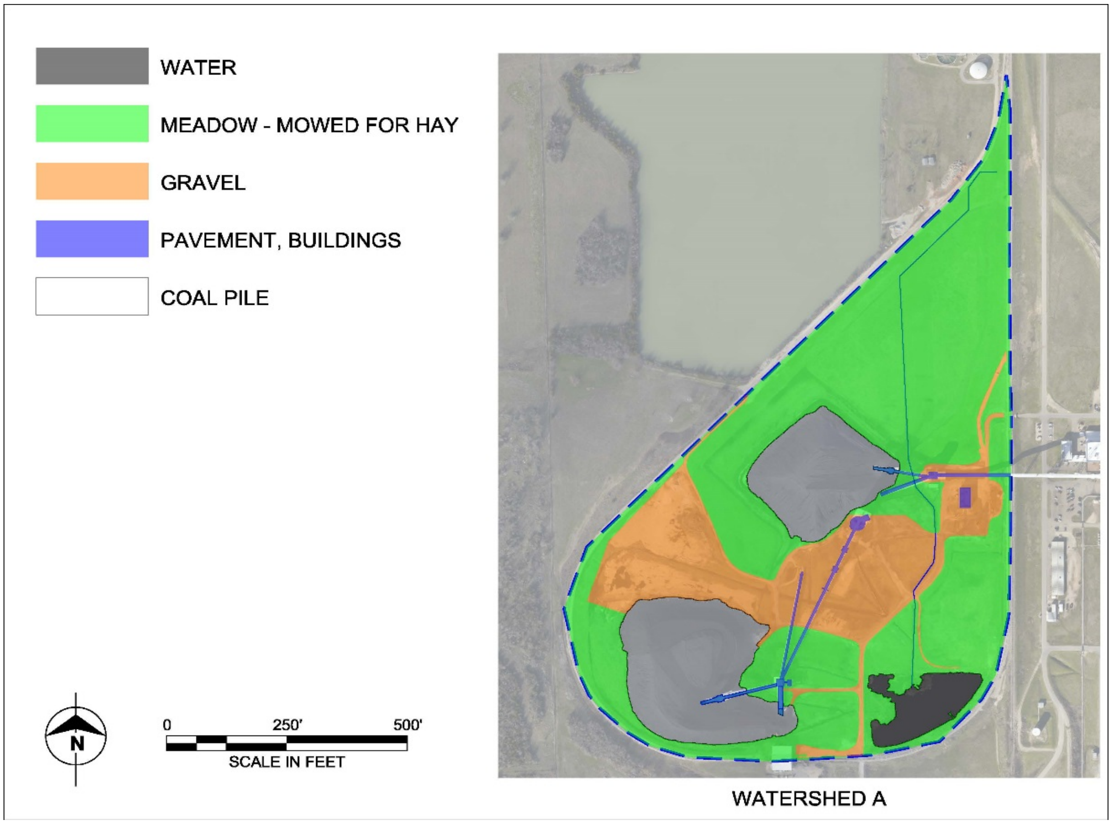

Figure 2 - Watershed A Ground Surface Features

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-002
ISSUED DATE:	10/14/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

PROCEDURE (continued):

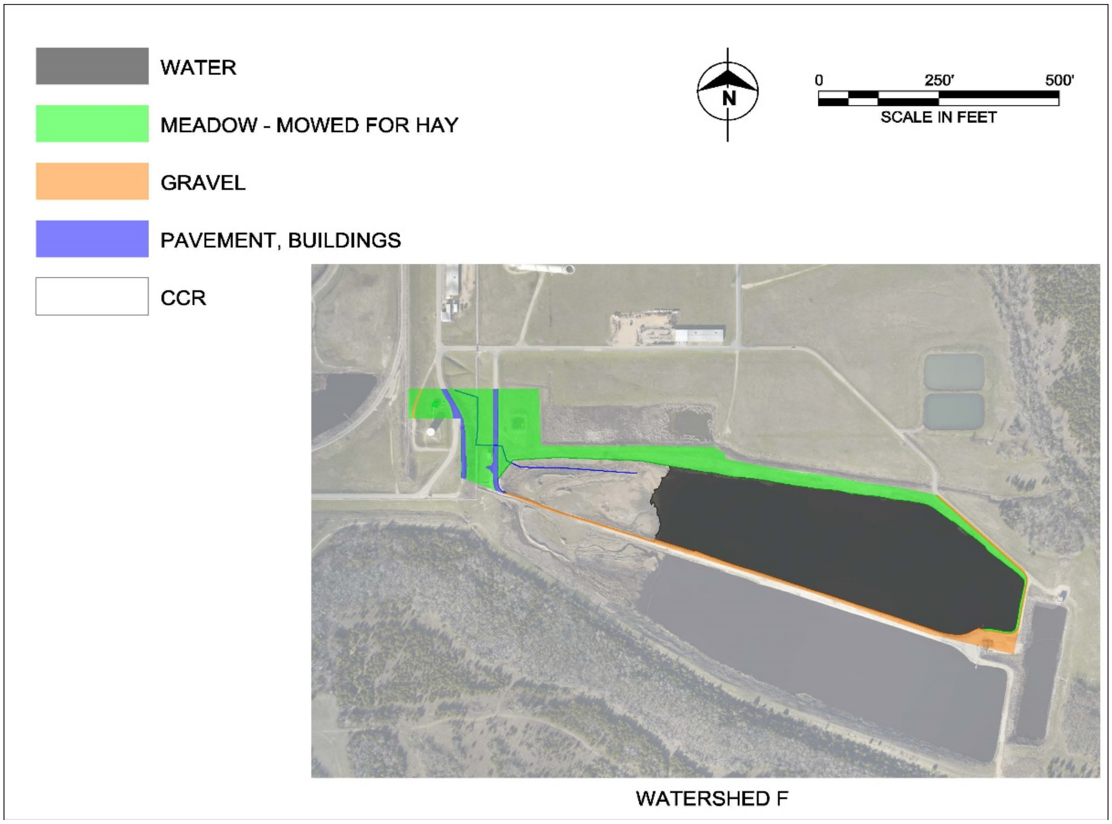

Figure 3 - Watershed F Ground Surface Features

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-002
ISSUED DATE:	10/14/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

PROCEDURE (continued):

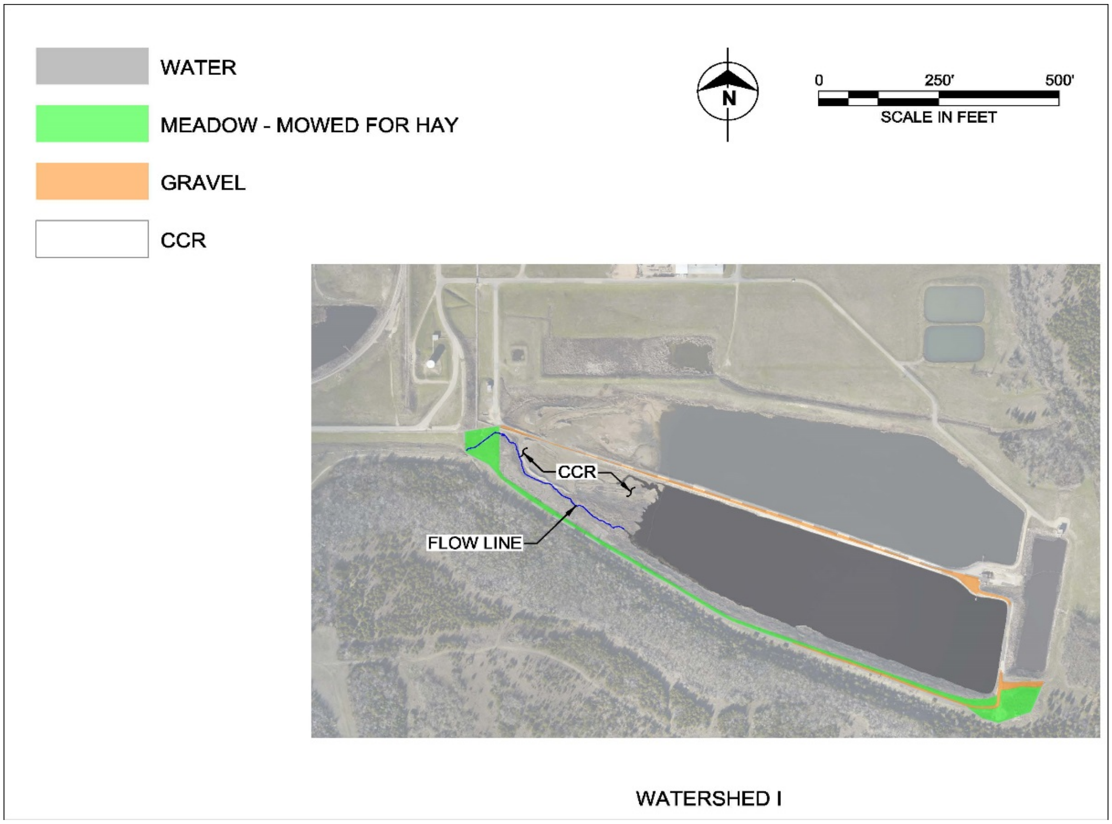

Figure 4 - Watershed I Ground Surface Features

Client : Mr. Stephen Jantzen
Project Name : Hugo CCR Documentation
Project Number : 85009

WORKSHEET TITLE:	Run-on and run-off	**CALCULATION NO.:**	85009-C-002
ISSUED DATE:	10/14/2016	**REVISION:**	0
PERFORMED BY:	J. Dowell	**REVIEWED BY:**	B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

PROCEDURE (continued):

3 Use topographic features to establish time of concentration.
See Table 3 for summary of time of concentration calculations.

Table 3

	A	F	I	Notes
Sheet				
n	0.150	0.150	0.150	
L (ft)	150.00	118.00	225.00	(total < 150ft)
P_2 (in)	4.45	4.45	4.45	
$S_{decimal}$ (ft/ft)	0.017	0.042	0.067	
t_{sheet} (hr)	**0.21**	**0.12**	**0.16**	Equation 1
t_{sheet} (min)	**12.36**	**12.03**	**14.06**	Equation 1
Shallow				
L (ft)	1800.00	377.00	**	
$S_{decimal}$ (ft/ft)	0.003	0.024		
$v_{shallow}$ (fps)	0.89	2.49		Equation 3
$t_{shallow}$ (s)	**2018.24**	**151.23**		Equation 2
$t_{shallow}$ (m)	**33.64**	**2.52**		Equation 2
Channel				
L (ft)	1050.00	739.00	860.00	
$S_{decimal}$ (ft/ft)	0.007	0.02		
$v_{channel}$ (fps)	5.00	5.00	5.00	
$t_{channel}$ (s)	**210.00**	**147.80**	**172.00**	Equation 4
$t_{channel}$ (m)	**3.50**	**0.03**	**0.03**	Equation 4
t_c (min)	**49.50**	**14.59**	**14.09**	Equation 5
t_{lag} (min)	**29.70**	**8.75**	**8.45**	Equation 6

*Rain that falls directly on the Impoundments immediately converts to runoff, therefore, there is no time of concentration.
** No shallow concentrated flow.

4 Establish non-stormwater inflows.
See Table 4 for process inflows.

Table 4

Source	**Flow MGD**	**Flow cfs**
Demineralizer	0.005	0.0077
Cooling Tower	0.390	0.6034
Boiler Blowdown	0.020	0.0309
Chemical Cleaning Rinse	0.000	0.0000
Oil Separator	0.320	0.4951
Coal Pond* **		
Air Heater	1.200	1.8567
Sanitary Treatment	0.060	0.0928
Sum	1.995	3.0867

*** Coal Pond included in stormwater runoff.

WORKSHEET TITLE: Run-on and run-off

CALCULATION NO.: 85009-C-002

ISSUED DATE: 10/14/2016

REVISION: 0

PERFORMED BY: J. Dowell

REVIEWED BY: B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

PROCEDURE (continued):

5 Establish discharge flows.
Discharge consists of two 24" vertical pipes.
To determine the flow characteristics of the vertical pipes, perform weir calculations and orifice calculations, and use the more conservative flow rates from the two.
Use that flow as elevation discharge function in HEC-HMS.
See Table 5 for Weir and Orifice Discharges.

Table 5

EL	Weir Discharge	Orifice Discharge	Smaller Discharge
(h) - ft	Q	Q	Q
443.0	0	0	0
443.1	0.661643579	6.537424086	0.661643579
443.2	1.871410644	9.245313805	1.871410644
443.3	3.438000883	11.32315067	3.438000883
443.4	5.293148628	13.07484817	5.293148628
443.5	7.397400092	14.61812465	7.397400092
443.6	9.724134954	16.01335324	9.724134954
443.7	12.25381056	17.29639835	12.25381056
443.8	14.97128515	18.49062761	14.97128515
443.9	17.86437662	19.61227226	17.86437662
444.0	20.92300707	20.67315014	20.67315014
444.1	24.13865844	21.68218279	21.68218279
444.2	27.50400707	22.64630133	22.64630133
444.3	31.01266803	23.57101775	23.57101775
444.4	34.65901016	24.46080112	24.46080112
444.5	38.43801841	25.31933461	25.31933461
444.6	42.34518902	26.14969634	26.14969634
444.7	46.37644813	26.95449002	26.95449002
444.8	50.5280874	27.73594141	27.73594141
444.9	54.79671241	28.49597094	28.49597094
445.0	59.17920074	29.23624931	29.23624931
445.1	63.67266741	29.95824072	29.95824072
445.2	68.2744363	30.66323696	30.66323696
445.3	72.98201601	31.35238451	31.35238451
445.4	77.79307963	32.02670648	32.02670648
445.5	82.70544731	32.68712043	32.68712043
445.6	87.71707146	33.33445298	33.33445298
445.7	92.82602385	33.969452	33.969452
445.8	98.03048446	34.59279669	34.59279669
445.9	103.3287317	35.20510612	35.20510612
446.0	108.7191339	35.8069464	35.8069464

6 Set up CCR Unit 2 and CCR Unit 3 as Reservoir to model the storage capacity.
See Table 6 for Elevation Area data.

WORKSHEET TITLE: Run-on and run-off | **CALCULATION NO.:** 85009-C-002

ISSUED DATE: 10/14/2016 | **REVISION:** 0

PERFORMED BY: J. Dowell | **REVIEWED BY:** B. Liu

OBJECTIVE: Provide calculations to demonstrate the hydrologic and hydraulic capacity per 40 C.F.R. Part 257 §257.82.

PROCEDURE (continued):

Table 6

	CCR Unit 2			CCR Unit 3		
Elevation	Area	Area	Stage Volume	Area	Area	Stage Volume
ft	sq ft	ac	ft3/ft	sq ft	ac	ft3/ft
427	0	0	0	0	0	
428	0	0	0	186201.3394	4.274594568	93100.6697
429	162395.0915	3.728078317	81197.54575	371031.8946	8.517720262	92415.2776
430	398759.166	9.154250826	118182.0373	554292.8693	12.72481334	91630.48735
431	580239.4718	13.32046538	90740.1529	659127.7855	15.13149186	52417.4581
432	660773.7767	15.16927862	40267.15245	692115.6167	15.88878826	16493.9156
433	736702.755	16.91236811	37964.48915	724610.3661	16.63476506	16247.3747
434	763851.4544	17.53561649	13574.3497	751078.0746	17.24238004	13233.85425
435	779604.9142	17.89726617	7876.7299	771876.9232	17.7198559	10399.4243
436	796083.3857	18.27555982	8239.23575	792651.7983	18.19678141	10387.43755
437	813571.7206	18.67703674	8744.16745	813403.5177	18.67317534	10375.8597
438	832034.5602	19.10088522	9231.4198	832401.1635	19.10930127	9498.8229
439	851447.3845	19.54654234	9706.41215	847415.5254	19.4539836	7507.18095
440	871823.4843	20.01431323	10188.0499	863065.6172	19.81326027	7825.0459
441	892445.4988	20.48772954	10311.00725	879863.9711	20.19889741	8399.17695
442	912855.2649	20.9562733	10204.88305	897880.6241	20.61250285	9008.3265
443	957760.795	21.98716242	22452.76505	914181.1589	20.98671164	8150.2674
444	973650.0595	22.35192974	7944.63225	957368.565	21.97815806	21593.70305
445	1058025.223	24.28891697	42187.5818	1015600.119	23.3149706	29115.77715
446	1098044.726	25.20763833	20009.7513	1080782.778	24.81135854	32591.32945

Set Initial Elevation to EL 443 to represent the operating water level in the Impoundment.

7 Set up Meteorological Model
SCS Storm Type 2
100 year - 24 hours Rainfall 9.66 inches

8 Set up Control Specification
Use 5 minute intervals.

9 Run HMS
Graphs of surface elevation in the CCR Surface Impoundment show the water elevation not over topping.

85009-C-002 ATTACHMENT 1
1 OF 2

www.nws.noaa.gov

NOAA's National Weather Service
Hydrometeorological Design Studies Center
Precipitation Frequency Data Server (PFDS)

Home Site Map News Organization Search ◉ NWS ○ All NOAA Go

General Info
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- Current Projects
- FAQ
- Glossary

Precipitation Frequency (PF)
- PF Data Server
- PF in GIS Format
- PF Maps
- Temporal Distr.
- Time Series Data
- PFDS Perform.
- PF Documents

Probable Maximum Precipitation (PMP)
- PMP Documents

Miscellaneous
- Publications
- AEP Storm Analysis
- Record Precipitation

Contact Us
- Inquiries
- List-server

USA.gov

NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: OK

DATA DESCRIPTION

Data type: precipitation depth **Units:** english **Time series type:** partial duration

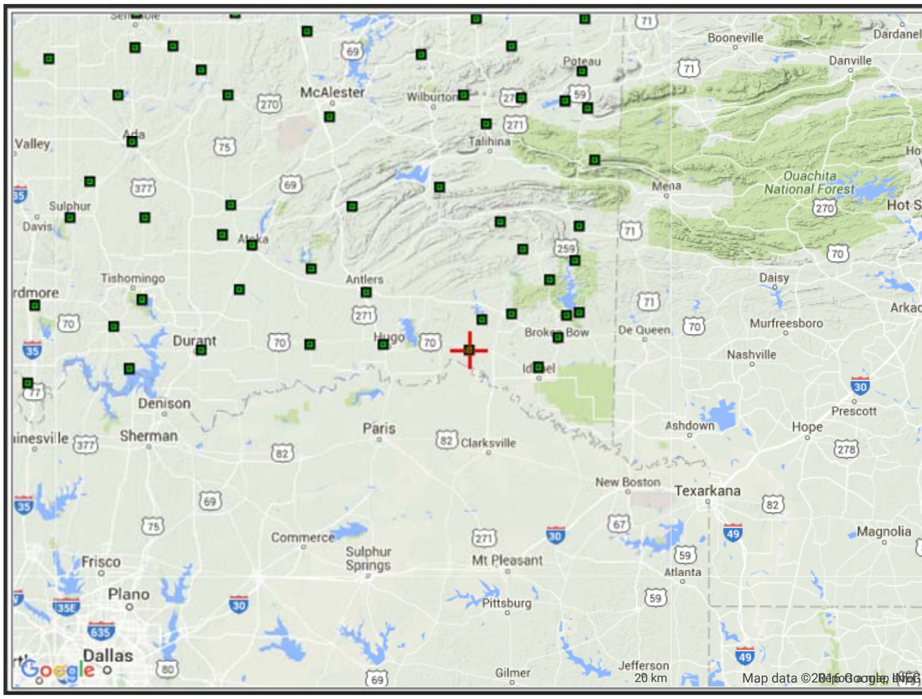
SELECT LOCATION

1. Manually:

a) Enter location (decimal degrees, use "-" for S and W): latitude: longitude: submit

b) Select station (click here for a list of stations used in frequency analysis for OK): select station

2. Use map:



a) Select location
(move crosshair or double click)

b) Click on station icon
(☑ show stations on map)

LOCATION INFORMATION:
Name: Valliant, Oklahoma, US*
Station Name: VALLIANT 3 W
Site ID: 34-9118
Latitude: 33.9981°
Longitude: -95.1433°
Elevation: 475 ft

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 8, Version 2

PF tabular PF graphical Supplementary information Print Page

85009-C-002 ATTACHMENT 1

SS 257.82 (a)(3) (iii), 100 year flood

PDS-based 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	0.468 (0.377–0.582)	0.534 (0.430–0.665)	0.644 (0.517–0.803)	0.737 (0.590–0.920)	0.867 (0.680–1.10)	0.969 (0.748–1.24)	1.07 (0.811–1.39)	1.18 (0.868–1.54)	1.32 (0.949–1.75)	1.44 (1.01–1.91)
10-min	0.685 (0.552–0.853)	0.782 (0.629–0.974)	0.943 (0.757–1.18)	1.08 (0.863–1.35)	1.27 (0.996–1.61)	1.42 (1.10–1.81)	1.57 (1.19–2.03)	1.73 (1.27–2.26)	1.94 (1.39–2.57)	2.10 (1.48–2.80)
15-min	0.836 (0.673–1.04)	0.954 (0.767–1.19)	1.15 (0.923–1.43)	1.32 (1.05–1.64)	1.55 (1.21–1.97)	1.73 (1.34–2.21)	1.92 (1.45–2.47)	2.11 (1.55–2.75)	2.37 (1.70–3.13)	2.56 (1.81–3.41)
30-min	1.23 (0.986–1.52)	1.40 (1.13–1.74)	1.69 (1.36–2.11)	1.94 (1.55–2.42)	2.28 (1.79–2.89)	2.55 (1.97–3.25)	2.82 (2.13–3.64)	3.10 (2.28–4.05)	3.48 (2.50–4.61)	3.77 (2.66–5.02)
60-min	1.62 (1.31–2.02)	1.86 (1.49–2.31)	2.25 (1.80–2.80)	2.58 (2.06–3.22)	3.05 (2.39–3.88)	3.42 (2.65–4.37)	3.81 (2.88–4.92)	4.21 (3.10–5.50)	4.75 (3.41–6.29)	5.17 (3.64–6.88)
2-hr	2.02 (1.64–2.49)	2.31 (1.88–2.85)	2.80 (2.27–3.45)	3.22 (2.60–3.98)	3.82 (3.03–4.81)	4.30 (3.35–5.44)	4.79 (3.65–6.14)	5.31 (3.94–6.89)	6.01 (4.34–7.90)	6.56 (4.65–8.67)
3-hr	2.27 (1.86–2.78)	2.60 (2.12–3.18)	3.15 (2.57–3.86)	3.63 (2.95–4.46)	4.32 (3.45–5.43)	4.88 (3.83–6.16)	5.46 (4.19–6.97)	6.08 (4.53–7.85)	6.92 (5.03–9.07)	7.59 (5.40–9.98)
6-hr	2.76 (2.28–3.34)	3.14 (2.60–3.81)	3.81 (3.14–4.62)	4.39 (3.61–5.35)	5.26 (4.25–6.55)	5.96 (4.73–7.47)	6.71 (5.19–8.50)	7.50 (5.64–9.63)	8.60 (6.30–11.2)	9.48 (6.79–12.4)
12-hr	3.31 (2.77–3.97)	3.76 (3.14–4.52)	4.56 (3.80–5.48)	5.26 (4.37–6.34)	6.31 (5.15–7.80)	7.17 (5.75–8.90)	8.08 (6.32–10.2)	9.06 (6.88–11.5)	10.4 (7.69–13.5)	11.5 (8.31–14.9)
24-hr	3.89 (3.28–4.62)	4.45 (3.76–5.29)	5.43 (4.57–6.45)	6.29 (5.27–7.49)	7.55 (6.21–9.22)	8.58 (6.93–10.5)	9.66 (7.61–12.0)	10.8 (8.26–13.6)	12.4 (9.21–15.9)	13.7 (9.93–17.6)
2-day	4.49 (3.83–5.28)	5.20 (4.43–6.11)	6.40 (5.44–7.53)	7.43 (6.29–8.76)	8.91 (7.39–10.8)	10.1 (8.22–12.3)	11.3 (8.99–13.9)	12.6 (9.71–15.8)	14.4 (10.7–18.2)	15.8 (11.5–20.1)
3-day	4.93 (4.23–5.75)	5.68 (4.88–6.63)	6.96 (5.96–8.14)	8.06 (6.86–9.44)	9.62 (8.02–11.5)	10.9 (8.89–13.1)	12.2 (9.69–14.9)	13.5 (10.4–16.8)	15.3 (11.5–19.3)	16.8 (12.3–21.3)
4-day	5.27 (4.54–6.12)	6.05 (5.22–7.03)	7.37 (6.34–8.58)	8.50 (7.28–9.92)	10.1 (8.47–12.1)	11.4 (9.36–13.7)	12.7 (10.2–15.5)	14.1 (10.9–17.4)	16.0 (12.0–20.1)	17.5 (12.8–22.1)
7-day	6.06 (5.27–6.98)	6.91 (6.01–7.96)	8.33 (7.22–9.61)	9.54 (8.24–11.0)	11.3 (9.49–13.3)	12.6 (10.4–15.0)	14.0 (11.3–16.9)	15.5 (12.1–19.0)	17.4 (13.2–21.7)	19.0 (14.0–23.8)
10-day	6.77 (5.92–7.75)	7.66 (6.70–8.78)	9.15 (7.98–10.5)	10.4 (9.04–12.0)	12.2 (10.3–14.3)	13.6 (11.3–16.1)	15.0 (12.1–18.0)	16.5 (12.9–20.1)	18.5 (14.0–22.9)	20.0 (14.9–25.1)
20-day	8.94 (7.92–10.1)	9.95 (8.80–11.3)	11.6 (10.2–13.2)	13.0 (11.4–14.8)	14.9 (12.7–17.2)	16.3 (13.7–19.1)	17.8 (14.5–21.1)	19.3 (15.2–23.3)	21.2 (16.2–26.1)	22.7 (17.0–28.2)
30-day	10.8 (9.61–12.1)	12.0 (10.6–13.5)	13.8 (12.3–15.6)	15.4 (13.6–17.4)	17.4 (14.9–20.0)	19.0 (16.0–22.0)	20.5 (16.8–24.1)	22.0 (17.4–26.3)	23.9 (18.3–29.2)	25.4 (19.0–31.3)
45-day	13.1 (11.8–14.7)	14.6 (13.1–16.3)	16.9 (15.1–18.9)	18.7 (16.6–21.0)	21.1 (18.1–24.0)	22.8 (19.3–26.2)	24.4 (20.1–28.5)	26.0 (20.6–30.9)	28.0 (21.5–33.8)	29.3 (22.1–36.1)
60-day	15.1 (13.6–16.8)	16.9 (15.2–18.8)	19.6 (17.6–21.9)	21.7 (19.4–24.3)	24.5 (21.1–27.6)	26.4 (22.4–30.2)	28.2 (23.2–32.7)	29.9 (23.8–35.3)	31.9 (24.5–38.4)	33.2 (25.1–40.7)

[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.

Estimates from the table in csv format: precipitation frequency estimates Submit

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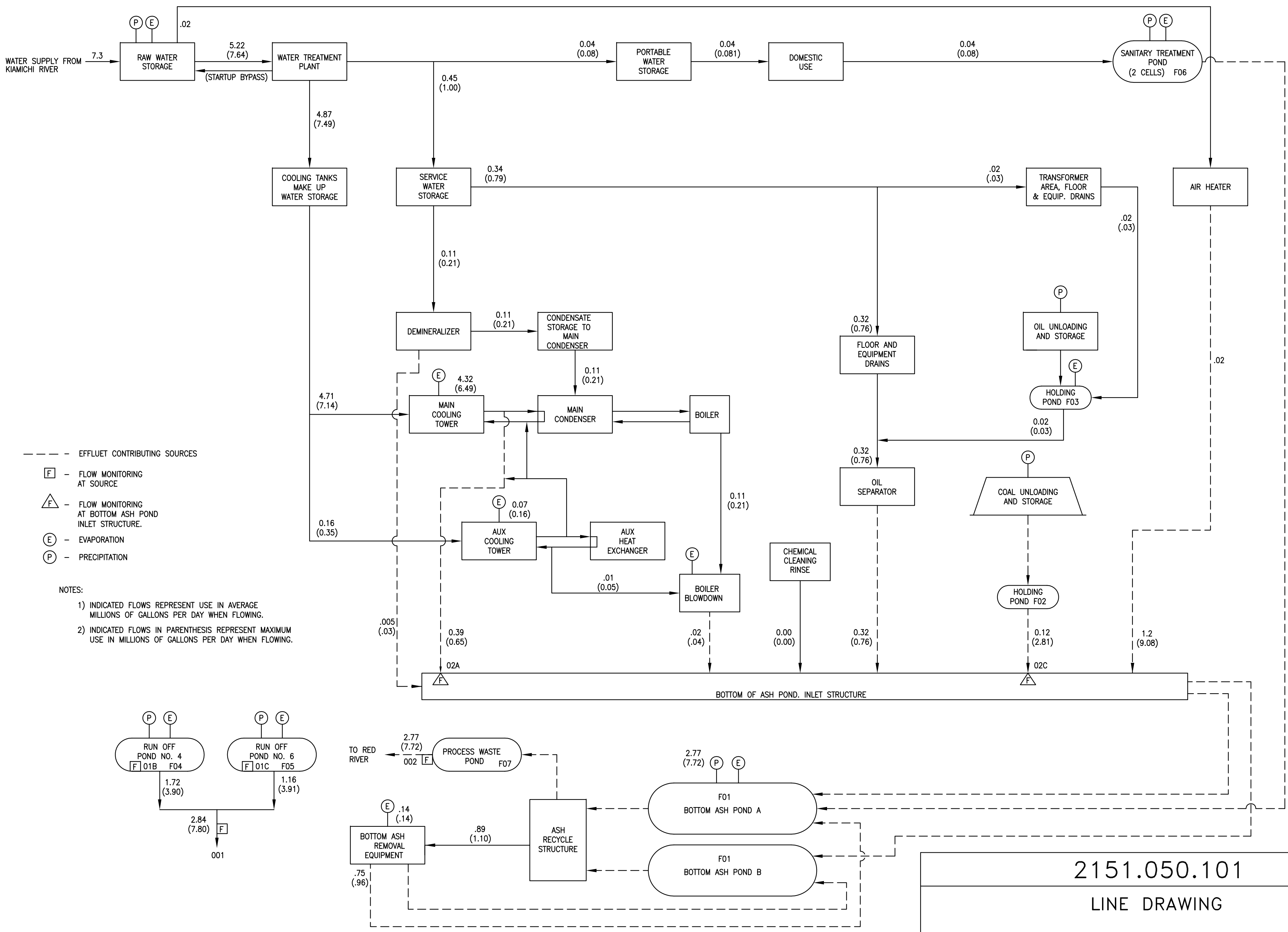


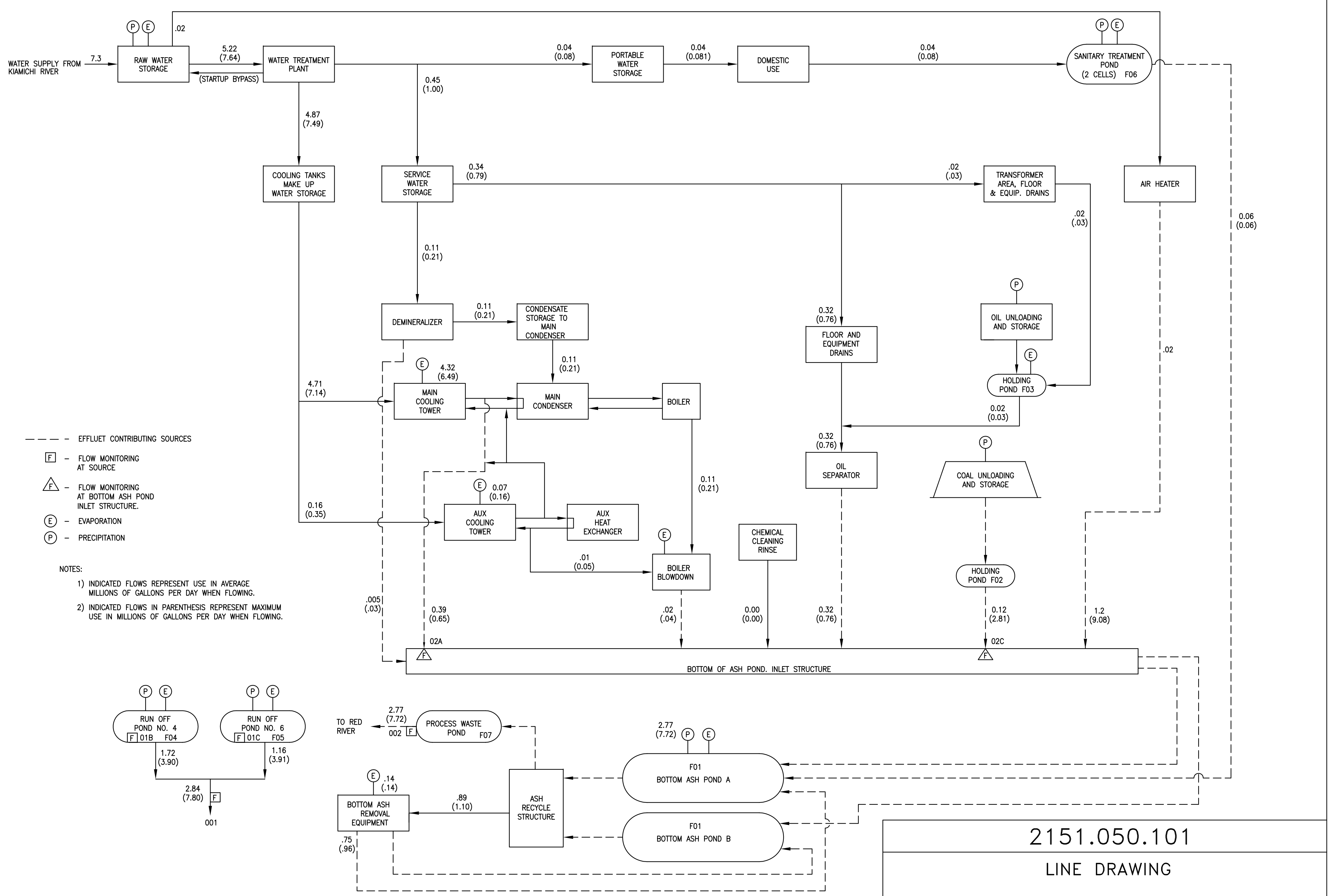
2151.050.101

LINE DRAWING

WESTERN FARMERS – HUGO PLANT
FORT TOWSON, OKLAHOMA

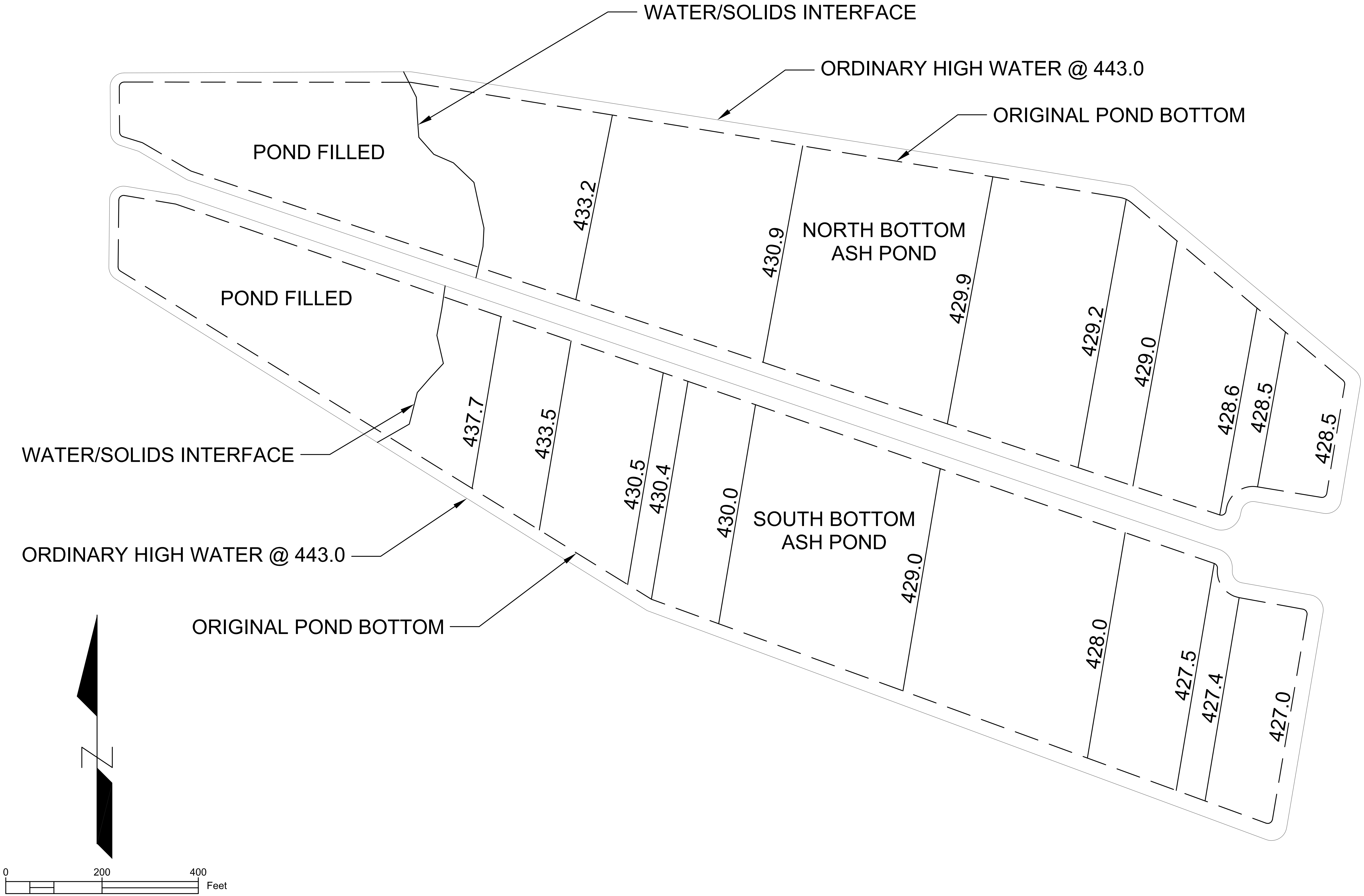
Approved by:	RBM	GBMc STRATEGIC ENVIRONMENTAL SERVICES 219 Brown Lane Bryant, AR 72022	Project No.:	2151–12–050
Checked by:	JBB		Date:	11/07/2012
Drawn by:	IT		Scale:	––

ATTACHMENT A – WATER BALANCE



2151.050.101				
LINE DRAWING				
WESTERN FARMERS – HUGO PLANT FORT TOWSON, OKLAHOMA				
Approved by:	RBM	GBMc	Project No.:	2151–12–050
Checked by:	JBB	STRATEGIC ENVIRONMENTAL SERVICES 219 Brown Lane Bryant, AR 72022	Date:	11/07/2012
Drawn by:	IT		Scale:	––

ATTACHMENT B – BOTTOM ASH PONDS BOTTOM ELEVATION



ENGINEERS
ARCHITECTS
CONSULTANTS
guernsey

BOTTOM ASH PONDS - BOTTOM ELEVATION

WFEC HUGO CCR IMPOUNDMENTS
CHOCTAW COUNTY, OKLAHOMA

DRAWN BY: SDB
APPROVED BY: KES
DATE: JUNE 15, 2016
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