Run-on And Run-off Control System Plan
Jeffrey Energy Center
Bottom Ash Landfill

Prepared for:
Westar Energy
Jeffrey Energy Center
St. Marys, Kansas

Prepared by:
CB&I Environmental & Infrastructure, Inc.

October 2016
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<thead>
<tr>
<th>Date of Review</th>
<th>Reviewer Name</th>
<th>Sections Amended and Reason</th>
<th>Version</th>
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### CCR Regulatory Requirements

<table>
<thead>
<tr>
<th>USEPA CCR Rule Criteria 40 CFR 257.81</th>
<th>Jeffrey Energy Center (JEC) Run-on and Run-off Control System Plan</th>
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<tr>
<td>§257.81(a)(1) stipulates:</td>
<td>Section 4.3.1</td>
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<tr>
<td>(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain:</td>
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<td>(1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm;</td>
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<td>§257.81(a)(2) stipulates:</td>
<td>Section 4.3.2</td>
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<tr>
<td>(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: …</td>
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<tr>
<td>(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.</td>
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<td>§257.81(b) stipulates:</td>
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<td>(b) Run-off from the active portion of the CCR unit must be handled in accordance with the surface water requirements under §257.3-3.</td>
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§257.81(c)(1) stipulates:

(c) Run-on and run-off control system plan—

(1) Content of the plan. The owner or operator must prepare initial and periodic run-on and run-off control system plans for the CCR unit according to the timeframes specified in paragraphs (c)(3) and (4) of this section. These plans must document how the run-on and run-off control systems have been designed and constructed to meet the applicable requirements of this section. Each plan must be supported by appropriate engineering calculations. The owner or operator has completed the initial run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).

§257.81(c)(2) stipulates:

(2) Amendment of the plan. The owner or operator may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility's operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.

Section 5.1

Sections 2.0 & 5.3
<table>
<thead>
<tr>
<th>USEPA CCR Rule Criteria 40 CFR 257.81</th>
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<td><strong>§257.81(c)(3) stipulates:</strong></td>
<td><strong>Section 1.0</strong></td>
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<tr>
<td>(3) Timeframes for preparing the initial plan—(i) Existing CCR landfills. The owner or operator of the CCR unit must prepare the initial run-on and run-off control system plan no later than October 17, 2016.</td>
<td><strong>Section 5.3</strong></td>
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<tr>
<td><strong>§257.81(c)(4) stipulates:</strong></td>
<td><strong>Section 6.0</strong></td>
</tr>
<tr>
<td>(4) Frequency for revising the plan. The owner or operator of the CCR unit must prepare periodic run-on and run-off control system plans required by paragraph (c)(1) of this section every five years. The date of completing the initial plan is the basis for establishing the deadline to complete the first subsequent plan. The owner or operator may complete any required plan prior to the required deadline provided the owner or operator places the completed plan into the facility's operating record within a reasonable amount of time. In all cases, the deadline for completing a subsequent plan is based on the date of completing the previous plan. For purposes of this paragraph (c)(4), the owner or operator has completed a periodic run-on and run-off control system plan when the plan has been placed in the facility's operating record as required by §257.105(g)(3).</td>
<td><strong>Section 6.0</strong></td>
</tr>
<tr>
<td><strong>§257.81(c)(5) stipulates:</strong></td>
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<tr>
<td>(5) The owner or operator must obtain a certification from a qualified professional engineer stating that the initial and periodic run-on and run-off control system plans meet the requirements of this section.</td>
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<tr>
<td>USEPA CCR Rule Criteria 40 CFR 257.81</td>
<td>Jeffrey Energy Center (JEC) Run-on and Run-off Control System Plan</td>
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<tr>
<td>§257.81(d) stipulates:</td>
<td>Sections 5.1 &amp; 5.2</td>
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<td>(d) The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in §257.105(g), the notification requirements specified in §257.106(g), and the internet requirements specified in §257.107(g).</td>
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1.0 INTRODUCTION

CB&I Environmental and Infrastructure, Inc. (CB&I) has prepared the following Run-On and Run-Off Control System Plan (Plan) at the request of Westar Energy (Westar) for the Bottom Ash Landfill (Landfill) located at the Jeffrey Energy Center (JEC) in St. Mary’s, Kansas. JEC is a coal-fired and natural gas fired power plant that has been in operation since 1980. The Bottom Ash Landfill has been deemed to be a regulated coal combustion residual (CCR) unit by the United States Environmental Protection Agency (USEPA), through the Disposal of Coal Combustion Residuals from Electric Utilities Final Rule (CCR Rule) 40 CFR §257 and §261.

CCR regulations set forth within Title 40 Code of Federal Regulations (CFR) Part §257.81, provide guidelines for stormwater management controls (run-on and run-off controls) to ensure that regulated CCR units are designed to safely manage storm events up to the 25-year, 24-hour storm. Specifically, §257.81 stipulates:

§257.81: “(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: (1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm; and (2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.”

As demonstrated in this Plan, the stormwater run-on and run-off controls have been designed for the 25-year, 24-hour storm and are in compliance with 40 CFR Part §257.81. This document provides discussion of CB&I’s professional opinion regarding specific aspects of the Rule as they pertain to the Bottom Ash Landfill which has been deemed as a regulated CCR unit at Westar’s Jeffrey Energy Center. This Plan will be placed in the Facility Operating Plan prior to October 17, 2016, per 40 CFR Part §257.81(c)(3).

2.0 REGULATORY OVERVIEW OF RUN-ON AND RUN-OFF CONTROL REQUIREMENTS

On April 17, 2015, the USEPA published the CCR Rule under Subtitle D of the Resource Conservation and Recovery Act (RCRA) as 40 CFR Parts §257 and §261. The purpose of the CCR Rule is to regulate the management of coal combustion residuals in regulated units for landfill and surface impoundments. The Bottom Ash Landfill has been deemed to be a regulated CCR unit at JEC.

This Plan marks the initial analysis of the facility run-on and run-off control features based on the permitted facility conditions. Construction activities may occur at the facility that will subsequently modify the current conditions as described within this Plan. This Plan will be amended in accordance with §257.81(c)(2), which stipulates:

§257.81(c)(2): “(c)(2) The owner or operator may amend the written run-on and run-off control system plan at any time provided the revised plan is placed in the facility’s operating record as required by §257.105(g)(3). The owner or operator must amend the written run-on and run-off control system plan whenever there is a change in conditions that would substantially affect the written plan in effect.”

This Plan will be amended to accurately analyze the run-on and run-off control features associated with the permitted facility conditions. Amendments to this Plan will be
documented within the Plan Review/Amendment Log immediately following the Table of Contents.

This Plan also details Westar’s compliance with the recordkeeping requirements specified in Section 5.0.

### 3.0 JEC LANDFILL OVERVIEW

#### 3.1 Site Location and Topography

Westar owns and operates an industrial landfill at JEC in St. Marys, Pottawatomie County, Kansas. JEC is located approximately 4.5 miles north of Belvue, Kansas and approximately 4.5 miles west of Highway 63 and resides in Sections 1, 2, 11, and 12, Township 9 South, Range 11 East and Sections 6 and 7, Township 9 South, Range 12 East. The location of the Bottom Ash Landfill is depicted in Figure 1.

The Bottom Ash Area is located due east of the Tower Hill Lake. The Bottom Ash Area is comprised of Bottom Ash Area 1 (Area 1) which is approximately 52.5 acres which includes both a landfill, which is approximately 32.7 acres, and impoundment, which is approximately 19.8 acres. The facility also has a proposed Bottom Ash Area 2 (Area 2) which is approximately 62.0 acres. Area 2 has not yet been constructed.

This Plan is designed to only address the stormwater management controls for currently operational areas. As such, only Area 1 is discussed herein. However, in accordance with Section 2.0 and §257.81(c)(2), run-on and run-off controls for Area 2 will be evaluated and appropriately described in updates to the Plan in the event that this area is constructed and becomes operational.

Area 1 currently consists of large berms and gentle depressions which are being filled with bottom ash. The topography varies across Area 1 between approximate elevation of 1226-1299 ft. mean sea level (MSL). Once bottom ash disposal and final cover installation and closure of the site is complete, Area 1 will have a 1% slope towards the Tower Hill Lake settling basin. Existing and permitted site topography is depicted in Figure 2 and Figure 3, respectively.

Tower Hill Lake was developed in 1978 through the construction of the Tower Hill Dam. The lake was developed to provide make-up water for JEC processes, as well to manage all stormwater associated with the facility, including the Bottom Ash Landfill, in accordance with Industrial Landfill Permit No. 0359. Tower Hill Lake has been designed to accept all non-contact stormwater and discharge off-site, in accordance with National Pollutant Discharge Elimination System (NPDES) Permit No. I-KS67-PO06 and 40 CFR Part §257.81(b). Tower Hill Lake is located downstream of the Bottom Ash Landfill.

#### 3.2 Existing Regulatory Permits and Consents

Westar has been granted an Industrial Landfill Permit at JEC by the Kansas Department of Health and Environment – Bureau of Waste Management (KDHE-BWM) Permit No. 0359, in accordance with Kansas Statutes Annotated (K.S.A.) 65-3407. The Industrial Landfill Permit allows CCR generated on-site at JEC to be properly disposed of within the Industrial Landfill Permit boundary, including the Bottom Ash Area 1.
Westar has also been granted a Kansas Water Pollution Control Permit and Authorization to Discharge under the National Pollutant Discharge Elimination System (NPDES) Permit No. I-KS67-PO06 from the KDHE-BWM. The NPDES Permit covers different outfall locations at JEC and allows the discharge of water into the Kansas River and Lost Creek in accordance with effluent limitations and monitoring requirements. All water within the Industrial Landfill Permit boundary ultimately discharge from the Tower Hill Lake system, which is covered under the NPDES Permit.

3.3 Stormwater Management System Overview

The existing stormwater management system at Area 1 includes a perimeter berm structure constructed along the north and west borders of the Area 1 Landfill. Stormwater run-on from the north and west is diverted away from Area 1 through natural drainage channels at the toe of the north and west perimeter berms. Stormwater run-on from the east flows towards the active portions of Area 1.

Stormwater generated at the Area 1 Landfill is permitted to collect within the surface impoundment in Area 1, denoted as the Bottom Ash Area Surface Impoundment (see Figure 2). Stormwater collects in the surface impoundment until it reaches the top of the constructed overflow riser structure (current elevation 1239.25 ft MSL). The overflow riser structure allows water to be conveyed from the surface impoundment, downward into a horizontal pipe. Stormwater is conveyed by the horizontal pipe through the perimeter berm. Stormwater flows from the pipe to a natural drainage channel that drains into Tower Hill Lake.

Tower Hill Lake and the Tower Hill Dam have been designed and constructed to manage non-contact stormwater run-on and run-off within a regional subcatchment that includes the Industrial Landfill Permit boundary, including the Bottom Ash Landfill, as well as adjacent areas outside of the Industrial Landfill Permit boundary. Direct precipitation and non-contact stormwater run-off the regional subcatchment flow to and are managed by Tower Hill Lake. The regional subcatchment that drains into Tower Hill Lake is depicted in Figure 5.

3.3.1 Area 1 Run-On

Potential run-on stormwater comes from subcatchments (also called watersheds, or watershed areas) that are directly adjacent to the landfill boundary. The North and West run-on subcatchments for Bottom Ash Area 1 are detailed in Figure 6. A berm has been constructed around portions of the perimeter of Area 1 in order to direct the stormwater run-on from the North and West run-on subcatchments away from the active portions of the landfill in a controlled manner. It is noted that the potential for stormwater run-on flowing into active portions of the landfill exist in small areas from the east. An appropriate remedy has been modeled and shown to be effective in this Plan, as further described in Section 4.3.1 of this Plan.

Stormwater subcatchments that are upstream of the Area 1 Landfill that will contribute to run-on if not appropriately managed are depicted in Figure 4.

3.3.2 Area 1 Stormwater Management Controls

Direct precipitation and stormwater run-off from Area 1 Landfill has historically been managed by the Bottom Ash Area Surface Impoundment (see Figure 2). Direct
precipitation falling on active portions of the landfill is defined as contact water. All contact water and stormwater run-off drains into the Bottom Ash Area Surface Impoundment where bottom ash particles are allowed to settle. Contact water and stormwater collects in the surface impoundment until it reaches the top of the constructed overflow riser structure. The overflow riser structure conveys water after treatment from the surface impoundment through a horizontal pipe, to a natural drainage channel that drains to the Bottom Ash Pond. The Bottom Ash Pond is used to settle any CCR particles within the contact water. Treated water will then drain from the Bottom Ash Pond into Tower Hill Lake. Positive drainage towards the overflow riser is maintained throughout landfilling operations. Once bottom ash disposal and final cover installation/closure is complete, direct precipitation and stormwater run-off from Area 1 will drain to Tower Hill Lake via gravity flow. Tower Hill Lake eventually drain into a tributary of the Kansas River. The outfall location at Tower Hill Lake is monitored to ensure that effluent limits meet the standards set by the NPDES Permit No. I-KS67-PO06 and 40 CFR Part §257.81(b).

3.3.3 Area 1 Stormwater Run-Off Location

Stormwater run-off is designed to collect in the Bottom Ash Area Surface Impoundment until it reaches the top of the overflow riser structure. Stormwater that passes through the overflow system is designed to drain into a natural drainage channel. The natural drainage channel collects stormwater flows from the North and West run-on subcatchments as well as stormwater overflow from the Bottom Ash Area Surface Impoundment. All stormwater that collects in the natural drainage channel drains into the Bottom Ash Pond. The Bottom Ash Pond is used to settle any CCR particles within the contact water. Treated water will then drain from the Bottom Ash Pond into Tower Hill Lake. The outfall location at Tower Hill Lake is monitored to ensure that effluent limits meet the standards set by the NPDES Permit No. I-KS67-PO06 and 40 CFR Part §257.81(b).

3.4 Stormwater Management Operations and Maintenance

3.4.1 Routine Operations and Maintenance

Area 1 is actively accepting bottom ash deposits from JEC. Historically, the bottom ash slurry mixture is sluiced through a piping network to the surface impoundment within Area 1 where the bottom ash mixture is allowed to settle. Dry bottom ash is then transported to the southern part of Area 1 where it is deposited and graded to a slope that promotes positive drainage towards the overflow riser structure. Dry bottom ash may also be utilized off site. Historically, the perimeter berm structure and overflow riser structure are raised contemporaneously as the bottom ash elevation increases. The perimeter berm and overflow riser structure are raised at a uniform interval to ensure that an appropriate freeboard between these structures and the top of bottom ash is maintained. Phased filling will continue at Area 1 until permitted final grades have been achieved within the Bottom Ash Landfill.

3.4.2 Previous Inspection review of Run-on / Run-off controls

Weekly and annual inspections occur at the facility for all CCR units in line with inspections requirements outlined in 40 CFR §257.84. A review of the weekly inspection reports conducted from October 2015 through May 2016 and previous annual report dated January 15, 2016 report that erosion occurred within exposed bottom ash along the north and west berm within Area 1 as well as seeps noted along the downstream slope of the west berm. The weekly inspection reports also noted areas of seepage and woody vegetation along the
north and west berm. Proposed remedial actions have been undertaken to progressively establish and maintain vegetation in these areas, to minimize the erosion through operational maintenance, to investigate and monitor areas of seepage, and maintain areas of erosion. Current site surveys confirm filling and grading processes are effectively advancing the site to design elevations.

3.4.3 Corrective Actions and Documentation

A review of the annual and weekly Bottom Ash Landfill inspection reports show that remedial actions have been proposed to minimize erosion. Remedial actions for run-on/run-off controls for the site will be reported in Operational Plan as they are undertaken.

4.0 HYDROLOGIC ANALYSES

4.1 Methodology Overview

In order to determine compliance with 40 CFR Part §257.81 regarding the management of stormwater run-on and run-off at the Area 1 Landfill, existing site topography, permitted final grades, and stormwater drainage features were modeled using the computer model software HydroCAD. This computer model is used to develop discharge rates and volumes for the 25-year, 24-hour storm event for each storm feature utilized at Area 1 to manage stormwater run-on and run-off.

4.1.1 Landfill Run-on and Run-off Analysis

Landfill Run-on

The purpose of the run-on analysis is to demonstrate that the run-on control system will safely convey stormwater around the permitted Area 1 Landfill boundary. The run-on analysis will determine stormwater run-on peak discharge rates and volumes associated with the 25-year, 24-hour storm event. A perimeter drainage channel will be sized to properly convey these peak discharge rates and volumes. The proposed system is modeled to ensure that the proposed drainage channel does not overtop. The run-on subcatchments flowing into the Bottom Ash Landfill boundary are depicted in Figure 4.

Landfill Run-off

A review of the permitted final grades for the Bottom Ash Landfill show that the CCR unit has been previously designed to have ponding water on top of the landfill final cover. CB&I recommends that the permitted final grades be modified to eliminate ponding water in order to comply with 40 CFR Part §257.102, which states:

§257.102: “(d) Closure performance standard when leaving CCR in place—(1) The owner or operator of a CCR unit must ensure that, at a minimum, the CCR unit is closed in a manner that will: (ii) Preclude the probability of future impoundment of water, sediment, or slurry;…”

As part of this recommendation, it is also anticipated that a drainage channel will be required along the inside toe of the impounding berm. Based on discussions with Westar, a 1% slope towards the impounding berm will be utilized to determine run-off discharge rates and volumes from the proposed modification of the permitted final grades, as depicted in Figure 4. The proposed drainage channel will be sized to properly convey stormwater run-
off from the modified final landform without overtopping. The proposed landfill drainage channel will be constructed concurrently with the closure of the Bottom Ash Surface Impoundment.

The locations of the proposed stormwater features are depicted in Figure 6.

4.1.2 Regional Run-off Analysis

As Tower Hill Lake was established to serve as the primary stormwater control for JEC, a regional run-off analysis has been modeled to demonstrate that Tower Hill Lake is appropriately sized to accommodate the stormwater run-off associated with the 25-year, 24-hour storm event for all contributing areas, of which the Bottom Ash Area 1 is a small proportion. The run-off analysis analyzes the peak discharge rate and volume from the regional watershed. The regional watershed was modeled to show that Tower Hill Lake has the available capacity to accept the stormwater run-off from the regional watershed. The regional watershed contributing to the overall stormwater flow into Tower Hill Lake is depicted in Figure 5.

4.2 Model Input Parameters

To ensure that all stormwater run-on and run-off control features comply with 40 CFR Part §257.81, all elements were computer modeled with numerous conservative assumptions. AutoCAD Civil3D 2014 (AutoCAD) was utilized to delineate key features and the computer model HydroCAD was used to develop discharge rates and volumes for the 25-year, 24-hour storm event to evaluate regulatory compliance with 40 CFR Part §257.81 at JEC.

The Natural Resources Conservation Service (NRCS), formerly the Soil Conservation Service (SCS), developed methods TR-20 and TR-55 as standardized stormwater modeling. Both provide similar results; the main differentiation in methodology is based on the use of chart-based solutions vs. computer modeling. TR-55, frequently called the “tabular method” was developed prior to the widespread use or computer modeling. As such it was developed to utilize chart based solutions to use the SCS runoff equation. TR-20 is a computer based modeling approach that is more complex and generally considered more accurate than TR-55, however some data from TR-55 method was more appropriate for some of the model and therefore used within the HydroCAD model, details of which are presented below.

HydroCAD was used to model hydrology and hydraulics of stormwater for the Bottom Ash Area 1 using the TR-20 procedures developed by the Soil Conservation Services (now the Natural Resource Conservation Service).

The stormwater modeling methodology used for the Bottom Ash Area 1 used the following analysis methods, as further describe in subsequent text:

- Runoff Calculation Method: SCS TR-20
- Reach Routing Method: Storage Indication plus Translation Method
- Pond Routing Method: Storage Indication Method (Modified-Puls)
- Storm Distribution: Rainfall Intensity Table for Kansas Counties - 1997
- Unit Hydrograph: SCS
- Antecedent Moisture Condition: 2
4.2.1 Rainfall Totals and Distributions

Rainfall intensities and distribution patterns for both analyses were determined using *Rainfall Intensity Tables for Kansas Counties - 1997*, developed for the Kansas Department of Transportation and authored by University of Kansas professor Bruce M. McEnroe. Rainfall depths for the modeled scenario were selected from this report and entered into HydroCAD. It is noted that TR-55 outlines that an NRCS Type II 24-hour storm distribution is appropriate within this region of Kansas. These distribution patterns may be selected in HydroCAD. The rainfall totals and distributions table utilized in both analyses can be found in Appendix A.

4.2.2 Subcatchment Boundaries

Subcatchment areas (also known as watersheds) were delineated using AutoCAD based on topographic breaks within the areas to be analyzed. For the landfill run-on and run-off analysis, all areas contributing to stormwater run-on and run-off for Area 1 are delineated and imported into HydroCAD. Subcatchment boundaries are depicted in Figure 4.

For the run-off analysis, the Industrial Landfill watershed was delineated using the United States Geological Survey (USGS) 7.5 minute topographic quadrangle for Emmett and Laclede, Kansas from 2015. Subcatchment boundaries are depicted in Figure 5.

4.2.3 Run-off Coefficient Variables

Curve numbers are used to identify the run-off characteristics of an area. Curve numbers consider both the land cover that will be encountered by surface water (such as grass, road, standing water, etc.) as well as the type of soil that underlies the land cover. The underlying soil is important because soil matrix has a large impact on whether water infiltrates the soil or is shed.

The SCS (NRCS) technical resource TR-55 provides lookup tables of curve numbers for combinations of various landcovers and the underlying surficial soils. As further described below, CB&I developed assumptions of surficial soil types and delineated various landcovers to develop a weighted average for each modeled subcatchment area. Using values specified in TR-55.

Surficial Soil Type

According to the KDHE-BWM Industrial Landfill Permit No. 0359 application (Permit application) for JEC, the site is covered with mostly silty clay loam as well as CCR material. The Permit application defines the surficial soil type as Hydrologic Soil Group D (HSG-D) based on the high run-off potential of both the native soils and CCR material. Surficial soil type within the HydroCAD model was conservatively assumed to be HSG-D in all areas within the Industrial Landfill Permit boundary and the regional subcatchment.

Land Covers

The land covers were determined based on a review of aerial photography and the topographic survey for the Industrial Landfill boundary.

For the landfill run-on and run-off analysis, stormwater run-on and run-off from grassland areas within the Industrial Landfill Permit boundary and landfill final cover were
conservatively assumed to be good grass cover. The TR-55 manual designates good grass cover as grassland with greater than 75% vegetative density. For the purposes of the models, all areas were defined as good grass cover in accordance with the TR-55 manual.

For the run-off analysis, land covers within the regional subcatchment were defined to accurately portray permitted facility conditions.

The Bottom Ash Pond that conveys stormwater to Tower Hill Lake was conservatively assumed to be at full capacity. This area was designated to have a land cover defined as “water surface” according to the TR-55 manual.

Based on permitted final conditions within the Industrial Landfill Permit boundary, all areas are defined to have good grass cover. The TR-55 manual designates good grass cover as grassland with greater than 75% vegetative density. For the purposes of the model, all landfill areas were defined as good grass cover in accordance with the TR-55 manual.

The Power Plant areas were conservatively defined as impervious surfaces. The TR-55 manual designates impervious surfaces as paved parking areas, which accurately reflects land covers in this area. For the purposes of the model, both areas were defined as parking lot areas in accordance with the TR-55 manual.

4.2.4 Time of Concentration

The time of concentration, defined as the longest amount of time a waterdrop would take to travel from the headwater of a subcatchment area to its downstream edge (ie. prior to being managed by a downstream element) was delineated in AutoCAD and manually entered in HydroCAD.

For the run-on model, the following assumptions were made in the calculations:

- For each subcatchment the time of concentration, $T_c$, is the sum of the travel times, $T_t$, of various consecutive flow segments. There are three types of flow: sheet flow, shallow concentrated flow, and open channel flow.

- Sheet flow is assumed to become shallow concentrated flow at 100 feet. It is noted that TR-20 and TR-55 methods specify 300 feet, but subsequent research has generally shown 100 feet to be more accurate.

- The Manning’s coefficient “$n$” for sheet flow was assumed to be 0.15, indicative of short-grass prairie vegetative cover. This number is appropriate for the grass covered run-on subcatchments and is the HydroCAD default.

- An average flow velocity of 7 ft/sec was assumed in shallow concentrated flow calculations for the subcatchment, which is the HydroCAD default for “short grass pasture”, which is considered most indicative of the grass type that exists in these areas.

The time of concentration flow paths are depicted in Figure 4.
For the run-off model, the following assumptions were made in the calculations:

- For each subcatchment the time of concentration, $T_c$, is the sum of the travel times, $T_t$, of various consecutive flow segments. There are three types of flow: sheet flow, shallow concentrated flow, and open channel flow.

- Sheet flow is assumed to become shallow concentrated flow at 100 feet. It is noted that TR-20 and TR-55 methods specify 300 feet, but subsequent research has generally shown 100 feet to be more accurate.

- The Manning’s coefficient “$n$” for sheet flow was assumed to be 0.15, indicative of short-grass prairie vegetative cover. This number is appropriate for the grass covered run-on subcatchments and is the HydroCAD default.

- An average flow velocity of 7 ft/sec was assumed in shallow concentrated flow calculations for the subcatchment, which is the HydroCAD default for “short grass pasture”, which is considered most indicative of the grass type that exists in these areas.

- The Manning’s coefficient “$n$” for channel flow was assumed to be 0.03, indicative of natural steams that are clean and straight. This number is appropriate for the natural drainage channel that conveys stormwater into the Tower Hill Lake and is the HydroCAD default.

The time of concentration flow paths are depicted in Figure 5.

4.2.5 Stormwater Conveyance Features

Stormwater run-off from the Power Plant areas are conveyed underneath a railway in order to flow into the perimeter drainage channel. Stormwater run-off from Power Plant Area 1 flows to three box culverts that are 9-feet wide and 1.5-feet deep. The box culverts are designated as Culvert 1. Stormwater run-off from Power Plant Area 2 flows through a 42-inch, corrugated metal pipe (CMP). This pipe is designated as Culvert 2. Dimensions, pipe material, and inlet/outlet elevations for these structures were provided by Westar. These features were manual imported into HydroCAD and are depicted in Figure 6.

4.2.6 Tower Hill Lake

Tower Hill Lake was modeled by entering the area at each minor and major contour interval to determine incremental detention volumes. The volume of the normal water elevation was also specified. Tower Hill Lake was modeled as a closed system without an outlet structure. This model parameter will provide the total available capacity without any water leaving the basin, which is conservative for this system. Site topography for the Jeffrey Energy Center was provided by Professional Engineering Consultants (PEC), was utilized to determine the available capacity for Tower Hill Lake.

4.3 Model Findings

The HydroCAD results for the 25-year, 24-hour storm duration were analyzed to evaluate run-on and run-off controls at the Bottom Ash Landfill. Results of the landfill run-on analysis indicate that a perimeter drainage channel is necessary to prevent flow onto the active portion of the Landfill during the peak discharge from the 25-year, 24-hour storm event per
40 CFR Part §257.81. Results of the landfill run-off analysis indicate that the proposed landfill drainage channel is appropriately sized to convey the 25-year, 24-hour storm event without overtopping. Results of the regional run-off analysis indicate that the basin (Tower Hill Lake) will not breach the top of berm elevation based on the total stormwater inflow from the 25-year, 24-hour storm event within the Industrial Landfill watershed.

4.3.1 Landfill Run-on and Run-off Analysis (§257.81(a)(1))

Landfill Run-on

The run-on analysis for the Bottom Ash Landfill was completed to determine if the run-on control system complies with 40 CFR Part §257.81(a)(1), which states,

“(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: (1) A run-on control system to prevent flow onto the active portion of the CCR unit during the peak discharge from a 24-hour, 25-year storm;”

Peak run-on rates were determined using HydroCAD. Areas contributing to run-on for the Bottom Ash Landfill have a total discharge rate of 135.58 cfs. At the present time, run-on from adjacent areas to the north and west are directed to perimeter drainage channels that run along the toe of the landfill berm. Run-on from the east currently flows onto active portions of the Bottom Ash Landfill prior to reaching the Bottom Ash surface impoundment.

To comply with 40 CFR Part §257.81(a)(1), CB&I recommends that a perimeter drainage channel be constructed to prevent flow onto the active portion of the Bottom Ash Landfill. It was determined that a v-notch perimeter channel with 4H:1V side slopes, and a 2.5-foot depth running adjacent to the Bottom Ash Landfill waste boundary would have the capacity to convey run-on from the 25-year, 24-hour storm event. The proposed north run-on channel is not required to be constructed until the Bottom Ash Surface Impoundment is deactivated. An alternative perimeter channel design may be utilized if it is appropriately sized to convey run-on from the 25-year, 24-hour storm event.

The flow velocity has been reviewed for the proposed perimeter channel along the east to determine whether scour or erosion is anticipated to occur. Erosion or scour may be anticipated to occur at flow velocities exceeding 5 ft/sec for drainage channels lined with vegetation. Based on observed flow velocities, CB&I ultimately modeled the proposed west run-on perimeter channel flow as a ditch lined with vegetation. This modeling was selected by utilizing a Manning’s coefficient of 0.030, indicative of a vegetative liner. CB&I modeled the proposed north run-on perimeter channel flow as a ditch lined with erosion control material (such as rip-rap or other appropriate erosion control measure). This modeling was selected by utilizing a Manning’s coefficient of 0.035, indicative of a rip-rap liner.

CB&I also reviewed flow velocities within the existing drainage channels noted North channel and West channel. Based on observed flow velocities, CB&I ultimately modeled these drainage channels to be lined with an erosion control material (such as rip-rap, concrete armor, or other appropriate erosion control measure). This modeling was selected by utilizing a Manning’s coefficient of 0.035, indicative of a rip-rap liner.
Landfill Run-off

To comply with 40 CFR Part §257.102, CB&I recommends that a landfill drainage channel be constructed to prevent ponding water on the landfill final cover based on the permitted final grades at the Bottom Ash Landfill Area 1. It was determined that a v-notch channel with 4H:1V side slopes, and a 3-foot depth running along the inside of the perimeter berm would have the capacity to convey stormwater run-off from the landfill for the 25-year, 24-hour storm event. An alternative landfill drainage channel design may be utilized if it is appropriately sized to convey landfill run-off from the 25-year, 24-hour storm event. The locations of the proposed stormwater features are depicted in Figure 6.

The landfill drainage channel flow velocity has been reviewed to determine whether scour or erosion is anticipated to occur. Erosion or scour may be anticipated to occur at flow velocities exceeding 5 ft/sec for drainage channels lined with vegetation. Based on observed flow velocities, CB&I ultimately modeled the proposed landfill drainage channel as a ditch lined with vegetation. This modeling was selected by utilizing a Manning’s coefficient of 0.030, indicative of a vegetative linen.

Results from the Landfill run-on and run-off hydrologic analysis can be found in Appendix B.

4.3.2 Regional Run-off Analysis (§257.81(a)(2) & (§257.81(b))

The run-off analysis for Tower Hill Lake was completed to determine if the run-off control system complies with 40 CFR Part §257.81(a)(2), which states,

“(a) The owner or operator of an existing or new CCR landfill or any lateral expansion of a CCR landfill must design, construct, operate, and maintain: …(2) A run-off control system from the active portion of the CCR unit to collect and control at least the water volume resulting from a 24-hour, 25-year storm.”

Tower Hill Lake is designed to serve as the stormwater run-off management system for the regional watershed including the Area 1. Tower Hill Lake was analyzed to determine if it has been designed to collect and control stormwater run-off from the regional subcatchment for a 25-year, 24-hour storm event.

For the 25-year, 24-hour storm event within the regional subcatchment, it was determined that the subcatchment contributes 327.2 acre-feet of run-off into Tower Hill Lake.

Tower Hill Lake was modeled by entering the area at each minor and major contour interval to determine incremental detention volumes. The available stormwater capacity for the Tower Hill Lake is approximately 2,805 acre-feet. Based on the model, Tower Hill Lake will not overtop from the stormwater discharge volume of the regional subcatchment. It is also noted that a freeboard of 17 feet will be achieved after the discharge volume from the 25-year, 24-hour storm event flows into the Tower Hill Lake.

Results from the run-off hydrologic analysis can be found in Appendix C.
4.4 Engineering Evaluation of Findings

4.4.1 Design Appropriateness Based on Model Findings

Landfill Run-on

Area 1 utilizes a perimeter berm system along the north and west boundaries of the landfill as a run-on control system at the time of this report. Based on model findings, a perimeter drainage channel lined with vegetation has been recommended to comply the 40 CFR Part §257.81. A v-notch perimeter channel with 4H:1V side slopes, and a 2.5-foot depth running adjacent to the east boundary of Area 1 would have the capacity to convey run-on from the 25-year, 24-hour storm event. The proposed north run-on channel is not required to be constructed until the Bottom Ash Surface Impoundment is deactivated. The proposed perimeter drainage channel has been designed to flow into the existing north and west perimeter channels. An alternative perimeter channel design may be utilized if proven to convey run-on from the 25-year, 24-hour storm event.

During Landfill operations, intermediate stormwater conveyance features are placed around active operational areas to properly convey stormwater run-on associated with the 25-year, 24-hour storm event.

Landfill Run-off

Based on model findings, a landfill drainage channel is recommended to be placed along the inside of the perimeter berm to prevent ponding water on the landfill final cover. It was determined that a v-notch channel with 4H:1V side slopes, and a 3-foot depth would have the capacity to convey stormwater run-off from the landfill for the 25-year, 24-hour storm event. The proposed landfill drainage channel has been designed to flow into the existing north and west perimeter channels. An alternative landfill drainage channel design may be utilized if it is appropriately sized to convey landfill run-off from the 25-year, 24-hour storm event.

Regional Run-off

Tower Hill Lake has been designed and constructed to manage stormwater from a regional subcatchment which includes Area 1. Based on model findings, it was determined that Tower Hill Lake has the available capacity to accept the stormwater run-off from the regional subcatchment, including Area 1.

4.4.2 Operations and Maintenance Considerations

Regular inspections of the landfill, perimeter drainage channels, and stormwater conveyance features are recommended in order to clear debris, repair erosion, and monitor any erosion controls.

Operations and maintenance of the Tower Hill Lake basin are recommended to continue as completed previously.
5.0 RECORDS RETENTION AND MAINTENANCE

5.1 Incorporation of Plan into Operating Record

§257.105(g) of 40 CFR Part §257 provides record keeping requirements to ensure that this Plan will be placed in the facility’s operating record. Specifically, §257.105(g) stipulates:

§257.105(g): (g) Operating criteria. The owner or operator of a CCR unit subject to this subpart must place the following information, as it becomes available, in the facility's operating record: (3) The initial and periodic run-on and run-off control system plans as required by §257.81(c).

This Report will be placed within the Facility Operating Record upon Westar's review and approval.

5.2 Notification Requirements (§257.81(d))

§257.106(g) of 40 CFR Part §257 provides guidelines for the notification of the availability of the initial and periodic plan. Specifically, §257.106(g) stipulates:

§257.106(g): (g) Operating criteria. The owner or operator of a CCR unit subject to this subpart must notify the State Director and/or appropriate Tribal authority when information has been placed in the operating record and on the owner or operator's publicly accessible internet site. The owner or operator must: (3) Provide notification of the availability of the initial and periodic run-on and run-off control system plans specified under §257.105(g)(3).

The State Director and appropriate Tribal Authority will be notified upon placement of this Plan in the Facility Operating Record.

§257.107(g) of 40 CFR Part §257 provides publicly accessible Internet site requirements to ensure that this Plan is accessible through the Westar Energy webpage. Specifically, §257.107(g) stipulates:

§257.107(g): (g) Operating criteria. The owner or operator of a CCR unit subject to this subpart must place the following information on the owner or operator's CCR Web site: (3) The initial and periodic run-on and run-off control system plans specified under §257.105(g)(3).

This Plan will be uploaded to Westar Energy's CCR Compliance reporting Website upon Westar’s review and approval.
5.3 Plan Amendments ((§257.81(c)(3) & §257.81(c)(4))

This Plan has been completed in accordance with §257.81(c)(3) to provide an initial analysis of the run-on and run-off control systems. This Plan will continue to undergo review as the Bottom Ash Landfill continues phased construction activities.

Westar Energy is required to prepare periodic run-on and run-off control system plans every five (5) years, as required by §257.81(c)(4) of the Rule. The amended Plan will be reviewed and recertified by a registered professional engineer and will be placed in JEC’s facility operating record as required per §257.105(g)(3). The amended Plan will supersede and replace any prior versions. Availability of the amended Plan will be noticed to the State Director per §257.106(g)(3) and posted to the publicly accessible internet site per §257.107(g)(3).

A record of Plan reviews/assessments is provided on the first page of this document, immediately following the Table of Contents.
6.0 PROFESSIONAL ENGINEER CERTIFICATION (§257.81(c)(5))

The undersigned registered professional engineer is familiar with the requirements of the CCR Rule and has visited and examined the Jeffrey Energy Center or has supervised examination of the Jeffrey Energy Center by appropriately qualified personnel. The undersigned registered professional engineer attests that this CCR Run-on and Run-off Control System Plan has been prepared in accordance with good engineering practice, including consideration of applicable industry standards and meets the requirements of 40 CFR Part §257.81, and that this Plan is adequate for JEC facility. This certification was prepared as required by 40 CFR Part §257.81(c)(5).

Name of Professional Engineer: Richard Southorn

Company: CB&I

Signature: [Signature]

Date: 10/13/16

PE Registration State: Kansas

PE Registration Number: PE25201

Professional Engineer Seal:
FIGURES

Figure 1 - Bottom Ash Landfill, Site Location Plan
Figure 2 - Bottom Ash Landfill, Existing Site Topography
Figure 3 - Bottom Ash Landfill, Permitted Final Landform
Figure 4 - Bottom Ash Landfill, Run-on / Run-off Subcatchments
Figure 5 - Bottom Ash Landfill, Regional Subcatchments
Figure 6 - Bottom Ash Landfill, Proposed Stormwater Features
1. AERIAL TOPO OBTAINED FROM USGS 7.5-MINUTE SERIES, EMMETT AND LACLEDE QUADRANGLE, KANSAS, 2014.
1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.

3. CCR BOUNDARY IS APPROX. 52.5 ACRES.

4. ALL BOUNDARIES AND BORDERS ARE APPROXIMATE.
1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.

3. FINAL GRADES WERE TAKEN FROM KDHE-BWM INDUSTRIAL LANDFILL PERMIT NO. 0359.

4. PERMITTED SITE GRADES REQUIRE MODIFICATION IN ORDER TO COMPLY WITH TITLE 40 CFR PART 257.102.

5. ALL BOUNDARIES ARE APPROXIMATE.
1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.

3. ALL BOUNDARIES ARE APPROXIMATE.

NOTES

1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.

3. ALL BOUNDARIES ARE APPROXIMATE.
1. FIGURE ADAPTED FROM USGS 7.5 MINUTE TOPOGRAPHIC QUADRANGLE FROM EMMETT AND LECLEDE, KS (2015).

2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.

3. ALL BOUNDARIES ARE APPROXIMATE.
1. EXISTING CONTOURS DEVELOPED BY PROFESSIONAL ENGINEERING CONSULTANTS IN APRIL 2016.
2. FOR CLARITY, NOT ALL SITE FEATURES MAY BE SHOWN.
3. ALL BOUNDARIES AND CHANNELS ARE APPROXIMATE.
APPENDIX A

Rainfall Intensity Tables for Kansas Counties
RAINFALL INTENSITY TABLES

FOR KANSAS COUNTIES

Developed for

Kansas Department of Transportation

by

Bruce M. McEnroe

Department of Civil and Environmental Engineering
University of Kansas
Lawrence, Kansas

June, 1997
## RAINFALL INTENSITY TABLE

**POTTAWATOMIE COUNTY KANSAS**

*This table contains average rainfall intensities in inches per hour.*

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RAINFALL INTENSITY TABLE
POTTAWATOMIE  COUNTY
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THIS TABLE CONTAINS AVERAGE RAINFALL INTENSITIES
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RAINFALL INTENSITY TABLE
POTTAWATOMIE COUNTY KANSAS

THIS TABLE CONTAINS AVERAGE RAINFALL INTENSITIES IN INCHES PER HOUR.

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APPENDIX B

Landfill Run-on / Run-off HydroCAD Output Files
## Area Listing (all nodes)

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<th>Area (acres)</th>
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<th>Description</th>
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<tr>
<td>61.608</td>
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<td>&gt;75% Grass cover, Good, HSG D (E1, E2, N, NLF, SLF, W)</td>
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<tr>
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<td>98</td>
<td>Paved parking, HSG D (P1, P2)</td>
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<tr>
<td><strong>72.496</strong></td>
<td>83</td>
<td><strong>TOTAL AREA</strong></td>
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Summary for Subcatchment E1: East Run-on 1

Runoff  =  24.54 cfs @  11.94 hrs,  Volume=  1.106 af,  Depth=  3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr  25-yr, 24-hr Rainfall=6.00"

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<td>Pervious Area</td>
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<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
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<td>Sheet Flow, Grass: Short n= 0.150 P2= 3.36&quot;</td>
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<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
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3.7  143  Total

Subcatchment E1: East Run-on 1

Hydrograph

Type II 24-hr  25-yr
24-hr Rainfall=6.00"
Runoff Area=3.509 ac
Runoff Volume=1.106 af
Runoff Depth=3.78"
Flow Length=143'
Slope=0.2500 '/'
Tc=3.7 min
CN=80
Summary for Subcatchment E2: East Run-on 2

Runoff = 15.02 cfs @ 11.94 hrs, Volume= 0.679 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr  25-yr, 24-hr Rainfall=6.00"

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<td>100.00% Pervious Area</td>
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<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
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Subcatchment E2: East Run-on 2

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=2.154 ac
Runoff Volume=0.679 af
Runoff Depth=3.78"
Flow Length=164'
Slope=0.2500 '/'
Tc=3.8 min
CN=80
Summary for Subcatchment N: North Run-on

Runoff = 46.14 cfs @ 12.15 hrs, Volume = 3.684 af, Depth = 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall = 6.00"

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22.1 1,798 Total

Subcatchment N: North Run-on

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall = 6.00"
Runoff Area = 11.691 ac
Runoff Volume = 3.684 af
Runoff Depth = 3.78"
Flow Length = 1,798'
Tc = 22.1 min
CN = 80
Summary for Subcatchment NLF: North Landfill

Runoff = 52.26 cfs @ 12.28 hrs, Volume= 5.426 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr  25-yr, 24-hr Rainfall=6.00"

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<th>Velocity (ft/sec)</th>
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<td>Sheet Flow,</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>Grass: Short n= 0.150</td>
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<tr>
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<td>P2= 3.36&quot;</td>
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<tr>
<td>21.0</td>
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<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td>Short Grass Pasture</td>
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<td></td>
<td>Kv= 7.0 fps</td>
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</tbody>
</table>

33.6 982 Total

Subcatchment NLF: North Landfill

Hydrograph

Type II 24-hr  25-yr
24-hr Rainfall=6.00"
Runoff Area=17.220 ac
Runoff Volume=5.426 af
Runoff Depth=3.78"
Flow Length=982'
Slope=0.0100 '/'
Tc=33.6 min
CN=80
Summary for Subcatchment P1: Power Plant Area 1

Runoff = 34.67 cfs @ 11.95 hrs, Volume= 1.904 af, Depth= 5.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
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<th>Area (ac)</th>
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<tr>
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<td>Sheet Flow, Smooth surfaces n= 0.011 P2= 3.36&quot;</td>
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<td>3.1</td>
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4.7 475 Total

Subcatchment P1: Power Plant Area 1

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=3.966 ac
Runoff Volume=1.904 af
Runoff Depth=5.76"
Flow Length=475'
Slope=0.0100 '/'
Tc=4.7 min
CN=98
Summary for Subcatchment P2: Power Plant Area 2

Runoff = 63.09 cfs @ 11.93 hrs, Volume = 3.324 af, Depth = 5.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

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<td>Sheet Flow, Smooth surfaces n = 0.011 P2 = 3.36&quot;</td>
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</table>

2.7 340 Total

Subcatchment P2: Power Plant Area 2

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=6.922 ac
Runoff Volume=3.324 af
Runoff Depth=5.76"
Flow Length=340'
Tc=2.7 min
CN=98
Summary for Subcatchment SLF: South Landfill

Runoff = 56.14 cfs @ 12.28 hrs, Volume= 5.829 af, Depth= 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
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<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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<tr>
<td>18.500</td>
<td>100</td>
<td>100.00% Pervious Area</td>
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<table>
<thead>
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<th>Tc (min)</th>
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<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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<tr>
<td>12.6</td>
<td>100</td>
<td>0.0100</td>
<td>0.13</td>
<td></td>
<td>Sheet Flow, Grass: Short  n= 0.150  P2= 3.36&quot;</td>
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<tr>
<td>21.0</td>
<td>882</td>
<td>0.0100</td>
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<td>Shallow Concentrated Flow, Short Grass Pasture  Kv= 7.0 fps</td>
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</table>

33.6 982 Total

Subcatchment SLF: South Landfill

Hydrograph

Type II 24-hr 25-yr
24-hr Rainfall=6.00"
Runoff Area=18.500 ac
Runoff Volume=5.829 af
Runoff Depth=3.78"
Flow Length=982'
Slope=0.0100 '/'
Tc=33.6 min
CN=80
Summary for Subcatchment W: West Run-on

Runoff = 40.11 cfs @ 12.08 hrs, Volume = 2.689 af, Depth = 3.78"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall = 6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
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<td>&gt;75% Grass cover, Good, HSG D</td>
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<tr>
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<td>100</td>
<td>100.00% Pervious Area</td>
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<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
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<tbody>
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<td>Sheet Flow, Grass: Short n = 0.150</td>
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<tr>
<td></td>
<td></td>
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<td>P2 = 3.36&quot;</td>
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<td>0.0800</td>
<td>1.98</td>
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<td>Shallow Concentrated Flow, Short Grass Pasture Kv = 7.0 fps</td>
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</table>

15.8 1,116 Total

Subcatchment W: West Run-on

Flow (cfs) vs Time (hours)

Type II 24-hr 25-yr
Runoff Area = 8.534 ac
Runoff Volume = 2.689 af
Runoff Depth = 3.78"
Flow Length = 1,116'
Tc = 15.8 min
CN = 80
Summary for Reach C1: Culvert 1

Inflow Area = 3.966 ac, 100.00% Impervious, Inflow Depth = 5.76" for 25-yr, 24-hr event
Inflow = 34.67 cfs @ 11.95 hrs, Volume = 1.904 af
Outflow = 34.12 cfs @ 11.95 hrs, Volume = 1.904 af, Attenuation = 2%, Lag = 0.2 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 5.86 fps, Min. Travel Time = 0.2 min
Avg. Velocity = 1.26 fps, Avg. Travel Time = 1.0 min

Peak Storage = 424 cf @ 11.95 hrs
Average Depth at Peak Storage = 0.22'
Bank-Full Depth = 1.50' Flow Area = 40.5 sf, Capacity = 502.93 cfs

A factor of 3.00 has been applied to the storage and discharge capacity
108.0" W x 18.0" H Box Pipe
n = 0.040 Earth, cobble bottom, clean sides
Length = 72.0' Slope = 0.2014 '/'
Inlet Invert = 1,294.00', Outlet Invert = 1,279.50'

Reach C1: Culvert 1

Hydrograph

Inflow Area = 3.966 ac
Avg. Flow Depth = 0.22'
Max Vel = 5.86 fps
108.0" x 18.0"
Box Pipe x 3.00
n = 0.040
L = 72.0'
S = 0.2014 '/'
Capacity = 502.93 cfs
Summary for Reach C2: Culvert 2

Inflow Area = 6.922 ac, 100.00% Impervious, Inflow Depth = 5.76" for 25-yr, 24-hr event
Inflow = 63.09 cfs @ 11.93 hrs, Volume = 3.324 af
Outflow = 62.83 cfs @ 11.93 hrs, Volume = 3.324 af, Atten = 0%, Lag = 0.1 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 16.47 fps, Min. Travel Time = 0.1 min
Avg. Velocity = 4.85 fps, Avg. Travel Time = 0.3 min

Peak Storage = 307 cf @ 11.93 hrs
Average Depth at Peak Storage = 1.46'
Bank-Full Depth = 3.50' Flow Area = 9.6 sf, Capacity = 174.39 cfs

42.0" Round Pipe
n = 0.025 Corrugated metal
Length = 81.0' Slope = 0.1111 '/'
Inlet Invert = 1,292.00', Outlet Invert = 1,283.00'

Reach C2: Culvert 2
Hydrograph

Inflow Area = 6.922 ac
Avg. Flow Depth = 1.46'
Max Vel = 16.47 fps
42.0"
Round Pipe
n = 0.025
L = 81.0'
S = 0.1111 '/'
Capacity = 174.39 cfs
Summary for Reach N1: North Channel

Inflow Area = 43.308 ac, 25.14% Impervious, Inflow Depth = 4.28" for 25-yr, 24-hr event
Inflow = 148.60 cfs @ 12.07 hrs, Volume = 15.444 af
Outflow = 142.77 cfs @ 12.15 hrs, Volume = 15.444 af, Attenuation = 4%, Lag = 4.5 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 8.35 fps, Min. Travel Time = 2.4 min
Avg. Velocity = 2.52 fps, Avg. Travel Time = 7.8 min

Peak Storage = 20,502 cf @ 12.11 hrs
Average Depth at Peak Storage = 2.22'
Bank-Full Depth = 3.00' Flow Area = 31.5 sf, Capacity = 321.41 cfs

0.00' x 3.00' deep channel, n = 0.035
Side Slope Z-value = 3.5 '/' Top Width = 21.00'
Length = 1,185.0' Slope = 0.0354 '/'
Inlet Invert = 1,250.00', Outlet Invert = 1,208.00'

Reach N1: North Channel

Inflow Area = 43.308 ac
Avg. Flow Depth = 2.22'
Max Vel = 8.35 fps
n = 0.035
L = 1,185.0'
S = 0.0354 '/'
Capacity = 321.41 cfs
Summary for Reach N2: Proposed North Run-on Channel

Inflow Area = 14.397 ac, 75.63% Impervious, Inflow Depth = 5.28" for 25-yr, 24-hr event
Inflow = 120.60 cfs @ 11.94 hrs, Volume= 6.334 af
Outflow = 99.35 cfs @ 12.05 hrs, Volume= 6.334 af, Atten= 18%, Lag= 6.9 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.53 fps, Min. Travel Time= 4.6 min
Avg. Velocity = 1.27 fps, Avg. Travel Time= 16.4 min

Peak Storage= 28,249 cf @ 11.98 hrs
Average Depth at Peak Storage= 2.37'
Bank-Full Depth= 2.50' Flow Area= 25.0 sf, Capacity= 118.03 cfs

0.00' x 2.50' deep channel, n= 0.035
Side Slope Z-value= 4.0 '/' Top Width= 20.00'
Length= 1,255.0' Slope= 0.0096 '/'
Inlet Invert= 1,282.00', Outlet Invert= 1,270.00'

Reach N2: Proposed North Run-on Channel

Hydrograph

Inflow Area=14.397 ac
Avg. Flow Depth=2.37'
Max Vel=4.53 fps
n=0.035
L=1,255.0'
S=0.0096 '/'
Capacity=118.03 cfs
Summary for Reach NLF1: Proposed North Landfill Channel

Inflow Area = 17.220 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 52.26 cfs @ 12.28 hrs, Volume = 5.426 af
Outflow = 49.01 cfs @ 12.48 hrs, Volume = 5.426 af, Atten = 6%, Lag = 11.6 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 3.34 fps, Min. Travel Time = 6.5 min
Avg. Velocity = 1.03 fps, Avg. Travel Time = 21.0 min

Peak Storage = 19,153 cf @ 12.37 hrs
Average Depth at Peak Storage = 1.92'
Bank-Full Depth = 3.00' Flow Area = 36.0 sf, Capacity = 161.92 cfs

0.00' x 3.00' deep channel, n = 0.030
Side Slope Z-value = 4.0 '/' Top Width = 24.00'
Length = 1,300.0' Slope = 0.0050 '/'
Inlet Invert = 0.00', Outlet Invert = -6.50'

Reach NLF1: Proposed North Landfill Channel

Hydrograph

Inflow Area = 17.220 ac
Avg. Flow Depth = 1.92'
Max Vel = 3.34 fps
n = 0.030
L = 1,300.0'
S = 0.0050 '/'
Capacity = 161.92 cfs
Summary for Reach SLF1: Proposed South Landfill Channel

Inflow Area = 18.500 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event

Inflow = 56.14 cfs @ 12.28 hrs, Volume= 5.829 af
Outflow = 53.04 cfs @ 12.47 hrs, Volume= 5.829 af, Atten= 6%, Lag= 11.1 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.40 fps, Min. Travel Time= 6.2 min
Avg. Velocity = 1.06 fps, Avg. Travel Time= 20.0 min

Peak Storage= 19.733 cf @ 12.37 hrs
Average Depth at Peak Storage= 1.97'
Bank-Full Depth= 3.00' Flow Area= 36.0 sf, Capacity= 161.98 cfs

0.00' x 3.00' deep channel, n= 0.030
Side Slope Z-value= 4.0 '/' Top Width= 24.00'
Length= 1,265.0' Slope= 0.0050 '/'
Inlet Invert= 0.00', Outlet Invert=-6.33'

Reach SLF1: Proposed South Landfill Channel

Hydrograph

Inflow Area=18.500 ac
Avg. Flow Depth=1.97'
Max Vel=3.40 fps
n=0.030
L=1,265.0'
S=0.0050 '/'
Capacity=161.98 cfs
Summary for Reach W1: West Channel

Inflow Area = 29.188 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 64.33 cfs @ 12.10 hrs, Volume= 9.197 af
Outflow = 63.63 cfs @ 12.12 hrs, Volume= 9.197 af, Atten= 1%, Lag= 1.5 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.22 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 3.25 fps, Avg. Travel Time= 2.5 min

Peak Storage= 3,349 cf @ 12.11 hrs
Average Depth at Peak Storage= 1.41'
Bank-Full Depth= 3.00' Flow Area= 31.5 sf, Capacity= 480.36 cfs

0.00' x 3.00' deep channel, n= 0.035
Side Slope Z-value= 3.5 '/' Top Width= 21.00'
Length= 480.0' Slope= 0.0792 '/'
Inlet Invert= 1,228.00', Outlet Invert= 1,190.00'

Reach W1: West Channel

Hydrograph

Inflow Area=29.188 ac
Avg. Flow Depth=1.41'
Max Vel=9.22 fps
n=0.035
L=480.0'
S=0.0792 '/'
Capacity=480.36 cfs
Summary for Reach W2: Proposed West Run-on Channel

Inflow Area = 2.154 ac, 0.00% Impervious, Inflow Depth = 3.78" for 25-yr, 24-hr event
Inflow = 15.02 cfs @ 11.94 hrs, Volume = 0.679 af
Outflow = 12.15 cfs @ 12.06 hrs, Volume = 0.679 af, Attenuation = 19%, Lag = 6.8 min

Routing by Stor-Ind+Trans method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Max. Velocity = 3.48 fps, Min. Travel Time = 4.5 min
Avg. Velocity = 1.10 fps, Avg. Travel Time = 14.1 min

Peak Storage = 3,372 cf @ 11.98 hrs
Average Depth at Peak Storage = 0.95'
Bank-Full Depth = 2.50' Flow Area = 25.0 sf, Capacity = 166.32 cfs

0.00' x 2.50' deep channel, n = 0.030
Side Slope Z-value = 4.0 '/' Top Width = 20.00'
Length = 932.0' Slope = 0.0139 '/
Inlet Invert = 1,283.00', Outlet Invert = 1,270.00'

Reach W2: Proposed West Run-on Channel

Hydrograph

Inflow Area = 2.154 ac
Avg. Flow Depth = 0.95'
Max Vel = 3.48 fps
n = 0.030
L = 932.0'
S = 0.0139 '/'
Capacity = 166.32 cfs
Summary for Pond THL: Tower Hill Lake

Inflow Area = 72.496 ac, 15.02% Impervious, Inflow Depth = 4.08" for 25-yr, 24-hr event
Inflow = 205.49 cfs @ 12.14 hrs, Volume = 24.641 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume = 0.000 af, Atten = 100%, Lag = 0.0 min

Routing by Stor-Ind method, Time Span = 0.00-48.00 hrs, dt = 0.05 hrs
Peak Elev = 1,146.21' @ 48.00 hrs  Surf.Area = 5,130,589 sf  Storage = 1,073,240 cf

Plug-Flow detention time = (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time = (not calculated: no outflow)

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<th>Avail.Storage</th>
<th>Storage Description</th>
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<td>122,166,852 cf</td>
<td>Custom Stage Data (Prismatic)</td>
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<table>
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Pond THL: Tower Hill Lake

Inflow Area=72.496 ac
Peak Elev=1,146.21'
Storage=1,073,240 cf
APPENDIX C

Regional Run-off HydroCAD Output Files
### Area Listing (all nodes)

<table>
<thead>
<tr>
<th>Area (acres)</th>
<th>CN</th>
<th>Description</th>
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<tbody>
<tr>
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<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D (WC)</td>
</tr>
<tr>
<td>76.350</td>
<td>98</td>
<td>Water Surface, HSG D (WC)</td>
</tr>
</tbody>
</table>
Summary for Subcatchment WC: Watershed Capacity

Runoff = 963.68 cfs @ 13.99 hrs, Volume= 327.155 af, Depth= 3.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr, 24-hr Rainfall=6.00"

<table>
<thead>
<tr>
<th>Area (ac)</th>
<th>CN</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>934.496</td>
<td>80</td>
<td>&gt;75% Grass cover, Good, HSG D</td>
</tr>
<tr>
<td>76.350</td>
<td>98</td>
<td>Water Surface, HSG D</td>
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<tr>
<td>1,010.846</td>
<td>81</td>
<td>Weighted Average</td>
</tr>
<tr>
<td>934.496</td>
<td>92.45% Pervious Area</td>
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</tr>
<tr>
<td>76.350</td>
<td>7.55% Impervious Area</td>
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</table>

<table>
<thead>
<tr>
<th>Tc (min)</th>
<th>Length (feet)</th>
<th>Slope (ft/ft)</th>
<th>Velocity (ft/sec)</th>
<th>Capacity (cfs)</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>7.2</td>
<td>100</td>
<td>0.0400</td>
<td>0.23</td>
<td></td>
<td>Sheet Flow, Grass: Short n= 0.150 P2= 3.36&quot;</td>
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<tr>
<td>13.5</td>
<td>1,138</td>
<td>0.0400</td>
<td>1.40</td>
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<td>Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps</td>
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<tr>
<td>147.2</td>
<td>4,737</td>
<td>0.1000</td>
<td>0.54</td>
<td>16.09</td>
<td>Channel Flow, Area= 30.0 sf Perim= 4,737.0' r= 0.01' n= 0.030 Stream, clean &amp; straight</td>
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167.9 5,975 Total

Subcatchment WC: Watershed Capacity

Type II 24-hr 25-yr, 24-hr Rainfall=6.00"
Runoff Area=1,010.846 ac
Runoff Volume=327.155 af
Runoff Depth=3.88"
Flow Length=5,975'
Tc=167.9 min
CN=81
Summary for Pond THL: Tower Hill Lake

Inflow Area = 1,010.846 ac, 7.55% Impervious, Inflow Depth = 3.88" for 25-yr, 24-hr event
Inflow = 963.68 cfs @ 13.99 hrs, Volume = 327.155 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume = 0.000 af, Attenuation = 100%, Lag = 0.0 min

Routing by Stor-Ind method, Time Span = 0.00-40.00 hrs, dt = 0.05 hrs
Peak Elev = 1,148.70' @ 33.65 hrs Surf.Area = 5,408,743 sf Storage = 14,250,505 cf
Plug-Flow detention time = (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time = (not calculated: no outflow)

Volume Invert Avail.Storage Storage Description
#1 1,146.00' 122,166,852 cf  \textbf{Custom Stage Data (Prismatic)} Listed below (Recalc)

<table>
<thead>
<tr>
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<tr>
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<td>5,104,361</td>
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<td>5,354,482</td>
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<td>7,276,829</td>
<td>14,252,789</td>
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</tbody>
</table>
Pond THL: Tower Hill Lake

**Inflow Area** = 1,010.846 ac
**Peak Elev** = 1,148.70'
**Storage** = 14,250,505 cf

Inflow = 963.68 cfs