SCS ENGINEERS







Run-On and Run-Off Control Plan
Phase 3 Module 1
Phase 3 Module 2
Phase 4 Module 1

Edgewater I-43 Ash Disposal Facility

Prepared for:

Wisconsin Power and Light Company
Edgewater Generating Station
3739 Lakeshore Drive
Sheboygan, Wisconsin 53081-7233

Prepared by:

SCS ENGINEERS
2830 Dairy Drive
Madison, Wisconsin 53718-6751
(608) 224-2830

September 2016
File No. 25216111.00

Run-On and Run-Off Control Plan
Phase 3 Module 1
Phase 3 Module 2
Phase 4 Module 1

Edgewater I-43 Ash Disposal Facility

Prepared for:

Wisconsin Power and Light Company
Edgewater Generating Station
3739 Lakeshore Drive
Sheboygan, Wisconsin 53081-7233

Prepared by:

SCS ENGINEERS
2830 Dairy Drive
Madison, Wisconsin 53718-6751
(608) 224-2830

September 2016
File No. 25216111.00

Table of Contents

Section **Page**

Figures

Appendix

I:\25216111.00\Deliverables\Run-On_Run-Off Control Plan\WPL_I43 Run-On and Run-Off Control Plan_Final_160929.docx

[This page left blank intentionally]

PE CERTIFICATION

WISCONSIN
ERIC J.
NELSON
E-37855-006
STITZER,
WIS.
PROFESSIONAL ENGINEER
9/29/16

I, Eric J. Nelson, hereby certify that this Run-On and Run-Off Control Plan meets the requirements of 40 CFR 257.81(c), was prepared by me or under my direct supervision, and that I am a duly licensed Professional Engineer under the laws of the State of Wisconsin.

9/29/16

(signature) (date)

ERIC J. NELSON

(printed or typed name)

License number E-37855-6

My license renewal date is 7/31/18.

Pages or sheets covered by this seal:

SEPTEMBER 2016 RUN-ON AND RUN-OFF CONTROL PLAN

I-43 ASH DISPOSAL FACILITY

[This page left blank intentionally]

1.0 INTRODUCTION AND PROJECT SUMMARY

On behalf of Wisconsin Power and Light (WPL), SCS Engineers (SCS) has prepared this Run-on and Run-off Control Plan for the I-43 Ash Disposal Facility (ADF) in accordance with 40 CFR 257.81(c) as follows.

<u>40 CFR 257.81(c)(1).</u> *"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 requirement 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 section 257.105(g)(3)."*

The I-43 facility includes a closed coal combustion residue (CCR) landfill, which consists of disposal Phase 1 and Phase 2, and an active CCR landfill. The active CCR landfill currently consists of three existing CCR units in disposal Phase 3 and Phase 4. The two landfills are located on the same property, but are not contiguous. The U. S. Environmental Protection Agency (USEPA) CCR rule does not apply to Phase 1 and Phase 2, because they were closed before the effective date of the CCR rule.

The active CCR landfill at I-43 is comprised of three existing CCR units, which are the subject of this Run-on and Run-off Control Plan. These CCR units are listed below.

- Phase 3, Module 1
- Phase 3, Module 2
- Phase 4, Module 1

Two future CCR units (Phase 4 Module 2 and Phase 4 Module 3) are permitted with the Wisconsin Department of Natural Resources (WDNR), but have not been developed. When developed, the units will be new CCR landfills, as defined at 40 CFR 257.53.

Refer to **Figure 1** for site location. **Figure 2** shows the run-on and run-off drainage areas.

2.0 RUN-ON AND RUN-OFF CONTROL

<u>40 CFR 257.81(a).</u> *"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."*

The entire facility has run-on and run-off control in place as approved by WDNR. Run-on is controlled by berms and swales around the perimeter of the landfill that divert storm water away from the landfill and to the detention basin on the north end of the property.

(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."*

Run-off from the active portions of the existing CCR units at the facility is handled as contact water and is collected by a leachate collection system or internal swales, which route the contact water to a composite-lined contact water basin. The contact water in the basin is used for ash conditioning, and other applications within the CCR units. If needed, excess water in the contact water basin is pumped into a tanker truck and taken to a local waste water treatment facility for disposal. Per 257.81(b), this is consistent with the surface water requirements under 40 CFR 257.3-3.

Run-off from areas of the existing CCR units where final cover is in place (which prevents contact with CCR) is diverted into the perimeter drainage swales, which drain to the on-site detention/sedimentation basin. Intermediate swales/berms, downslope flumes, and energy dissipaters on the final cover help minimize erosion of the final cover. These features divert water to the perimeter drainage system, and ultimately to the on-site detention/sedimentation basin. Per 257.81(b), this is consistent with the surface water requirements under 40 CFR 257.3-3.

2.1 DESIGN CRITERIA

The storm water features described above are designed to handle run-on and run-off from a 25-year, 24-hour storm event as required by 40 CFR 257.81(a)(1) and (2). Storm water run-off calculations were updated in 2015. The calculations were performed assuming a 25-year, 24-hour precipitation depth of 4.79 inches, based on NOAA Atlas 14 precipitation data published in April 2013. The storm water run-on calculations were performed in 2008. The calculations were performed assuming a 25-year, 24-hour precipitation depth of 4.4 inches, based on Technical Paper-40 (TP-40) precipitation data published in May 1961. The off-site detention basin and on-site detention/sedimentation basin outlet structures are designed to safely pass run-off from a 100-year, 24-hour storm event.

2.2 DESIGN WITH CALCULATIONS

Storm water management design calculations (as described above) from the WDNR approved Plan of Operation (2008) and Plan of Operation Modification (2015) for Phase 3 and Phase 4 at the I-43 ADF are contained in **Appendix A**. As described in **Section 2.1**, the calculations from the 2008 Plan of Operation describe the storm water management design and provide calculations showing that the run-on control system will prevent flow onto the active portion of the CCR units during the peak discharge from a 25-year, 24-hour storm. The calculations from the 2015 Plan of Operation Modification describe the storm water management design and provide calculations showing that the run-off control system for the active portions of the CCR units will collect and control the water volume resulting from a 25-year, 24-hour storm. The calculations were performed by or overseen by a professional engineer licensed in the State of Wisconsin.

2.3 CONSTRUCTION

Existing storm water management features were constructed to site specifications with construction oversight directed by a professional engineer licensed in the State of Wisconsin. Construction documentation reports for the storm water management features were prepared, submitted to the WDNR, and approved by the WDNR.

3.0 CERTIFICATIONS

40 CFR 257.81(c)(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."*

Eric Nelson, PE, a licensed profession engineer in the State of Wisconsin, has overseen the preparation of this Run-on and Run-off Control Plan. A certification statement is provided on **page iii** of this plan.

4.0 RECORDKEEPING AND PERIOD UPDATES

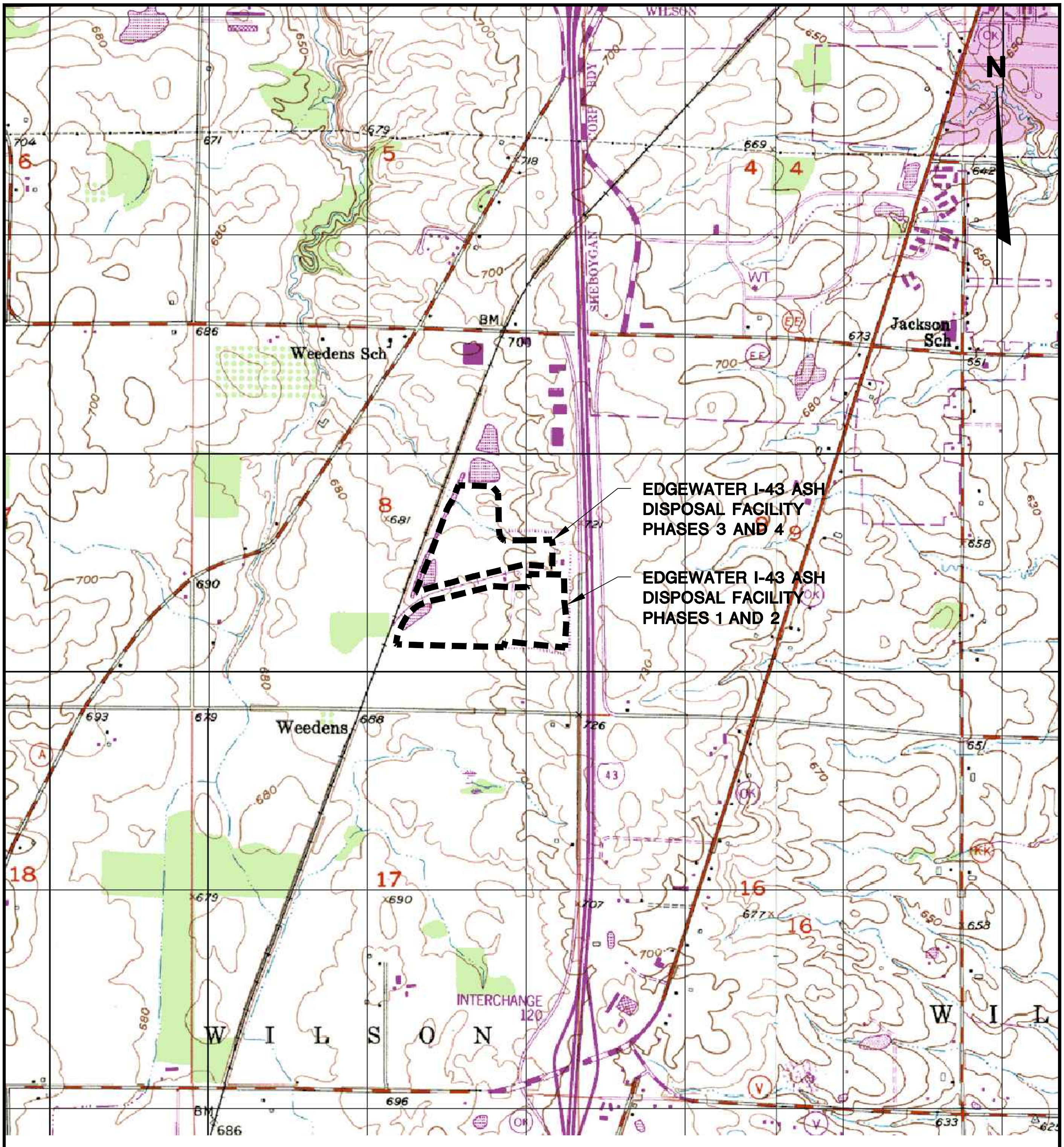
40 CFR 257.81(d). *"The owner or operator of the CCR unit must comply with the recordkeeping requirements specified in section 257.105(g), the notification requirements specified in section 257.106(g), and the internet requirements specified in section 257.107(g)."*

This Run-On and Run-Off Control Plan, and all periodic plans, will be placed in facility's operating record and on Alliant Energy's CCR Rule Compliance Data and Information website, as will all amendments. Periodic plans will be completed every 5 years per 40 CFR 257.81(c)(4).

Notification will be provided when this Run-On and Run-Off Control Plan, and all periodic plans, are available in the facility's operating record and on the facility's website per 40 CFR 257.105(g), 257.106(g), and 257.107(g).

[This page left blank intentionally]

FIGURES



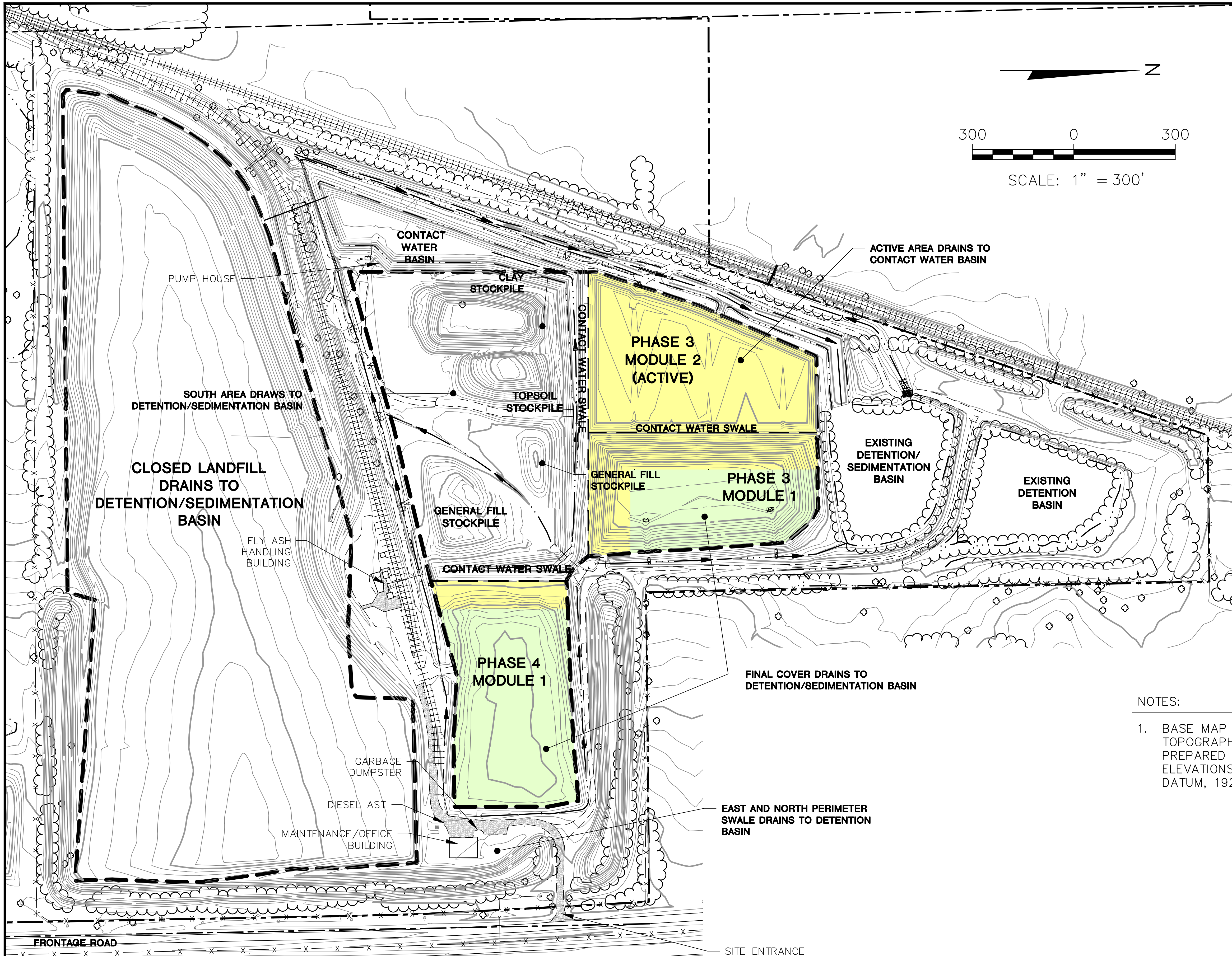
N

SHEBOYGAN HILLS QUADRANGLE
WISCONSIN–SHEBOYGAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
SCALE: 1" = 2,000'

CLIENT	SITE	
WISCONSIN POWER AND LIGHT COMPANY EDGEWATER GENERATING STATION 3739 LAKESHORE DRIVE SHEBOYGAN, WI 53081	RUN–ON AND RUN–OFF CONTROL PLAN EDGEWATER I–43 ASH DISPOSAL FACILITY TOWN OF WILSON, WISCONSIN	SITE LOCATION MAP

				ENGINEER	
PROJECT NO.	25216111.00	DRAWN BY:	AHB	SCS ENGINEERS 2830 DAIRY DRIVE MADISON, WI 53718–6751 PHONE: (608) 224–2830	FIGURE
DRAWN:	08/09/16	CHECKED BY:	LB		1
REVISED:	08/09/16	APPROVED BY:	EN 09/26/16		

I:\25216111.00\Drawings\Run Off Control\Site Location Map.dwg, 9/28/2016 4:02:29 PM



LEGEND

- APPROXIMATE PROPERTY LINE
- LIMITS OF WASTE
- MODULE LIMITS
- GRADE (2' CONTOUR)
- 690 — GRADE (10' CONTOUR)
- EDGE OF WATER
- SWALE
- WETLAND
- CULVERT
- MH — MANHOLE
- W — CONTACT WATER TRANSFER PIPE
- AB — ABANDONED 3" DIA. HDPE PIPE
- TREELINE/TREES
- PAVED ROAD
- UNPAVED ACCESS ROAD
- RAILROAD TRACKS
- X — FENCE
- UTILITY/LIGHT POLE
- CONTROL MONUMENT
- ACTIVE LANDFILL DRAINAGE AREA
- FINAL COVER DRAINAGE AREA

NOTES:

1. BASE MAP PREPARED BY KBM, INC. BASED ON AERIAL TOPOGRAPHIC SURVEY FLOWN DECEMBER 1, 2014. BASE MAP PREPARED USING WISCONSIN STATE PLANE COORDINATES. ELEVATIONS BASED ON USGS NATIONAL GEODETIC VERTICAL DATUM, 1929.

PROJECT NO.	25216111.00	DRAWN BY:	AHB
DRAWN:	08/09/16	CHECKED BY:	LAB
REVISED:	09/10/16	APPROVED BY:	EN 09/28/16

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

CLIENT: WISCONSIN POWER AND LIGHT COMPANY
EDGEWATER GENERATING STATION
3739 LAKESHORE DRIVE
SHEBOYGAN, WI 53081

SITE: RUN-ON AND RUN-OFF CONTROL PLAN
EDGEWATER I-43 ASH DISPOSAL FACILITY
TOWN OF WILSON, WISCONSIN

RUN-ON AND RUN-OFF CONTROL PLAN

FIGURE 2

I:\25216111.00\Drawings\Run Off Control\Runoff Control Plan.dwg, 9/28/2016 4:03:52 PM

APPENDIX A

Drainage Design Calculations

APPENDIX G

Stormwater Control Design Calculations

Appendix G
Surface Water Management Calculations

Purpose:

The purpose of the surface water runoff calculations is to demonstrate the following:

- The proposed Phase 3 and 4 landfill expansion surface water management system design meets the requirements of NR 504.09 Wis. Admin. Code.
- That the stormwater design features installed in 1984, (i.e., the detention/sedimentation basin, detention basin, outlet structures, and swales) are adequate for current regulations.

Existing Features:

There are two stormwater outlets for the site. These outlets are; 1) an 36-inch diameter culvert under the railroad tracks to the west of the site and 2) an 24-inch diameter culvert under the railroad tracks. The culverts are shown on Figure G1.

The detention/sedimentation basin, detention basin, run-on diversion swale, perimeter swales around Phases 1 and 2, and culverts were installed in 1984. Currently, runoff from the areas of Phase 1 and 2 of the landfill that are at final grades is directed to the detention/sedimentation basin for treatment and runoff from the active portion of Phase 1 and 2 is directed to the interior Southern Ash Contact Holding Basin for use as dust control water. When Phase 1 and 2 are complete, runoff will be directed to the detention/sedimentation basin. Stormwater from off-site of the landfill to the east is directed via the run-on diversion swale to the detention basin for treatment.

The detention/sedimentation basin discharges through a 24-inch riser outlet structure to the 36-inch diameter culvert under the railroad tracks to the west. The detention basin discharges through an 18-inch riser outlet structure to the 24-inch diameter culvert under the railroad tracks.

Methodologies:

Design of Stormwater Management Features:
To design the storm water management features, runoff hydrographs for the 25-year, 24-hour and 100-year, 24-hour storm event were developed. Hydrographs were developed using the TR-55 method contained within the Pond Pack® computer model developed by Bentley Systems, Inc. The TR-55 method for computing hydrographs is based on the methodologies presented in the Urban Hydrology for Small Watersheds manual developed by the Natural Resources Conservation Service (NRCS). The TR-55 model is designed to simulate the surface response of a watershed to a precipitation event. Input parameters for the model include precipitation depth for a given storm event, contributing drainage areas, runoff curve numbers, time of concentration, and travel time. The TR-55 model develops a runoff hydrograph for the watershed.

The following assumptions were used in the TR-55 model:

- The rainfall depths used were: 4.4 in for the 25-yr storm event and 5.1 in for the 100-yr event.
- A runoff curve number (CN) of 80 was used. This CN is for pasture in good condition (>75% ground cover) and a hydrologic soil group D.
- Sheet flow was assumed for the top of the landfill across the final grades.
- For flow in the perimeter swales, a mannings n value of 0.035 was used.

The hydrograph developed by TR-55 was routed through the existing detention/sedimentation basin and outlet using the Pond Pack® model to determine the outflow from the basin.

The sediment removal properties for the basins were evaluated using the P8 Urban Catchment Model. Wis. Admin. Code NR 504.09 requires sediment control measures be designed to settle 0.015 mm (15 micron) particle. Settling of the 15-micron particle corresponds to a trapping efficiency of 49%.

The design of the swales and culverts surrounding the landfill was evaluated using a channel and culvert calculator included in AutoCAD 2008. The channel calculator uses Manning's Equation to determine the maximum flow that a channel can carry given the geometry of the channel.

RESULTS:

The proposed surface water management system design meets the requirements of s. NR 504.09, Wis. Admin. Code. Further details are provided below.

Runoff Calculations

Runoff from Phases 1 and 2 of the landfill flows to the perimeter swales around the landfill and is directed to the sedimentation/detention basin.

Phase 3 & 4 of the landfill can be divided into 3 watersheds. The watersheds are shown on Figure G1. A southwest watershed that drains to the south and west perimeter swale of the landfill, a northeast watershed that drains to the north and northeast perimeter swale of the landfill, and a third watershed is located in the northern portion of the landfill and drains directly into the sedimentation/detention basin. This third watershed is small, approximately 2 acres, and considered insignificant and no runoff is calculated for this watershed.

Drainage Area	Area (acres)	Runoff Curve Number	Time of Concentration (hr)	25-yr Storm Peak Runoff
Phases 1&2	53.1	80	0.61	107.2 cfs
Ph 3&4 Southwest	32.0	80	0.78	55.4 cfs
PH 3&4 Northeast	13.3	80	0.51	30.7 cfs

Sedimentation / Detention Basin

All of these runoff from these watersheds is directed to the sedimentation / detention basin by the perimeter swales. The outlet structure of this basin is a 24-inch diameter riser outlet structure with a 25 foot wide emergency spillway located at elevation 685.0 ft with a top of berm elevation of 686.0 ft.

The flow through the sedimentation / detention basin was simulated using the Pond Pack® computer model. The peak inflow into the basin was 188.9 cfs for the 25-yr storm event. The peak outflow for the 25-yr storm event through the outlet structure was 37.3 cfs with a peak water elevation of 685.37. The 100-yr storm event was also modeled to ensure the emergency spillway was adequate, the peak elevation in the detention basin for the 100-yr storm was 685.79 ft.

Due to the water elevation during the 25-yr storm event (685.41) being above the elevation of the emergency spillway (685.0), a new outlet of the sedimentation/detention basin was designed. The new outlet design is shown on the detail drawings and consists of a 36-inch diameter CMP culvert with a 36-inch diameter CMP riser. This new outlet structure will need to be installed when the base grades for

Phase 4, Module 2 of the landfill is prepared. At the current rate of ash disposal, the outlet will not need to be replaced for approximately 10 years after disposal begins in Phase 3, Module 1.

The runoff for the site when Phase 3 Modules 1 and 2 and Phase 4 Module 1 are at final grades and contribute to the runoff going to the detention / sedimentation basin was also calculated to ensure the runoff from the 25-year storm event is contained within the basin using the existing outlet structure. The maximum water level obtained within the basin during the 25-yr storm event is 684.98 with a peak outflow of 19.8 cfs. The peak water level obtained during the 100-year storm event is 685.43 with a peak outflow of 41.6 cfs.

the proposed outlet structure for the detention / sedimentation basin was also modeled to ensure the 25-year storm event runoff from the entire Phase 3 and 4 can be contained within the basin. The maximum water level obtained within the basin during the 25-yr storm event is 684.99 with a peak outflow of 38.1 cfs. The peak water level obtained during the 100-year storm event is 685.45 with a peak outflow of 73.1 cfs. The basin will also take longer than 3 day to completely drain.

Detention Basin

Stormwater run-on is directed to the detention basin by the run-on diversion swale. The off-site area that contributes to run-on is approximately 91 acres. The outlet structure of the detention basin is an 18-inch diameter riser outlet structure with a 25-ft wide emergency spillway at elevation 691.0 and a top of berm elevation of 693.0 ft. The flow through the detention basin was simulated using the Pond Pack® computer model. The peak outflow for the 25-yr storm is 8.8 cfs with a peak elevation of 688.4 ft. The peak outflow for the 100-yr storm is 12.2 cfs with a peak elevation of 689.3 ft. The basin will also take longer than 3 day to completely drain.

Sediment Removal

The sediment removal properties for the basins were evaluated using the P8 Urban Catchment Model. Wis. Admin. Code NR 504.09 requires sediment control measures be designed to settle 0.015 mm (15 micron) particle. Settling of the 15-micron particle corresponds to a trapping efficiency of 49%.

The P8 model showed the sedimentation / detention basin will capture 69.9% of the total suspended solids (TSS) and the detention basin will capture 74.2% of the TSS.

Perimeter Swale Sizing

The design of the perimeter swales surrounding the landfill was evaluated using a channel calculator included in AutoCAD 2008. The channel calculator uses Manning's Equation to determine the maximum flow that a channel can carry given the geometry of the channel.

The channel calculator shows the swales can carry the 25-yr storm event with a minimum of 0.5 feet of freeboard.

There will be a culvert installed in the swale to provide access to the leachate pumpout riser. The culvert calculator shows that two 24-inch diameter corrugated metal pipes (CMP) culverts can carry the design flow.

Intermediate Diversion Swales

The Universal Soil Loss Equation (USLE) was used to determine if intermediate diversion berms were required on the final grades to prevent erosion. The equation showed that no berms were required.

KRG/krg/TR
I:\3391\Calculations\Stormwater\Summary.doc

Runoff Calculation

Phase 1 & 2

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
Phases 1&2	84	53.100			84.00
COMPOSITE AREA & WEIGHTED CN --->		53.100			84.00 (84)

Table of Contents

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400	
Hydraulic Length	170.00	ft
2yr, 24hr P	2.5000	in
Slope	.040000	ft/ft
Avg.Velocity	.15	ft/sec

Segment #1 Time: .3118 hrs

Segment #2: Tc: TR-55 Sheet

Mannings n	.2400	
Hydraulic Length	50.00	ft
2yr, 24hr P	2.5000	in
Slope	.130000	ft/ft
Avg.Velocity	.19	ft/sec

Segment #2 Time: .0731 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	13.5000	sq.ft
Wetted Perimeter	16.30	ft
Hydraulic Radius	.83	ft
Slope	.012000	ft/ft
Mannings n	.0350	
Hydraulic Length	3350.00	ft
Avg.Velocity	4.11	ft/sec

Segment #3 Time: .2263 hrs

Total Tc: .6111 hrs

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration       = 24.0000 hrs     Rain Depth = 4.4000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID  =  - TypeII  24hr
Unit Hyd Type  = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID  = work_pad.hyg - PHASE 1+2 Dev 25
Tc             = .6111 hrs
Drainage Area  = 53.100 acres  Runoff CN= 84

============================================
Computational Time Increment   =   .08148 hrs
Computed Peak Time             =  12.2224 hrs
Computed Peak Flow             =   108.07 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.2500 hrs
Peak Flow, Interpolated Output =   107.19 cfs
============================================

              DRAINAGE AREA
             -------------------
             ID:PHASE 1+2
             CN   =   84
             Area =      53.100 acres
             S    =   1.9048 in
             0.2S =     .3810 in

              Cumulative Runoff
             -------------------
                     2.7267 in
                     12.066 ac-ft

HYG Volume...        12.065 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .61112 hrs (ID: PHASE 1+2)
Computational Incr, Tm =   .08148 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,          qp =    98.45 cfs
Unit peak time      Tp =   .40741 hrs
Unit receding limb, Tr =  1.62966 hrs
Total unit time,    Tb =  2.03707 hrs
```

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 100 year storm
Duration       = 24.0000 hrs     Rain Depth = 5.1000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID  =  - TypeII  24hr
Unit Hyd Type  = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID  = work_pad.hyg - PHASE 1+2 Dev100
Tc             = .6111 hrs
Drainage Area  = 53.100 acres  Runoff CN= 84

============================================
Computational Time Increment   =   .08148 hrs
Computed Peak Time             =  12.2224 hrs
Computed Peak Flow             =   133.12 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.2500 hrs
Peak Flow, Interpolated Output =   131.89 cfs
============================================

              DRAINAGE AREA
              -------------------
              ID:PHASE 1+2
              CN    =   84
              Area =      53.100 acres
              S    =   1.9048 in
              0.2S =    .3810 in

               Cumulative Runoff
              -------------------
                      3.3620 in
                      14.877 ac-ft

HYG Volume...         14.876 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .61112 hrs (ID: PHASE 1+2)
Computational Incr, Tm =   .08148 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =    .7491)

Unit peak,           qp =    98.45 cfs
Unit peak time       Tp =   .40741 hrs
Unit receding limb,  Tr =  1.62966 hrs
Total unit time,     Tb =  2.03707 hrs
```

Runoff Calculation

Phase 3 & 4 Northeast Drainage Area

Table of Contents

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Northeast	84	13.300			84.00
COMPOSITE AREA & WEIGHTED CN --->		13.300			84.00 (84)

Table of Contents

```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::

------------------------------------------------------------------------

Segment #1:  Tc: TR-55 Sheet

Mannings n            .2400
Hydraulic Length   160.00 ft
2yr, 24hr P         2.5000 in
Slope              .030000 ft/ft

Avg.Velocity          .13 ft/sec

                                     Segment #1 Time:     .3332 hrs
------------------------------------------------------------------------

Segment #2:  Tc: TR-55 Sheet

Mannings n            .2400
Hydraulic Length     30.00 ft
2yr, 24hr P         2.5000 in
Slope              .250000 ft/ft

Avg.Velocity          .22 ft/sec

                                     Segment #2 Time:     .0374 hrs
------------------------------------------------------------------------

Segment #3:  Tc: TR-55 Channel

Flow Area           5.9000 sq.ft
Wetted Perimeter     13.60 ft
Hydraulic Radius       .43 ft
Slope              .025000 ft/ft
Mannings n           .0350
Hydraulic Length    730.00 ft

Avg.Velocity         3.86 ft/sec

                                     Segment #3 Time:     .0526 hrs
------------------------------------------------------------------------
```

File.... I:\3391\Calculations\Stormwater\Final Grades.ppw

Segment #4: Tc: TR-55 Channel

Flow Area	5.9000	sq.ft
Wetted Perimeter	13.60	ft
Hydraulic Radius	.43	ft
Slope	.010000	ft/ft
Mannings n	.0350	
Hydraulic Length	580.00	ft
Avg.Velocity	2.44	ft/sec

Segment #4 Time: .0660 hrs

Segment #5: Tc: TR-55 Channel

Flow Area	13.5000	sq.ft
Wetted Perimeter	16.30	ft
Hydraulic Radius	.83	ft
Slope	.025000	ft/ft
Mannings n	.0350	
Hydraulic Length	350.00	ft
Avg.Velocity	5.94	ft/sec

Segment #5 Time: .0164 hrs

Total Tc: .5056 hrs

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration       = 24.0000 hrs     Rain Depth = 4.4000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID = work_pad.hyg - PHASE 3+4 NE Dev 25
Tc             = .5056 hrs
Drainage Area = 13.300 acres  Runoff CN= 84

============================================
Computational Time Increment   =   .06741 hrs
Computed Peak Time             =  12.2021 hrs
Computed Peak Flow             =    30.71 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.2000 hrs
Peak Flow, Interpolated Output =    30.69 cfs
============================================

                 DRAINAGE AREA
              -------------------
              ID:PHASE 3+4 NE
              CN   =   84
              Area =      13.300 acres
              S    =   1.9048 in
              0.2S =    .3810 in

               Cumulative Runoff
              -------------------
                      2.7267 in
                       3.022 ac-ft

HYG Volume...           3.022 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .50561 hrs (ID: PHASE 3+4 NE)
Computational Incr, Tm =   .06741 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =    .7491)

Unit peak,          qp =    29.80 cfs
Unit peak time      Tp =   .33707 hrs
Unit receding limb, Tr =  1.34829 hrs
Total unit time,    Tb =  1.68537 hrs
```

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 100 year storm
Duration       = 24.0000 hrs     Rain Depth = 5.1000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID = work_pad.hyg - PHASE 3+4 NE Dev100
Tc             = .5056 hrs
Drainage Area = 13.300 acres  Runoff CN= 84

============================================
Computational Time Increment   =   .06741 hrs
Computed Peak Time             =  12.2021 hrs
Computed Peak Flow             =    37.72 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.2000 hrs
Peak Flow, Interpolated Output =    37.70 cfs
============================================

              DRAINAGE AREA
             -------------------
             ID:PHASE 3+4 NE
             CN   =   84
             Area =      13.300 acres
             S    =   1.9048 in
             0.2S =    .3810 in

              Cumulative Runoff
             -------------------
                    3.3620 in
                     3.726 ac-ft

HYG Volume...          3.726 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .50561 hrs (ID: PHASE 3+4 NE)
Computational Incr, Tm =   .06741 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,          qp =    29.80 cfs
Unit peak time      Tp =   .33707 hrs
Unit receding limb, Tr =  1.34829 hrs
Total unit time,    Tb =  1.68537 hrs
```

Runoff Calculation

Phase 3 & 4 Southwest Drainage Area

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Southwest Area	84	32.000			84.00
COMPOSITE AREA & WEIGHTED CN --->		32.000			84.00 (84)

Table of Contents

::
TIME OF CONCENTRATION CALCULATOR
::

Segment #1: Tc: TR-55 Sheet

Mannings n	.2400
Hydraulic Length	130.00 ft
2yr, 24hr P	2.5000 in
Slope	.030000 ft/ft
Avg.Velocity	.13 ft/sec

Segment #1 Time: .2822 hrs

Segment #2: Tc: TR-55 Sheet

Mannings n	.2400
Hydraulic Length	30.00 ft
2yr, 24hr P	2.5000 in
Slope	.250000 ft/ft
Avg.Velocity	.22 ft/sec

Segment #2 Time: .0374 hrs

Segment #3: Tc: TR-55 Channel

Flow Area	5.9000 sq.ft
Wetted Perimeter	13.60 ft
Hydraulic Radius	.43 ft
Slope	.015000 ft/ft
Mannings n	.0350
Hydraulic Length	940.00 ft
Avg.Velocity	2.99 ft/sec

Segment #3 Time: .0874 hrs

Segment #4: Tc: TR-55 Channel

Flow Area	5.9000	sq.ft
Wetted Perimeter	13.60	ft
Hydraulic Radius	.43	ft
Slope	.014000	ft/ft
Mannings n	.0350	
Hydraulic Length	1300.00	ft

Avg.Velocity 2.89 ft/sec

Segment #4 Time: .1251 hrs

Segment #5: Tc: TR-55 Channel

Flow Area	13.5000	sq.ft
Wetted Perimeter	16.30	ft
Hydraulic Radius	.83	ft
Slope	.003300	ft/ft
Mannings n	.0350	
Hydraulic Length	1900.00	ft

Avg.Velocity 2.16 ft/sec

Segment #5 Time: .2447 hrs

Total Tc: .7768 hrs

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration       = 24.0000 hrs     Rain Depth = 4.4000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID = work_pad.hyg - PHASE 3+4 SW Dev 25
Tc             = .7768 hrs
Drainage Area = 32.000 acres  Runoff CN= 84

============================================
Computational Time Increment   =    .10358 hrs
Computed Peak Time             =   12.3255 hrs
Computed Peak Flow             =     55.83 cfs

Time Increment for HYG File    =     .0500 hrs
Peak Time, Interpolated Output =   12.3500 hrs
Peak Flow, Interpolated Output =     55.41 cfs
============================================

                DRAINAGE AREA
              -------------------
              ID:PHASE 3+4 SW
              CN    =   84
              Area =       32.000 acres
              S     =   1.9048 in
              0.2S =     .3810 in

               Cumulative Runoff
              -------------------
                     2.7267 in
                      7.271 ac-ft

HYG Volume...           7.269 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =    .77682 hrs (ID: PHASE 3+4 SW)
Computational Incr, Tm =    .10358 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =    .7491)

Unit peak,           qp =     46.67 cfs
Unit peak time       Tp =    .51788 hrs
Unit receding limb, Tr =  2.07151 hrs
Total unit time,     Tb =  2.58939 hrs
```

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 100 year storm
Duration       = 24.0000 hrs     Rain Depth = 5.1000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID  =  - TypeII  24hr
Unit Hyd Type  = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID  = work_pad.hyg - PHASE 3+4 SW Dev100
Tc             = .7768 hrs
Drainage Area  = 32.000 acres  Runoff CN= 84

============================================
Computational Time Increment   =    .10358 hrs
Computed Peak Time             =  12.3255 hrs
Computed Peak Flow             =    68.81 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.3500 hrs
Peak Flow, Interpolated Output =    68.24 cfs
============================================

                DRAINAGE AREA
              -------------------
              ID:PHASE 3+4 SW
              CN   =   84
              Area =      32.000 acres
              S    =   1.9048 in
              0.2S =    .3810 in

               Cumulative Runoff
              -------------------
                      3.3620 in
                       8.965 ac-ft

HYG Volume...          8.963 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .77682 hrs (ID: PHASE 3+4 SW)
Computational Incr, Tm =   .10358 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,           qp =    46.67 cfs
Unit peak time       Tp =   .51788 hrs
Unit receding limb, Tr =  2.07151 hrs
Total unit time,     Tb =  2.58939 hrs
```

Detention / Sedimentation Basin Routing
Existing Outlet Structure

File.... I:\3391\Calculations\Stormwater\Final Grades.ppw

Elevation (ft)	Planimeter (sq.in)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume Sum (ac-ft)
681.46	-----	2.7500	.0000	.000	.000
682.00	-----	2.8800	8.4442	1.520	1.520
684.00	-----	3.2100	9.1305	6.087	7.607
686.00	-----	4.0000	10.7933	7.196	14.802

POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

REQUESTED POND WS ELEVATIONS:

Min. Elev.= 681.46 ft
Increment = .10 ft
Max. Elev.= 686.00 ft

****
OUTLET CONNECTIVITY
****

---> Forward Flow Only (UpStream to DnStream)
<--- Reverse Flow Only (DnStream to UpStream)
<---> Forward and Reverse Both Allowed

Structure	No.		Outfall	E1, ft	E2, ft
Orifice-Area	O4	--->	C0	682.000	686.000
Orifice-Area	O5	--->	C0	682.250	686.000
Orifice-Area	O1	--->	C0	682.500	686.000
Orifice-Area	O6	--->	C0	682.750	686.000
Orifice-Area	O2	--->	C0	683.000	686.000
Orifice-Area	O7	--->	C0	683.250	686.000
Orifice-Area	O3	--->	C0	683.500	686.000
Stand Pipe	R0	--->	C0	684.030	686.000
Orifice-Area	O0	--->	C0	681.830	686.000
Culvert-Circular	C0	--->	TW	681.460	686.000
Weir-Rectangular	W0	--->	TW	685.000	686.000
TW SETUP, DS Channel					

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = O4
Structure Type     = Orifice-Area
------------------------------------
# of Openings      =       4
Invert Elev.       =    682.00 ft
Area               =     .0210 sq.ft
Top of Orifice     =       .00 ft
Datum Elev.        =    682.00 ft
Orifice Coeff.     =      .700
```

```
Structure ID       = O5
Structure Type     = Orifice-Area
------------------------------------
# of Openings      =       4
Invert Elev.       =    682.25 ft
Area               =     .0210 sq.ft
Top of Orifice     =       .00 ft
Datum Elev.        =    682.25 ft
Orifice Coeff.     =      .700
```

```
Structure ID       = O1
Structure Type     = Orifice-Area
------------------------------------
# of Openings      =       4
Invert Elev.       =    682.50 ft
Area               =     .0210 sq.ft
Top of Orifice     =       .00 ft
Datum Elev.        =    682.50 ft
Orifice Coeff.     =      .700
```

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = O6
Structure Type     = Orifice-Area
------------------------------------
# of Openings      =        4
Invert Elev.       =    682.75 ft
Area               =     .0210 sq.ft
Top of Orifice     =       .00 ft
Datum Elev.        =    682.75 ft
Orifice Coeff.     =      .700


Structure ID       = O2
Structure Type     = Orifice-Area
------------------------------------
# of Openings      =        4
Invert Elev.       =    683.00 ft
Area               =     .0210 sq.ft
Top of Orifice     =       .00 ft
Datum Elev.        =    683.00 ft
Orifice Coeff.     =      .700


Structure ID       = O7
Structure Type     = Orifice-Area
------------------------------------
# of Openings      =        4
Invert Elev.       =    683.25 ft
Area               =     .0210 sq.ft
Top of Orifice     =       .00 ft
Datum Elev.        =    683.25 ft
Orifice Coeff.     =      .700


Structure ID       = O3
Structure Type     = Orifice-Area
------------------------------------
# of Openings      =        4
Invert Elev.       =    683.50 ft
Area               =     .0210 sq.ft
Top of Orifice     =       .00 ft
Datum Elev.        =    683.50 ft
Orifice Coeff.     =      .700
```

OUTLET STRUCTURE INPUT DATA

Structure ID = R0
Structure Type = Stand Pipe

# of Openings	=	1
Invert Elev.	=	684.03 ft
Diameter	=	2.0000 ft
Orifice Area	=	3.1416 sq.ft
Orifice Coeff.	=	.700
Weir Length	=	6.28 ft
Weir Coeff.	=	3.300
K, Reverse	=	1.000
Mannings n	=	.0000
Kev,Charged Riser	=	.000
Weir Submergence	=	No

Structure ID = O0
Structure Type = Orifice-Area

# of Openings	=	4
Invert Elev.	=	681.83 ft
Area	=	.0210 sq.ft
Top of Orifice	=	.00 ft
Datum Elev.	=	681.83 ft
Orifice Coeff.	=	.700

```
OUTLET STRUCTURE INPUT DATA


Structure ID       = C0
Structure Type     = Culvert-Circular
------------------------------------
No. Barrels        =        1
Barrel Diameter    =    2.0000 ft
Upstream Invert    =    681.46 ft
Dnstream Invert    =    681.05 ft
Horiz. Length      =     30.00 ft
Barrel Length      =     30.00 ft
Barrel Slope       =    .01367 ft/ft

OUTLET CONTROL DATA...
Mannings n         =     .0240
Ke                 =     .5000  (forward entrance loss)
Kb                 =   .042300  (per ft of full flow)
Kr                 =     .5000  (reverse entrance loss)
HW Convergence     =      .001  +/- ft

INLET CONTROL DATA...
Equation form      =        1
Inlet Control K    =     .0078
Inlet Control M    =    2.0000
Inlet Control c    =    .03790
Inlet Control Y    =     .6900
T1 ratio (HW/D)    =     1.129
T2 ratio (HW/D)    =     1.290
Slope Factor       =     -.500

Use unsubmerged inlet control Form 1 equ. below T1 elev.
Use   submerged inlet control Form 1 equ. above T2 elev.

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...
At T1 Elev =     683.72 ft  --->  Flow =     15.55 cfs
At T2 Elev =     684.04 ft  --->  Flow =     17.77 cfs
```

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = W0
Structure Type     = Weir-Rectangular
-----------------------------------
# of Openings      =         1
Crest Elev.        =    685.00 ft
Weir Length        =     25.00 ft
Weir Coeff.        =  2.630000

Weir TW effects      (Use adjustment equation)



Structure ID       = TW
Structure Type     = TW SETUP, DS Channel
-----------------------------------
FREE OUTFALL CONDITIONS SPECIFIED

CONVERGENCE TOLERANCES...
Maximum Iterations=    40
Min. TW tolerance =    .01 ft
Max. TW tolerance =    .01 ft
Min. HW tolerance =    .01 ft
Max. HW tolerance =    .01 ft
Min.  Q tolerance =    .00 cfs
Max.  Q tolerance =    .00 cfs
```

```
                    LEVEL POOL ROUTING SUMMARY

HYG Dir           = I:\3391\Calculations\Stormwater\
Inflow  HYG file = work_pad.hyg - DET / SED     IN  Dev 25
Outflow HYG file = work_pad.hyg - DET / SED     OUT Dev 25

Pond Node   Data = DET / SED
Pond Volume Data = DET / SED
Pond Outlet Data = Existing Outlet

No Infiltration

INITIAL CONDITIONS
----------------------------------
Starting WS Elev    =    681.46 ft
Starting Volume     =      .000 ac-ft
Starting Outflow    =       .00 cfs
Starting Infiltr.   =       .00 cfs
Starting Total Qout=        .00 cfs
Time Increment      =     .0500 hrs


INFLOW/OUTFLOW HYDROGRAPH SUMMARY
=====================================================
Peak Inflow      =    188.91 cfs    at   12.2500 hrs
Peak Outflow     =     37.26 cfs    at   13.2000 hrs
-----------------------------------------------------
Peak Elevation   =    685.37 ft
Peak Storage =        12.365 ac-ft
=====================================================


MASS BALANCE (ac-ft)
--------------------------
+ Initial Vol  =          .000
+ HYG Vol IN   =        22.357
- Infiltration =          .000
- HYG Vol OUT  =        21.085
- Retained Vol =         1.272
                    ----------
  Unrouted Vol =        -.000 ac-ft  (.002% of Inflow Volume)


WARNING: Outflow hydrograph truncated on right side.
```

← Peak WATER Elevation is Above 685.0, the level of the emergency spillway. A new outlet Design is Required.

LEVEL POOL ROUTING SUMMARY

```
HYG Dir            = I:\3391\Calculations\Stormwater\
Inflow  HYG file = work_pad.hyg - DET / SED    IN  Dev100
Outflow HYG file = work_pad.hyg - DET / SED    OUT Dev100

Pond Node   Data = DET / SED
Pond Volume Data = DET / SED
Pond Outlet Data = Existing Outlet

No Infiltration

INITIAL CONDITIONS
----------------------------------
Starting WS Elev   =   681.46 ft
Starting Volume    =     .000 ac-ft
Starting Outflow   =      .00 cfs
Starting Infiltr.  =      .00 cfs
Starting Total Qout=      .00 cfs
Time Increment     =    .0500 hrs

INFLOW/OUTFLOW HYDROGRAPH SUMMARY
=====================================================
Peak Inflow      =   232.63 cfs    at   12.2500 hrs
Peak Outflow     =    71.28 cfs    at   12.9000 hrs
-----------------------------------------------------
Peak Elevation   =   685.79 ft
Peak Storage =       13.979 ac-ft
=====================================================

MASS BALANCE (ac-ft)
--------------------------
+ Initial Vol   =        .000
+ HYG Vol IN    =      27.565
- Infiltration =        .000
- HYG Vol OUT   =      26.281
- Retained Vol =       1.284
                   ----------
  Unrouted Vol =       -.000 ac-ft  (.001% of Inflow Volume)

WARNING: Outflow hydrograph truncated on right side.
```

SCS UNIT HYDROGRAPH METHOD

PHASE 3 MOD 1+2
AND PHASE 4-MOD1

```
STORM EVENT: 25 year storm
Duration      = 24.0000 hrs     Rain Depth = 4.4000 in
Rain Dir      = I:\3391\Calculations\Stormwater\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir       = I:\3391\Calculations\Stormwater\
HYG File - ID = work_pad.hyg - PHASE 3+4 SW Dev 25
Tc            = .7768 hrs
Drainage Area = 14.800 acres  Runoff CN= 84

============================================
Computational Time Increment   =    .10358 hrs
Computed Peak Time             =  12.3255 hrs
Computed Peak Flow             =    25.82 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.3500 hrs
Peak Flow, Interpolated Output =    25.63 cfs
============================================

              DRAINAGE AREA
              -------------------
              ID:PHASE 3+4 SW
              CN   =   84
              Area =       14.800 acres
              S    =   1.9048 in
              0.2S =     .3810 in

               Cumulative Runoff
              -------------------
                      2.7267 in
                       3.363 ac-ft

HYG Volume...           3.362 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =   .77682 hrs (ID: PHASE 3+4 SW)
Computational Incr, Tm =   .10358 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =    .7491)

Unit peak,           qp =    21.59 cfs
Unit peak time       Tp =   .51788 hrs
Unit receding limb,  Tr =  2.07151 hrs
Total unit time,     Tb =  2.58939 hrs
```

LEVEL POOL ROUTING SUMMARY

```
HYG Dir           = I:\3391\Calculations\Stormwater\
Inflow  HYG file = work_pad.hyg - DET / SED    IN  Dev 25
Outflow HYG file = work_pad.hyg - DET / SED    OUT Dev 25

Pond Node   Data = DET / SED
Pond Volume Data = DET / SED
Pond Outlet Data = Existing Outlet

No Infiltration

INITIAL CONDITIONS
----------------------------------
Starting WS Elev   =   681.46 ft
Starting Volume    =     .000 ac-ft
Starting Outflow   =      .00 cfs
Starting Infiltr.  =      .00 cfs
Starting Total Qout=      .00 cfs
Time Increment     =    .0500 hrs


INFLOW/OUTFLOW HYDROGRAPH SUMMARY
=====================================================
Peak Inflow      =   160.65 cfs    at   12.2500 hrs
Peak Outflow     =    19.77 cfs    at   13.6000 hrs
-----------------------------------------------------
Peak Elevation   =   684.98 ft
Peak Storage =       10.946 ac-ft
=====================================================


MASS BALANCE (ac-ft)
--------------------------
+ Initial Vol  =        .000
+ HYG Vol IN   =      18.450
- Infiltration =        .000
- HYG Vol OUT  =      17.183
- Retained Vol =       1.266
                  ----------
  Unrouted Vol =       -.000 ac-ft  (.002% of Inflow Volume)


WARNING: Outflow hydrograph truncated on right side.
```

← PEAK WATER ELEV. 25-yr STORM

LEVEL POOL ROUTING SUMMARY

```
HYG Dir           = I:\3391\Calculations\Stormwater\
Inflow  HYG file = work_pad.hyg - DET / SED    IN  Dev100
Outflow HYG file = work_pad.hyg - DET / SED    OUT Dev100

Pond Node   Data = DET / SED
Pond Volume Data = DET / SED
Pond Outlet Data = Existing Outlet

No Infiltration

INITIAL CONDITIONS
----------------------------------
Starting WS Elev   =   681.46 ft
Starting Volume    =     .000 ac-ft
Starting Outflow   =      .00 cfs
Starting Infiltr.  =      .00 cfs
Starting Total Qout=      .00 cfs
Time Increment     =    .0500 hrs


INFLOW/OUTFLOW HYDROGRAPH SUMMARY
=====================================================
Peak Inflow     =   197.69 cfs   at   12.2500 hrs
Peak Outflow    =    41.57 cfs   at   13.1000 hrs
-----------------------------------------------------
Peak Elevation  =   685.43 ft
Peak Storage =      12.598 ac-ft
=====================================================


MASS BALANCE (ac-ft)
--------------------------
+ Initial Vol  =       .000
+ HYG Vol IN   =     22.748
- Infiltration =       .000
- HYG Vol OUT  =     21.470
- Retained Vol =      1.278
                 ----------
Unrouted Vol =       -.000 ac-ft  (.001% of Inflow Volume)


WARNING: Outflow hydrograph truncated on right side.
```

← PEAK WATER ELEV.
100-yr STORM

Detention / Sedimentation Basin Routing
Proposed Outlet Structure

REQUESTED POND WS ELEVATIONS:

Min. Elev.= 681.00 ft
Increment = .10 ft
Max. Elev.= 686.00 ft

****
OUTLET CONNECTIVITY
****

---> Forward Flow Only (UpStream to DnStream)
<--- Reverse Flow Only (DnStream to UpStream)
<---> Forward and Reverse Both Allowed

Structure	No.		Outfall	E1, ft	E2, ft
Orifice-Circular	O1	--->	C0	681.750	686.000
Orifice-Circular	O4	--->	C0	682.250	686.000
Orifice-Circular	O5	--->	C0	682.750	686.000
Orifice-Circular	O2	--->	C0	683.250	686.000
Stand Pipe	R0	--->	C0	684.250	686.000
Orifice-Circular	O0	--->	C0	681.250	686.000
Culvert-Circular	C0	--->	TW	681.000	686.000
Weir-Rectangular	W0	--->	TW	685.000	686.000
TW SETUP, DS Channel					

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = O1
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =         4
Invert Elev.       =    681.75 ft
Diameter           =     .5000 ft
Orifice Coeff.     =      .700


Structure ID       = O4
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =         4
Invert Elev.       =    682.25 ft
Diameter           =     .5000 ft
Orifice Coeff.     =      .700


Structure ID       = O5
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =         4
Invert Elev.       =    682.75 ft
Diameter           =     .5000 ft
Orifice Coeff.     =      .700


Structure ID       = O2
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =         4
Invert Elev.       =    683.25 ft
Diameter           =     .5000 ft
Orifice Coeff.     =      .700
```

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = R0
Structure Type     = Stand Pipe
------------------------------------
# of Openings      =       1
Invert Elev.       =    684.25 ft
Diameter           =    3.0000 ft
Orifice Area       =    7.0686 sq.ft
Orifice Coeff.     =      .700
Weir Length        =      9.42 ft
Weir Coeff.        =     3.300
K, Reverse         =     1.000
Mannings n         =     .0000
Kev,Charged Riser  =      .000
Weir Submergence   = No


Structure ID       = O0
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =       4
Invert Elev.       =    681.25 ft
Diameter           =     .5000 ft
Orifice Coeff.     =      .700
```

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = C0
Structure Type     = Culvert-Circular
------------------------------------
No. Barrels        =        1
Barrel Diameter    =    3.0000 ft
Upstream Invert    =    681.00 ft
Dnstream Invert    =    680.50 ft
Horiz. Length      =     30.00 ft
Barrel Length      =     30.00 ft
Barrel Slope       =    .01667 ft/ft

OUTLET CONTROL DATA...
Mannings n         =     .0240
Ke                 =     .5000  (forward entrance loss)
Kb                 =   .024635  (per ft of full flow)
Kr                 =     .5000  (reverse entrance loss)
HW Convergence     =      .001  +/- ft

INLET CONTROL DATA...
Equation form      =        1
Inlet Control K    =     .0078
Inlet Control M    =    2.0000
Inlet Control c    =    .03790
Inlet Control Y    =     .6900
T1 ratio (HW/D)    =      .000
T2 ratio (HW/D)    =     1.288
Slope Factor       =     -.500
```

```
Use unsubmerged inlet control Form 1 equ. below T1 elev.
Use   submerged inlet control Form 1 equ. above T2 elev.

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...
At T1 Elev =     681.00 ft   ---> Flow =      42.85 cfs
At T2 Elev =     684.86 ft   ---> Flow =      48.97 cfs
```

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = WO
Structure Type     = Weir-Rectangular
------------------------------------
# of Openings      =          1
Crest Elev.        =     685.00 ft
Weir Length        =      25.00 ft
Weir Coeff.        =   2.630000

Weir TW effects      (Use adjustment equation)



Structure ID       = TW
Structure Type     = TW SETUP, DS Channel
------------------------------------
FREE OUTFALL CONDITIONS SPECIFIED

CONVERGENCE TOLERANCES...
Maximum Iterations=    40
Min. TW tolerance =    .01 ft
Max. TW tolerance =    .01 ft
Min. HW tolerance =    .01 ft
Max. HW tolerance =    .01 ft
Min.  Q tolerance =    .00 cfs
Max.  Q tolerance =    .00 cfs
```

```
                    LEVEL POOL ROUTING SUMMARY

 HYG Dir          = I:\3391\Calculations\Stormwater\
 Inflow  HYG file = work_pad.hyg - DET / SED    IN  Dev 25
 Outflow HYG file = work_pad.hyg - DET / SED    OUT Dev 25

 Pond Node   Data = DET / SED
 Pond Volume Data = DET / SED
 Pond Outlet Data = Proposed Outlet

 No Infiltration

 INITIAL CONDITIONS
 ----------------------------------
 Starting WS Elev    =   681.25 ft
 Starting Volume     =     .692 ac-ft
 Starting Outflow    =      .00 cfs
 Starting Infiltr.   =      .00 cfs
 Starting Total Qout=       .00 cfs
 Time Increment      =    .0500 hrs


 INFLOW/OUTFLOW HYDROGRAPH SUMMARY
 =====================================================
 Peak Inflow      =   188.91 cfs    at   12.2500 hrs
 Peak Outflow     =    38.05 cfs    at   13.2000 hrs
 -----------------------------------------------------
 Peak Elevation   =   684.99 ft
 Peak Storage =       12.276 ac-ft
 =====================================================


 MASS BALANCE (ac-ft)
 --------------------------
+ Initial Vol   =       .692
+ HYG Vol IN    =     22.357
- Infiltration =        .000
- HYG Vol OUT   =     22.241
- Retained Vol =        .807
                  ----------
 Unrouted Vol =       -.000 ac-ft  (.000% of Inflow Volume)


 WARNING: Outflow hydrograph truncated on right side.
```

← Peak water Elevation
25-yr storm

LEVEL POOL ROUTING SUMMARY

```
HYG Dir          = I:\3391\Calculations\Stormwater\
Inflow  HYG file = work_pad.hyg - DET / SED    IN  Dev100
Outflow HYG file = work_pad.hyg - DET / SED    OUT Dev100

Pond Node   Data = DET / SED
Pond Volume Data = DET / SED
Pond Outlet Data = Proposed Outlet

No Infiltration

INITIAL CONDITIONS
----------------------------------
Starting WS Elev   =   681.25 ft
Starting Volume    =     .692 ac-ft
Starting Outflow   =      .00 cfs
Starting Infiltr.  =      .00 cfs
Starting Total Qout=      .00 cfs
Time Increment     =    .0500 hrs

INFLOW/OUTFLOW HYDROGRAPH SUMMARY
=====================================================
Peak Inflow     =    232.63 cfs    at   12.2500 hrs
Peak Outflow    =     73.09 cfs    at   12.9000 hrs
-----------------------------------------------------
Peak Elevation  =    685.45 ft
Peak Storage =       13.977 ac-ft
=====================================================

MASS BALANCE (ac-ft)
--------------------------
+ Initial Vol  =        .692
+ HYG Vol IN   =      27.565
- Infiltration =        .000
- HYG Vol OUT  =      27.448
- Retained Vol =        .809
                  ----------
Unrouted Vol =       -.000 ac-ft  (.000% of Inflow Volume)

WARNING: Outflow hydrograph truncated on right side.
```

← Peak water Elevation 100-yr storm

Type.... Pond Routed HYG (total out) Page 1.06
Name.... DET / SED OUT Tag: Dev 25 Event: 25 yr
File.... I:\3391\Calculations\Stormwater\Final Grades-new outlet.ppw
Storm... TypeII 24hr Tag: Dev 25

HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0500 hrs
Time on left represents time for first value in each row.

Time hrs					
69.7000	.08	.08	.08	.08	.08
69.9500	.08	.08	.08	.08	.08
70.2000	.08	.08	.08	.08	.08
70.4500	.08	.08	.08	.08	.08
70.7000	.08	.08	.08	.08	.08
70.9500	.08	.08	.08	.08	.08
71.2000	.08	.08	.08	.08	.08
71.4500	.07	.07	.07	.07	.07
71.7000	.07	.07	.07	.07	.07
71.9500	.07	.07	.07	.07	.07
72.2000	.07	.07	.07	.07	.07
72.4500	.07	.07	.07	.07	.07
72.7000	.07	.07	.07	.07	.07
72.9500	.07	.07	.07	.07	.07
73.2000	.07	.07	.07	.07	.07
73.4500	.07	.07	.07	.07	.07
73.7000	.07	.07	.07	.07	.07
73.9500	.07	.07	.07	.06	.06
74.2000	.06	.06	.06	.06	.06
74.4500	.06	.06	.06	.06	.06
74.7000	.06	.06	.06	.06	.06
74.9500	.06	.06	.06	.06	.06
75.2000	.06	.06	.06	.06	.06
75.4500	.06	.06	.06	.06	.06
75.7000	.06	.06	.06	.06	.06
75.9500	.06	.06	.06	.06	.06
76.2000	.06	.06	.06	.06	.06
76.4500	.06	.06	.06	.06	.06
76.7000	.06	.06	.06	.06	.06
76.9500	.06	.06	.06	.06	.06
77.2000	.05	.05	.05	.05	.05
77.4500	.05	.05	.05	.05	.05
77.7000	.05	.05	.05	.05	.05
77.9500	.05	.05	.05	.05	.05
78.2000	.05	.05	.05	.05	.05
78.4500	.05	.05	.05	.05	.05
78.7000	.05	.05	.05	.05	.05
78.9500	.05	.05	.05	.05	.05
79.2000	.05	.05	.05	.05	.05
79.4500	.05	.05	.05	.05	.05
79.7000	.05	.05	.05	.05	.05
79.9500	.05	.05	.05	.05	.05
80.2000	.05	.05	.05	.05	.05
80.4500	.05	.05	.05	.05	.05
80.7000	.05	.05	.05	.05	.04

72.0 Hr

OUTFLOW AT 72.0 HRS (3 Days) = 0.07 CFS
∴ BASIN TAKES MORE THAN 3 DAYS TO DRAIN.

Detention Basin Routing

RUNOFF CURVE NUMBER DATA

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	Impervious Adjustment %UC	Adjusted CN
Off-site	79	91.000			79.00
COMPOSITE AREA & WEIGHTED CN --->		91.000			79.00 (79)

Table of Contents (continued)

```
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::
TIME OF CONCENTRATION CALCULATOR
::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::::


------------------------------------------------------------------------


Segment #1:  Tc: TR-55 Sheet

Mannings n            .2400
Hydraulic Length    400.00 ft
2yr, 24hr P         2.5000 in
Slope             .010000 ft/ft

Avg.Velocity           .10 ft/sec

                                        Segment #1 Time:    1.0763 hrs
------------------------------------------------------------------------

Segment #2:  Tc: TR-55 Channel

Flow Area           5.9000 sq.ft
Wetted Perimeter     13.60 ft
Hydraulic Radius       .43 ft
Slope              .010000 ft/ft
Mannings n           .0350
Hydraulic Length  3600.00 ft

Avg.Velocity          2.44 ft/sec

                                        Segment #2 Time:     .4099 hrs
------------------------------------------------------------------------

                                              =========================
                                               Total Tc:    1.4862 hrs
                                              =========================
```

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 25 year storm
Duration       = 24.0000 hrs     Rain Depth = 4.4000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID =  - OFF-SITE AREA 25
Tc             = 1.4862 hrs
Drainage Area = 91.000 acres  Runoff CN= 79

============================================
Computational Time Increment   =   .19816 hrs
Computed Peak Time             =  12.8806 hrs
Computed Peak Flow             =    81.53 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.8500 hrs
Peak Flow, Interpolated Output =    81.27 cfs
============================================

                 DRAINAGE AREA
              -------------------
              ID:OFF-SITE AREA
              CN   =   79
              Area =      91.000 acres
              S    =  2.6582 in
              0.2S =    .5316 in

               Cumulative Runoff
              -------------------
                      2.2928 in
                      17.387 ac-ft

HYG Volume...         17.386 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =  1.48623 hrs (ID: OFF-SITE AREA)
Computational Incr, Tm =   .19816 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =   .7491)

Unit peak,           qp =    69.38 cfs
Unit peak time       Tp =   .99082 hrs
Unit receding limb, Tr =  3.96327 hrs
Total unit time,     Tb =  4.95408 hrs
```

```
SCS UNIT HYDROGRAPH METHOD

STORM EVENT: 100 year storm
Duration       = 24.0000 hrs     Rain Depth = 5.1000 in
Rain Dir       = I:\3391\Calculations\Stormwater\
Rain File -ID =  - TypeII  24hr
Unit Hyd Type = Default Curvilinear
HYG Dir        = I:\3391\Calculations\Stormwater\
HYG File - ID =  - OFF-SITE AREA 100
Tc             = 1.4862 hrs
Drainage Area = 91.000 acres  Runoff CN= 79

============================================
Computational Time Increment   =   .19816 hrs
Computed Peak Time             =  12.8806 hrs
Computed Peak Flow             =   103.19 cfs

Time Increment for HYG File    =    .0500 hrs
Peak Time, Interpolated Output =  12.8500 hrs
Peak Flow, Interpolated Output =   102.94 cfs
============================================

              DRAINAGE AREA
              -------------------
              ID:OFF-SITE AREA
              CN   =   79
              Area =       91.000 acres
              S    =   2.6582 in
              0.2S =    .5316 in

               Cumulative Runoff
              -------------------
                      2.8879 in
                      21.900 ac-ft

HYG Volume...         21.899 ac-ft (area under HYG curve)

***** SCS UNIT HYDROGRAPH PARAMETERS *****

Time Concentration, Tc =  1.48623 hrs (ID: OFF-SITE AREA)
Computational Incr, Tm =   .19816 hrs = 0.20000 Tp

Unit Hyd. Shape Factor =  483.432 (37.46% under rising limb)
K =  483.43/645.333,  K =     .7491 (also, K = 2/(1+(Tr/Tp))
Receding/Rising, Tr/Tp =   1.6698 (solved from K =    .7491)

Unit peak,          qp =    69.38 cfs
Unit peak time      Tp =   .99082 hrs
Unit receding limb, Tr =  3.96327 hrs
Total unit time,    Tb =  4.95408 hrs
```

Elevation (ft)	Planimeter (sq.in)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume Sum (ac-ft)
685.50	-----	2.7000	.0000	.000	.000
686.00	-----	2.8800	8.3685	1.395	1.395
688.00	-----	3.5800	9.6710	6.447	7.842
690.00	-----	4.4900	12.0793	8.053	15.895
692.00	-----	6.5000	16.3923	10.928	26.823

POND VOLUME EQUATIONS

* Incremental volume computed by the Conic Method for Reservoir Volumes.

Volume = (1/3) * (EL2-EL1) * (Area1 + Area2 + sq.rt.(Area1*Area2))

where: EL1, EL2 = Lower and upper elevations of the increment
Area1,Area2 = Areas computed for EL1, EL2, respectively
Volume = Incremental volume between EL1 and EL2

REQUESTED POND WS ELEVATIONS:

Min. Elev.= 685.50 ft
Increment = .10 ft
Max. Elev.= 692.00 ft

****
OUTLET CONNECTIVITY
****

---> Forward Flow Only (UpStream to DnStream)
<--- Reverse Flow Only (DnStream to UpStream)
<---> Forward and Reverse Both Allowed

Structure	No.		Outfall	E1, ft	E2, ft
Orifice-Circular	O1	--->	C0	687.000	692.000
Orifice-Circular	O2	--->	C0	687.500	692.000
Orifice-Circular	O3	--->	C0	688.000	692.000
Orifice-Circular	O4	--->	C0	688.500	692.000
Orifice-Circular	O5	--->	C0	689.000	692.000
Stand Pipe	R0	--->	C0	689.880	692.000
Orifice-Circular	O0	--->	C0	686.230	692.000
Culvert-Circular	C0	--->	TW	685.500	692.000
Weir-Rectangular	W0	--->	TW	692.000	692.000
TW SETUP, DS Channel					

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = O1
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =          3
Invert Elev.       =     687.00 ft
Diameter           =      .0810 ft
Orifice Coeff.     =       .700


Structure ID       = O2
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =          3
Invert Elev.       =     687.50 ft
Diameter           =      .0810 ft
Orifice Coeff.     =       .700


Structure ID       = O3
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =          3
Invert Elev.       =     688.00 ft
Diameter           =      .0810 ft
Orifice Coeff.     =       .070


Structure ID       = O4
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =          3
Invert Elev.       =     688.50 ft
Diameter           =      .0810 ft
Orifice Coeff.     =       .700
```

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = O5
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =        3
Invert Elev.       =    689.00 ft
Diameter           =     .0810 ft
Orifice Coeff.     =      .700


Structure ID       = R0
Structure Type     = Stand Pipe
------------------------------------
# of Openings      =        1
Invert Elev.       =    689.88 ft
Diameter           =    1.5000 ft
Orifice Area       =    1.7671 sq.ft
Orifice Coeff.     =      .700
Weir Length        =      4.71 ft
Weir Coeff.        =     3.300
K, Reverse         =     1.000
Mannings n         =     .0000
Kev,Charged Riser  =      .000
Weir Submergence   = No


Structure ID       = O0
Structure Type     = Orifice-Circular
------------------------------------
# of Openings      =        3
Invert Elev.       =    686.23 ft
Diameter           =     .0810 ft
Orifice Coeff.     =      .700
```

OUTLET STRUCTURE INPUT DATA

```
Structure ID       = CO
Structure Type     = Culvert-Circular
------------------------------------
No. Barrels        =        1
Barrel Diameter    =    1.5000 ft
Upstream Invert    =    685.50 ft
Dnstream Invert    =    685.00 ft
Horiz. Length      =     65.00 ft
Barrel Length      =     65.00 ft
Barrel Slope       =    .00769 ft/ft

OUTLET CONTROL DATA...
Mannings n         =     .0240
Ke                 =     .5000  (forward entrance loss)
Kb                 =   .062076  (per ft of full flow)
Kr                 =     .5000  (reverse entrance loss)
HW Convergence     =      .001  +/- ft

INLET CONTROL DATA...
Equation form      =         1
Inlet Control K    =     .0078
Inlet Control M    =    2.0000
Inlet Control c    =    .03790
Inlet Control Y    =     .6900
T1 ratio (HW/D)    =     1.132
T2 ratio (HW/D)    =     1.293
Slope Factor       =     -.500
```

Use unsubmerged inlet control Form 1 equ. below T1 elev.
Use   submerged inlet control Form 1 equ. above T2 elev.

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...
At T1 Elev =   687.20 ft   ---> Flow =   7.58 cfs
At T2 Elev =   687.44 ft   ---> Flow =   8.66 cfs

```
OUTLET STRUCTURE INPUT DATA


Structure ID       = WO
Structure Type     = Weir-Rectangular
------------------------------------
# of Openings      =         1
Crest Elev.        =    692.00 ft
Weir Length        =     25.00 ft
Weir Coeff.        =  2.630000

Weir TW effects      (Use adjustment equation)



Structure ID       = TW
Structure Type     = TW SETUP, DS Channel
------------------------------------
FREE OUTFALL CONDITIONS SPECIFIED

CONVERGENCE TOLERANCES...
Maximum Iterations=    40
Min. TW tolerance =    .01 ft
Max. TW tolerance =    .01 ft
Min. HW tolerance =    .01 ft
Max. HW tolerance =    .01 ft
Min.  Q tolerance =    .00 cfs
Max.  Q tolerance =    .00 cfs
```

```
                LEVEL POOL ROUTING SUMMARY

 HYG Dir            = I:\3391\Calculations\Stormwater\
 Inflow  HYG file = NONE STORED - DETENTION    IN  25
 Outflow HYG file = NONE STORED - DETENTION    OUT 25

 Pond Node    Data = DETENTION
 Pond Volume Data = DETENTION
 Pond Outlet Data = Existing Outlet

 No Infiltration

 INITIAL CONDITIONS
 ----------------------------------
 Starting WS Elev   =   685.50 ft
 Starting Volume    =     .000 ac-ft
 Starting Outflow   =      .00 cfs
 Starting Infiltr.  =      .00 cfs
 Starting Total Qout=      .00 cfs
 Time Increment     =    .0500 hrs


 INFLOW/OUTFLOW HYDROGRAPH SUMMARY
 =====================================================
 Peak Inflow        =    81.27 cfs   at   12.8500 hrs
 Peak Outflow       =     2.30 cfs   at   24.8500 hrs
 -----------------------------------------------------
 Peak Elevation     =   690.10 ft
 Peak Storage =        16.358 ac-ft
 =====================================================


 MASS BALANCE (ac-ft)
 --------------------------
+ Initial Vol  =        .000
+ HYG Vol IN   =      17.386
- Infiltration =        .000
- HYG Vol OUT  =       5.359
- Retained Vol =      12.027
                  ----------
 Unrouted Vol =        -.000 ac-ft  (.000% of Inflow Volume)


 WARNING: Outflow hydrograph truncated on right side.
```

LEVEL POOL ROUTING SUMMARY

```
HYG Dir          = I:\3391\Calculations\Stormwater\
Inflow  HYG file = NONE STORED - DETENTION    IN  100
Outflow HYG file = NONE STORED - DETENTION    OUT 100

Pond Node   Data = DETENTION
Pond Volume Data = DETENTION
Pond Outlet Data = Existing Outlet

No Infiltration

INITIAL CONDITIONS
----------------------------------
Starting WS Elev    =   685.50 ft
Starting Volume     =     .000 ac-ft
Starting Outflow    =      .00 cfs
Starting Infiltr.   =      .00 cfs
Starting Total Qout=       .00 cfs
Time Increment      =    .0500 hrs

INFLOW/OUTFLOW HYDROGRAPH SUMMARY
=====================================================
Peak Inflow      =    102.94 cfs    at    12.8500 hrs
Peak Outflow     =      6.35 cfs    at    19.9000 hrs
-----------------------------------------------------
Peak Elevation   =    690.39 ft
Peak Storage =        17.718 ac-ft
=====================================================

MASS BALANCE (ac-ft)
-------------------------
+ Initial Vol  =       .000
+ HYG Vol IN   =     21.899
- Infiltration =       .000
- HYG Vol OUT  =      9.716
- Retained Vol =     12.182
                 ----------
Unrouted Vol =        -.000 ac-ft  (.002% of Inflow Volume)

WARNING: Outflow hydrograph truncated on right side.
```

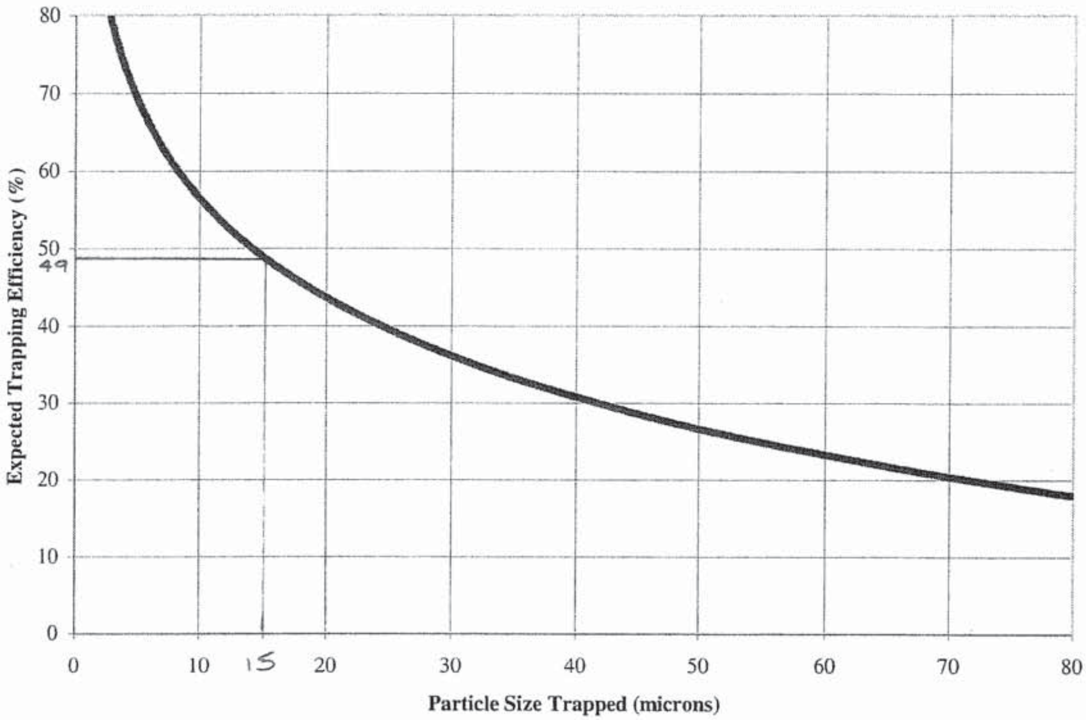
HYDROGRAPH ORDINATES (cfs)
Output Time increment = .0500 hrs
Time on left represents time for first value in each row.

Time hrs					
71.4000	.56	.56	.56	.56	.56
71.6500	.56	.56	.56	.56	.56
71.9000	.56	.56	.56	.56	.56
72.1500	.56	.56	.56	.56	.56
72.4000	.56	.56	.56	.56	.56
72.6500	.56	.56	.56	.56	.56
72.9000	.56	.56	.56	.56	.56
73.1500	.56	.56	.56	.56	.56
73.4000	.56	.56	.56	.56	.56
73.6500	.56	.56	.56	.56	.56
73.9000	.56	.56	.56	.56	.56
74.1500	.56	.56	.56	.56	.56
74.4000	.56	.56	.56	.56	.56
74.6500	.56	.56	.56	.56	.56
74.9000	.56	.56	.56	.56	.56
75.1500	.55	.55	.55	.55	.55
75.4000	.55	.55	.55	.55	.55
75.6500	.55	.55	.55	.55	.55
75.9000	.55	.55	.55	.55	.55
76.1500	.55	.55	.55	.55	.55
76.4000	.55	.55	.55	.55	.55
76.6500	.55	.55	.55	.55	.55
76.9000	.55	.55	.55	.55	.55
77.1500	.55	.55	.55	.55	.55
77.4000	.55	.55	.55	.55	.55
77.6500	.55	.55	.55	.55	.55
77.9000	.55	.55	.55	.55	.55
78.1500	.55	.55	.55	.55	.55
78.4000	.55	.55	.55	.55	.55
78.6500	.55	.55	.55	.55	.55
78.9000	.55	.55	.55	.55	.55
79.1500	.55	.55	.55	.55	.55
79.4000	.55	.55	.55	.55	.54
79.6500	.54	.54	.54	.54	.54
79.9000	.54	.54	.54	.54	.54
80.1500	.54	.54	.54	.54	.54
80.4000	.54	.54	.54	.54	.54
80.6500	.54	.54	.54	.54	.54
80.9000	.54	.54	.54	.54	.54
81.1500	.54	.54	.54	.54	.54
81.4000	.54	.54	.54	.54	.54
81.6500	.54	.54	.54	.54	.54
81.9000	.54	.54	.54	.54	.54
82.1500	.54	.54	.54	.54	.54
82.4000	.54	.54	.54	.54	.54

72.0 Hr

OUTFLOW AT 72.0 Hr = 0.56 cfs
∴ BASIN TAKES MORE THAN 3 DAYS TO DRAIN.

Sediment Removal Analysis
(P8 Urban Catchment Model)



Convert the storage volume from the 1-year, 24-hour storm event into cubic feet. This volume of storage is then divided by the time required to settle the particle obtained by Stokes Law.

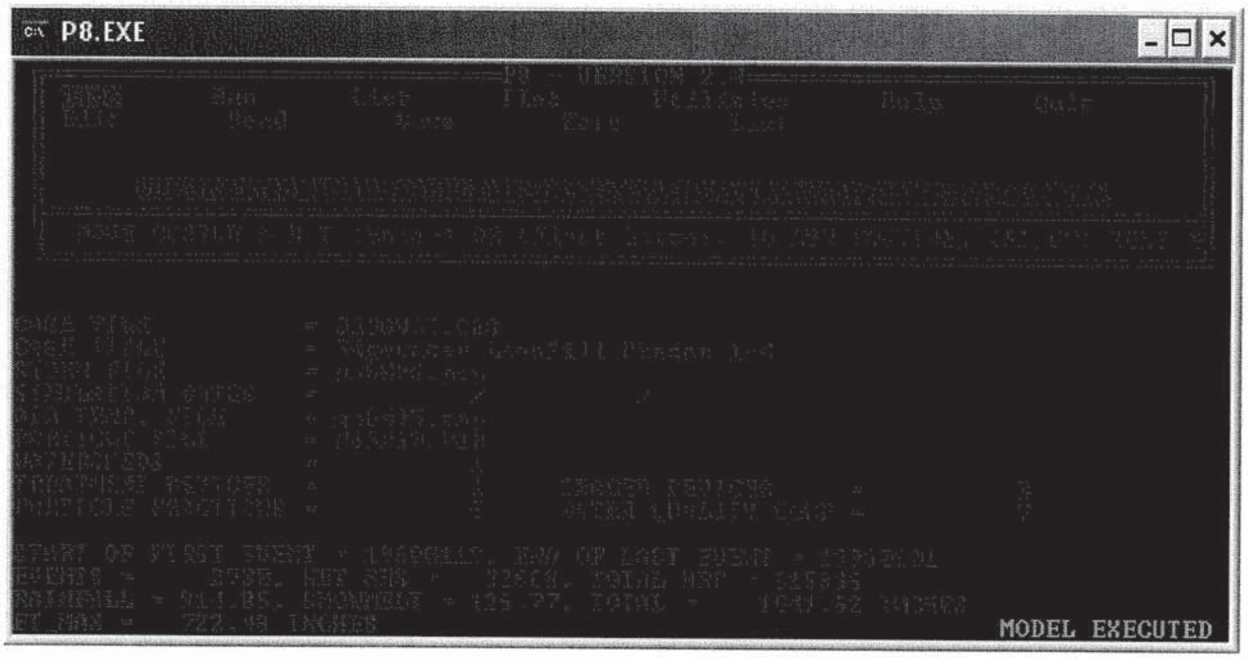
$$Q_{\max imum}(cfs) = \frac{V_{Storage}(ft^3)}{Time(\sec)}$$

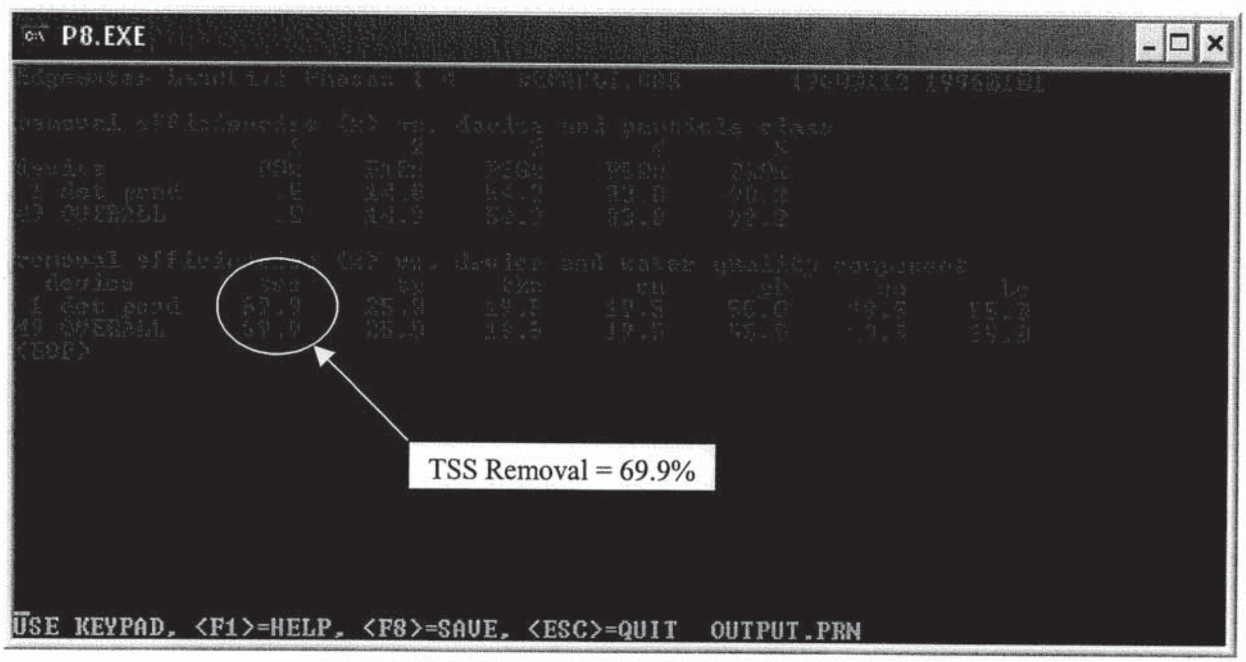
Q $_{maximum}$ is the rate at which the basin must be released in order to obtain the expected efficiency.

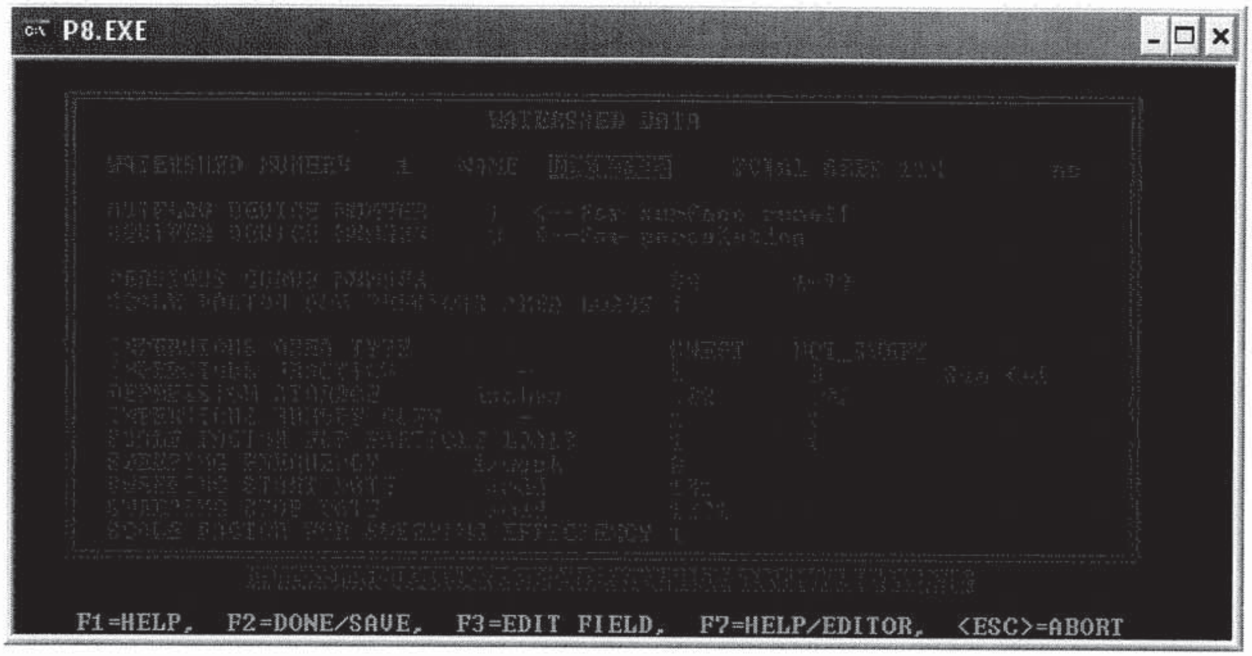
*See table on following page for particle settling velocities to calculate Time (sec)

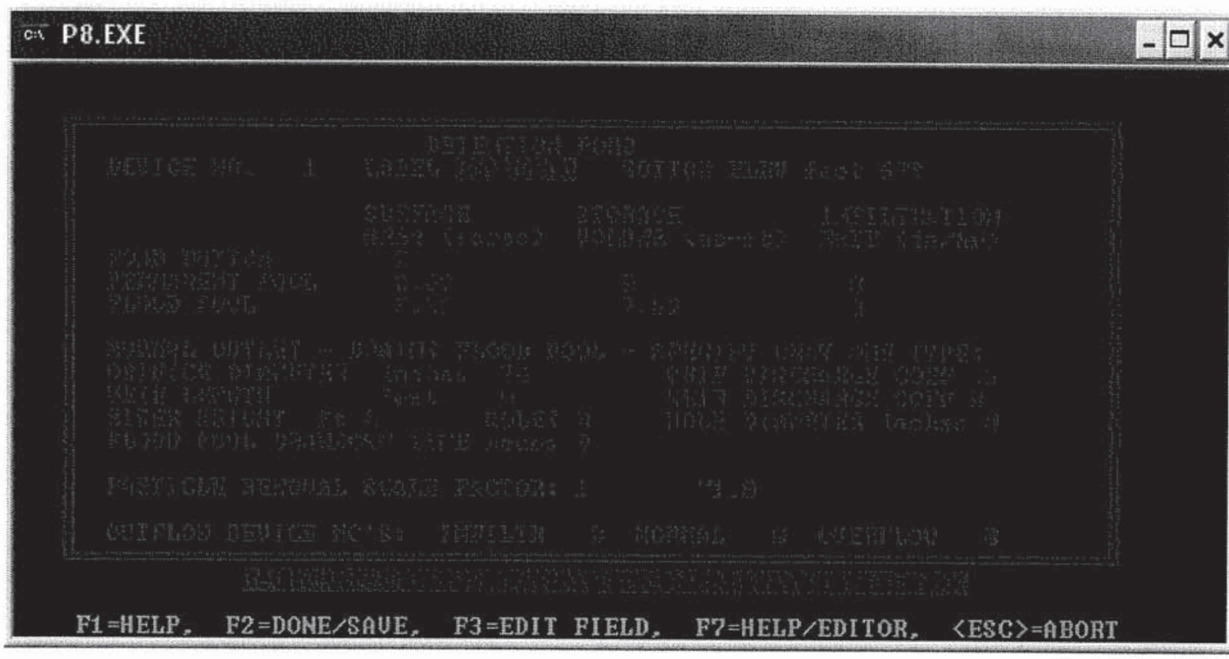
TO Trap the 15 micron particle, must HAVE A Trapping efficiency of at least 49%

P8 - Sediment Removal Analysis
Sedimentation / Detention Basin
Edgewater Landfill



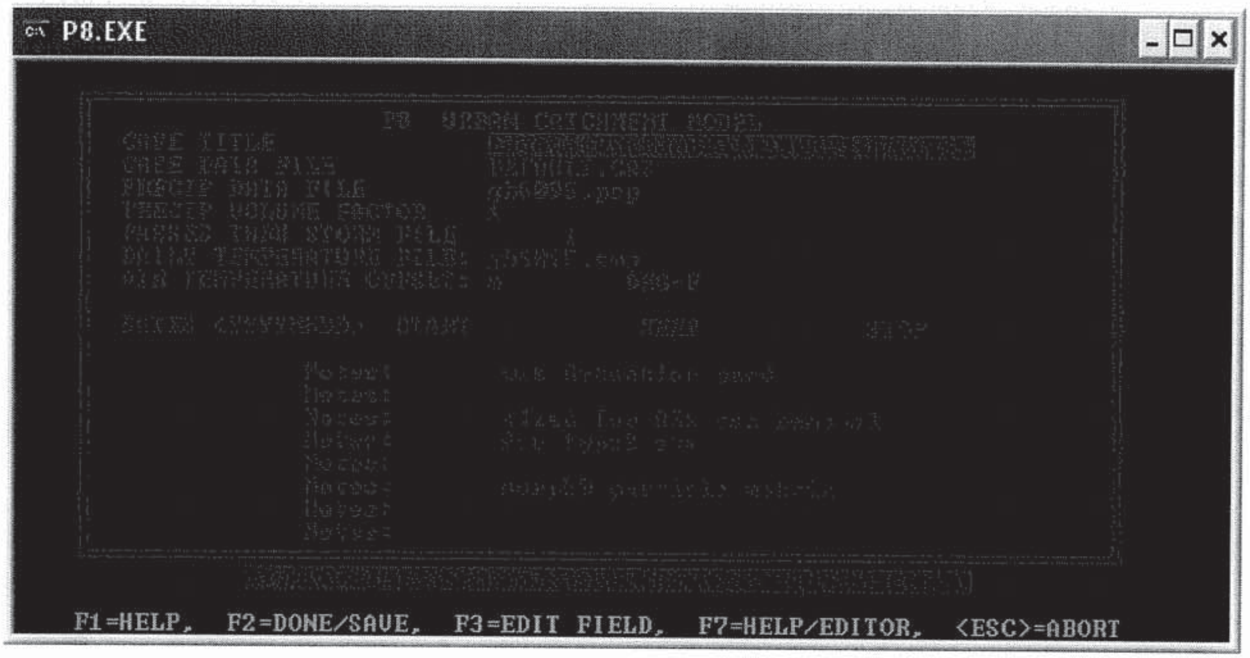


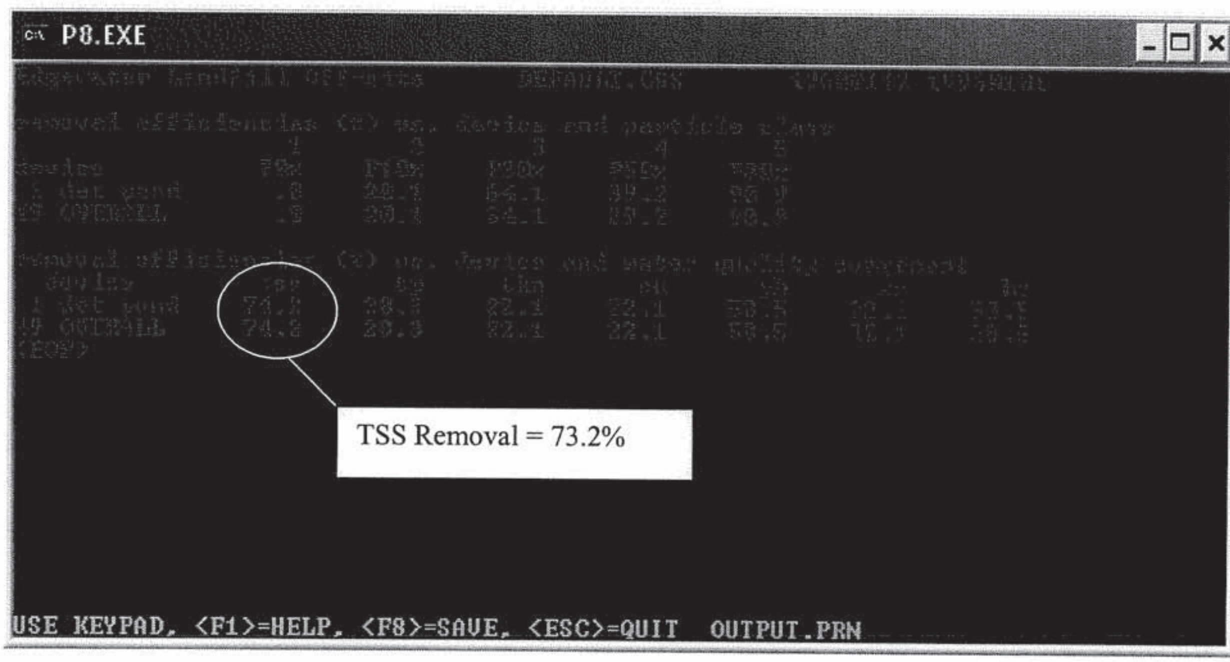


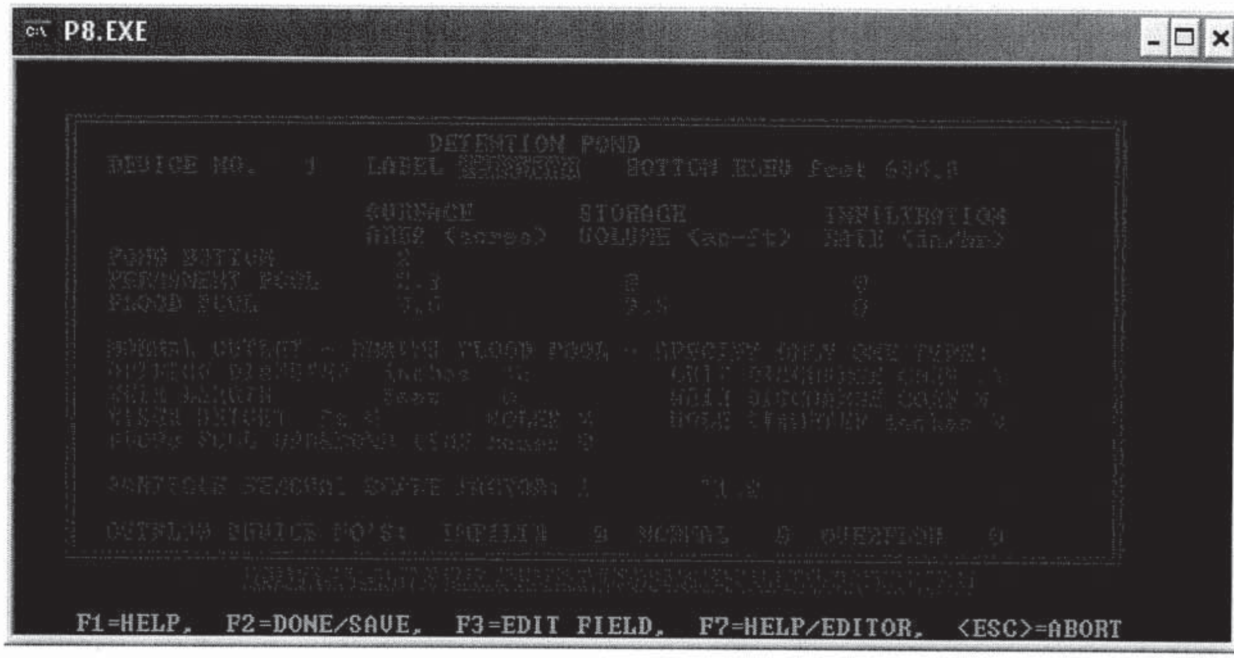


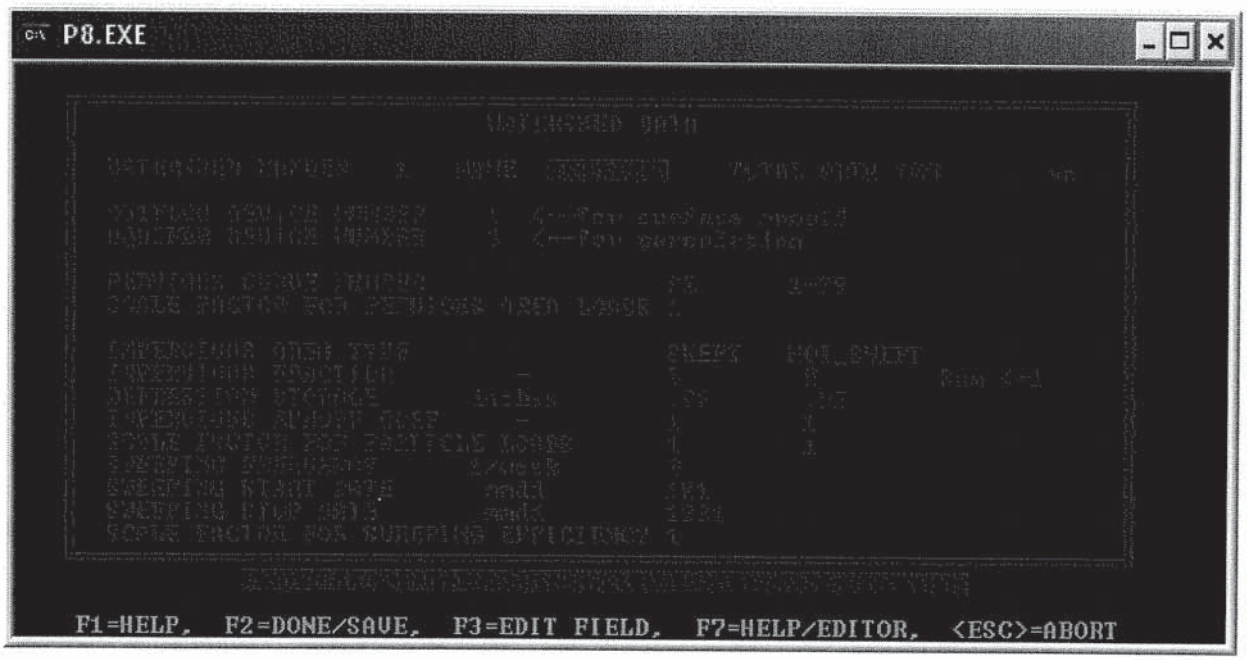
KRG/
I:\3391\Calculations\Stormwater\P8 - Sed-Det Basin.doc

P8 Sediment Removal Analysis
Detention Basin for Off-site Stormwater Runon
Edgewater Landfill









KRG/krg
I:\3391\Calculations\Stormwater\P8 Offsite Det Basin.doc

BT² inc.		Sheet No.
		Calc. No.
		Rev. No.
Job No. 3391	Job Edgewater Landfill	By KRG Date 12/4/07
Client	Subject	Chk'd. Date

Another method of checking sediment Removal is to Determine the surface Area of the basin and the discharge. This ratio can be compared to the Table below.

To settle the 0.015mm particle, A_n^{min} Ratio of 3125 is required.

8.16 **Erosion and Sediment Control Handbook**

TABLE 8.1 Surface Area Requirements of Sediment Traps and Basins

Particle size, mm	Settling velocity, ft/sec (m/sec)	Surface area requirements, ft^2 per ft^3/sec discharge	(m^2 per m^3/sec discharge)
0.5 (coarse sand)	0.19 (0.058)	6.3	(20.7)
0.2 (medium sand)	0.067 (0.020)	17.9	(58.7)
0.1 (fine sand)	0.023 (0.0070)	52.2	(171.0)
0.05 (coarse silt)	0.0062 (0.0019)	193.6	(635.0)
0.02 (medium silt)	0.00096 (0.00029)	1,250.0	(4,101.0)
0.01 (fine silt)	0.00024 (0.000073)	5,000.0	(16,404.0)
0.005 (clay)	0.00006 (0.000018)	20,000.0	(65,617.0)

→ .015 3125.0 ←

With the proposed outlet, the outlet Flow From the 25-yr storm is 38.05 CFS at a elevation of 684.99. The surface area at this elevation = 3.6 Ac = 156816 Ft^2

$$\frac{156816\ Ft^2}{38.05\ Ft^3/sec} = 4121\ \frac{Ft^2}{Ft^3/sec}$$

∴ The basin will settle the 0.015mm particle

Swale and Culvert Calculations

Channel Calculator

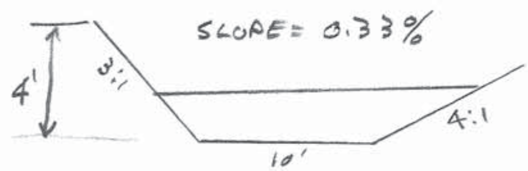
SWALE LOCATED WEST OF PHASES 3+4

Given Input Data:

Shape	Trapezoidal
Solving for	Depth of Flow
Flowrate	163.0000 cfs
Slope	0.0033 ft/ft
Manning's n	0.0300
Height	48.0000 in
Bottom width	120.0000 in
Left slope	4.0000 ft/ft (V/H)
Right slope	3.0000 ft/ft (V/H)

Computed Results:

Depth	38.3721 in ←
Velocity	4.6626 fps
Full Flowrate	230.0749 cfs
Flow area	34.9591 ft2
Flow perimeter	200.0008 in
Hydraulic radius	25.1704 in
Top width	142.3837 in
Area	44.6667 ft2
Perimeter	220.0737 in
Percent full	79.9419 %



25-YR STORM

PHASE 1+2 = 107.2

PHASE 3+4 SW = 55.4

162.6 CFS

SWALE CARRIES FLOW FROM PHASES 1+2 + PHASE 3+4 - SOUTHWEST

MAX FLOW DEPTH = 38.4"

FREE BOARD = 48" - 38.4" = 9.6"

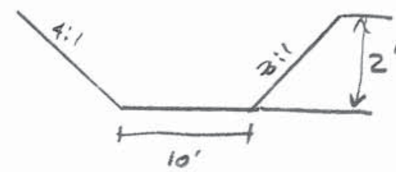
Channel Calculator

SWALE LOCATED
EAST OF PHASE 3

```
Given Input Data:
     Shape ........................... Trapezoidal
     Solving for ..................... Depth of Flow
     Flowrate ........................ 30.7000 cfs
     Slope ........................... 0.0100 ft/ft
     Manning's n ..................... 0.0300
     Height .......................... 24.0000 in
     Bottom width .................... 120.0000 in
     Left slope ...................... 4.0000 ft/ft (V/H)
     Right slope ..................... 3.0000 ft/ft (V/H)

Computed Results:
     Depth ........................... 9.3523 in
     Velocity ........................ 3.8516 fps
     Full Flowrate ................... 137.0073 cfs
     Flow area ....................... 7.9708 ft2
     Flow perimeter .................. 139.4984 in
     Hydraulic radius ................ 8.2280 in
     Top width ....................... 125.4555 in
     Area ............................ 21.1667 ft2
     Perimeter ....................... 170.0369 in
     Percent full .................... 38.9680 %
```

1% SLOPE



25-YR STORM = 30.7 CFS

MAX DEPTH = 9.4"

Free Board = 14.6"

Manning Pipe Calculator

CULVERT NEAR LEACHATE PUMPOUT

Given Input Data:

Shape	Circular
Solving for	Flowrate
Diameter	24.0000 in
Depth	24.0000 in
Slope	0.0140 ft/ft
Manning's n	0.0240

Computed Results:

Flowrate	14.4989 cfs ←
Area	3.1416 ft2
Wetted Area	3.1416 ft2
Wetted Perimeter	75.3982 in
Perimeter	75.3982 in
Velocity	4.6151 fps
Hydraulic Radius	6.0000 in
Percent Full	100.0000 %
Full flow Flowrate	14.4989 cfs
Full flow velocity	4.6151 fps

25-YR PEAK RUNOFF FOR PHASE 3+4 SW = 55.4 cfs

ONLY 1/2 OF this watershed will Flow through this culvert

DESIGN FLOW = 27.7 cFS

SLOPE = 1.4%
24" CMP
FLOW = 14.5 CFS

2 - 24" CMP CAN HANDLE 29 cFS ✓

Intermediate Diversion Berm Calculation

BT² inc.	Sheet No.
	Calc. No.
	Rev. No.
Job No. 3391 — Job Edgewater Landfill	By KRG Date 12/3/07
Client — Subject	Chk'd. Date

Determine if INTERMEDIATE DIVERSION BERMS ARE REQUIRED ON THE FINAL COVER.
MAINTAIN SOIL LOSS TO 3 TON/AC OR LESS.

UNIVERSAL SOIL LOSS Equation

$$A = R \times K \times LS \times C \times P$$

A = Average Annual Soil Loss, ton/AC.
R = Rainfall + Runoff Erosivity index
K = Soil Erodibility factor, ton/AC
LS = Slope length + Steepness factor
C = cover management factor
P = Practice factor

For the top of the Final Grades, slope = 3%, length = 330 FT

R = 100
K = 0.29
LS = 0.41
C = 0.1
P = 0.9

$$A = (100)(0.29)(0.41)(0.1)(0.9)$$
$$= 1.07 \text{ ton/Ac} \quad \text{ok}$$

For SIDES OF Final Cover, SLOPE = 25%, length = 170'

R = 100
K = 0.29
LS = 7.66
C = 0.1
P = 0.9

$$A = (100)(0.29)(7.66)(0.1)(0.9)$$
$$A = 2.00 \text{ TON/AC} \quad \text{ok.}$$

∴ No Intermediate SWALE IS REQUIRED.

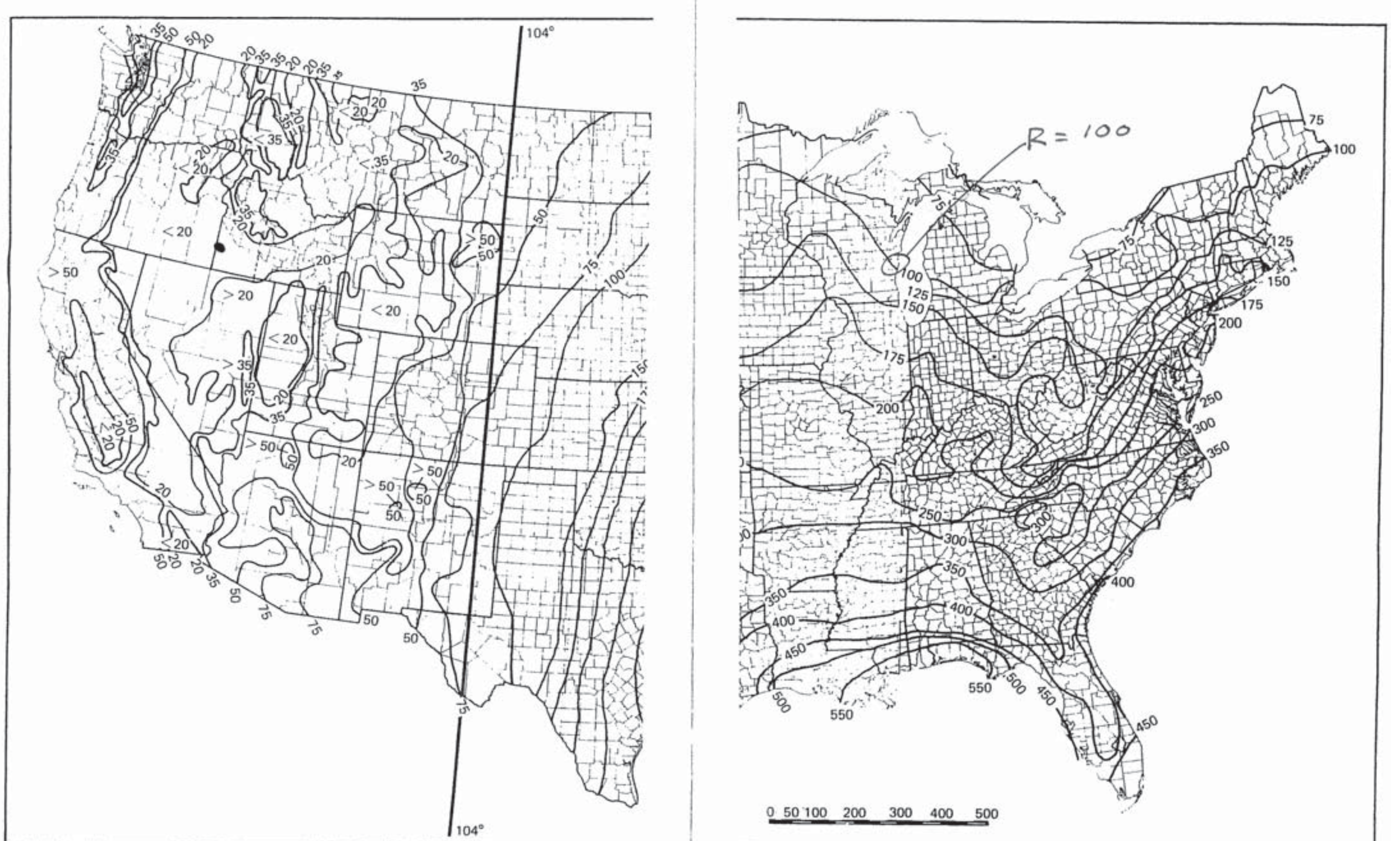


Fig. 5.2 *R* values for areas east of 104°. Because of irregular topography in the west United States, calculate *R* values in this region by using local rainfall data. *R* is in ui of 100 ft · tons/acre per in/hr. To convert *R* to units of 10^7 J/ha per mm/hr, multiply 1.70. (20) Scale is in miles.

TABLE 5.6 *C* Values for Soil Loss Equation*

Type of cover	*C* factor	Soil loss reduction, %
None	1.0	0
Native vegetation (undisturbed)	0.01	99
Temporary seedings:		
90% cover, annual grasses, no mulch	0.1	90
Wood fiber mulch, ¾ ton/acre (1.7 t/ha), with seed†	0.5	50
Excelsior mat, jute†	0.3	70
Straw mulch†		
1.5 tons/acre (3.4 t/ha), tacked down	0.2	80
4 tons/acre (9.0 t/ha), tacked down	0.05	95

*Adapted from Refs. 11, 15, and 20

†For slopes up to 2:1.

TABLE 5.7 *P* Factors for Construction Sites (Adapted from Ref. 15)

Surface condition	*P* value
Compacted and smooth	1.3
Trackwalked along contour*	1.2
Trackwalked up and down slope†	0.9
Punched straw	0.9
Rough, irregular cut	0.9
Loose to 12-in (30-cm) depth	0.8

*Tread marks oriented up and down slope.

†Tread marks oriented parallel to contours, as in Figs. 6.9 and 6.10.

TABLE 5. APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES[11]

Texture class	Organic matter content		
	<0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine sand	.16	.14	.10
Very fine sand	.42	.36	.28
Loamy sand	.12	.10	.08
Loamy fine sand	.24	.20	.16
Loamy very fine sand	.44	.38	.30
Sandy loam	.27	.24	.19
Fine sandy loam	.35	.30	.24
Very fine sandy loam	.47	.41	.33
Loam	.38	.34	.29
Silt loam	.48	.42	.33
Silt	.60	.52	.42
Sandy clay loam	.27	.25	.21
Clay loam	.28	.25	.21
Silty clay loam	.37	.32	.26
Sandy clay	.14	.13	.12
Silty clay	.25	.23	.19
Clay		0.13-0.29	

Ave= 0,29

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

TABLE 5.5 LS Values* (10)

Slope ratio	Slope gradient s, %	LS values for following slope lengths l, ft (m): 10 (3.0)	20 (6.1)	30 (9.1)	40 (12.2)	50 (15.2)	60 (18.3)	70 (21.3)	80 (24.4)	90 (27.4)	100 (30.5)
	0.5	0.06	0.07	0.07	0.08	0.08	0.09	0.09	0.09	0.09	0.10
100:1	1	0.08	0.09	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.12
	2	0.10	0.12	0.14	0.15	0.16	0.17	0.18	0.19	0.19	0.20
	3	0.14	0.18	0.20	0.22	0.23	0.25	0.26	0.27	0.28	0.29
	4	0.16	0.21	0.25	0.28	0.30	0.33	0.35	0.37	0.38	0.40
20:1	5	0.17	0.24	0.29	0.34	0.38	0.41	0.45	0.48	0.51	0.53
	6	0.21	0.30	0.37	0.43	0.48	0.52	0.56	0.60	0.64	0.67
	7	0.26	0.37	0.45	0.52	0.58	0.64	0.69	0.74	0.78	0.82
12½:1	8	0.31	0.44	0.54	0.63	0.70	0.77	0.83	0.89	0.94	0.99
	9	0.37	0.52	0.64	0.74	0.83	0.91	0.98	1.05	1.11	1.17
10:1	10	0.43	0.61	0.75	0.87	0.97	1.06	1.15	1.22	1.30	1.37
	11	0.50	0.71	0.86	1.00	1.12	1.22	1.32	1.41	1.50	1.58
8:1	12.5	0.61	0.86	1.05	1.22	1.36	1.49	1.61	1.72	1.82	1.92
	15	0.81	1.14	1.40	1.62	1.81	1.98	2.14	2.29	2.43	2.56
6:1	16.7	0.96	1.36	1.67	1.92	2.15	2.36	2.54	2.72	2.88	3.04
5:1	20	1.29	1.82	2.23	2.58	2.88	3.16	3.41	3.65	3.87	4.08
4½:1	22	1.51	2.13	2.61	3.02	3.37	3.69	3.99	4.27	4.53	4.77
4:1	25	1.86	2.63	3.23	3.73	4.16	4.56	4.93	5.27	5.59	5.89
	30	2.51	3.56	4.36	5.03	5.62	6.16	6.65	7.11	7.54	7.95
3:1	33.3	2.98	4.22	5.17	5.96	6.67	7.30	7.89	8.43	8.95	9.43
	35	3.23	4.57	5.60	6.46	7.23	7.92	8.55	9.14	9.70	10.22
2½:1	40	4.00	5.66	6.93	8.00	8.95	9.80	10.59	11.32	12.00	12.65
	45	4.81	6.80	8.33	9.61	10.75	11.77	12.72	13.60	14.42	15.20
2:1	50	5.64	7.97	9.76	11.27	12.60	13.81	14.91	15.94	16.91	17.82
	55	6.48	9.16	11.22	12.96	14.48	15.87	17.14	18.32	19.43	20.48
1¾:1	57	6.82	9.64	11.80	13.63	15.24	16.69	18.03	19.28	20.45	21.55
	60	7.32	10.35	12.68	14.64	16.37	17.93	19.37	20.71	21.96	23.15
1½:1	66.7	8.44	11.93	14.61	16.88	18.87	20.67	22.32	23.87	25.31	26.68
	70	8.98	12.70	15.55	17.96	20.08	21.99	23.75	25.39	26.93	28.39
	75	9.78	13.83	16.94	19.56	21.87	23.95	25.87	27.66	29.34	30.92
1¼:1	80	10.55	14.93	18.28	21.11	23.60	25.85	27.93	29.85	31.66	33.38
	85	11.30	15.98	19.58	22.61	25.27	27.69	29.90	31.97	33.91	35.74
	90	12.02	17.00	20.82	24.04	26.88	29.44	31.80	34.00	36.06	38.01
	95	12.71	17.97	22.01	25.41	28.41	31.12	33.62	35.94	38.12	40.18
1:1	100	13.36	18.89	23.14	26.72	29.87	32.72	35.34	37.78	40.08	42.24

Slope ratio	Slope gradient s, %	LS values for following slope lengths l, ft (m): 150 (46)	200 (61)	250 (76)	300 (91)	350 (107)	400 (122)	450 (137)	500 (152)	600 (183)	700 (213)	800 (244)	900 (274)
	0.5	0.10	0.11	0.11	0.12	0.12	0.13	0.13	0.13	0.14	0.14	0.14	0.15
100:1	1	0.14	0.14	0.15	0.16	0.16	0.16	0.17	0.17	0.18	0.18	0.19	0.19
	2	0.23	0.25	0.26	0.28	0.29	0.30	0.32	0.33	0.34	0.36	0.37	0.39
	3	0.32	0.35	0.38	0.40	0.42	0.43	0.45	0.46	0.49	0.51	0.54	0.55
	4	0.47	0.53	0.58	0.62	0.66	0.70	0.73	0.76	0.82	0.87	0.92	0.96
20:1	5	0.66	0.76	0.85	0.93	1.00	1.07	1.13	1.20	1.31	1.42	1.51	1.60
	6	0.82	0.95	1.06	1.16	1.26	1.34	1.43	1.50	1.65	1.78	1.90	2.02
	7	1.01	1.17	1.30	1.43	1.54	1.65	1.75	1.84	2.02	2.18	2.33	2.47
12½:1	8	1.21	1.40	1.57	1.72	1.85	1.98	2.10	2.22	2.43	2.62	2.80	2.97
	9	1.44	1.66	1.85	2.03	2.19	2.35	2.49	2.62	2.87	3.10	3.32	3.52
10:1	10	1.68	1.94	2.16	2.37	2.56	2.74	2.90	3.06	3.35	3.62	3.87	4.11
	11	1.93	2.23	2.50	2.74	2.95	3.16	3.35	3.53	3.87	4.18	4.47	4.74
8:1	12.5	2.35	2.72	3.04	3.33	3.59	3.84	4.08	4.30	4.71	5.08	5.43	5.76
	15	3.13	3.62	4.05	4.43	4.79	5.12	5.43	5.72	6.27	6.77	7.24	7.68
6:1	16.7	3.72	4.30	4.81	5.27	5.69	6.08	6.45	6.80	7.45	8.04	8.60	9.12
5:1	20	5.00	5.77	6.45	7.06	7.63	8.16	8.65	9.12	9.99	10.79	11.54	12.24
4½:1	22	5.84	6.75	7.54	8.26	8.92	9.54	10.12	10.67	11.68	12.62	13.49	14.31
4:1	25	7.21	8.33	9.31	10.20	11.02	11.78	12.49	13.17	14.43	15.58	16.66	17.67
	30	9.74	11.25	12.57	13.77	14.88	15.91	16.87	17.78	19.48	21.04	22.49	23.86
3:1	33.3	11.55	13.34	14.91	16.33	17.64	18.86	20.00	21.09	23.10	24.95	26.67	28.29
	35	12.52	14.46	16.16	17.70	19.12	20.44	21.68	22.86	25.04	27.04	28.91	30.67
2½:1	40	15.50	17.89	20.01	21.91	23.67	25.30	26.84	28.29	30.99	33.48	35.79	37.96
	45	18.62	21.50	24.03	26.33	28.44	30.40	32.24	33.99	37.23	40.22	42.99	45.60
2:1	50	21.83	25.21	28.18	30.87	33.34	35.65	37.81	39.85	43.66	47.16	50.41	53.47
	55	25.09	28.97	32.39	35.48	38.32	40.97	43.45	45.80	50.18	54.20	57.94	61.45
1¾:1	57	26.40	30.48	34.08	37.33	40.32	43.10	45.72	48.19	52.79	57.02	60.96	64.66
	60	28.35	32.74	36.60	40.10	43.31	46.30	49.11	51.77	56.71	61.25	65.48	69.45
1½:1	66.7	32.68	37.74	42.19	46.22	49.92	53.37	56.60	59.66	65.36	70.60	75.47	80.05
	70	34.77	40.15	44.89	49.17	53.11	56.78	60.23	63.48	69.54	75.12	80.30	85.17
	75	37.87	43.73	48.89	53.56	57.85	61.85	65.60	69.15	75.75	81.82	87.46	92.77
1¼:1	80	40.88	47.20	52.77	57.81	62.44	66.75	70.80	74.63	81.76	88.31	94.41	100.13
	85	43.78	50.55	56.51	61.91	66.87	71.48	75.82	79.92	87.55	94.57	101.09	107.23
	90	46.55	53.76	60.10	65.84	71.11	76.02	80.63	84.99	93.11	100.57	107.51	114.03
	95	49.21	56.82	63.53	69.59	75.17	80.36	85.23	89.84	98.42	106.30	113.64	120.54
1:1	100	51.74	59.74	66.79	73.17	79.03	84.49	89.61	94.46	103.48	111.77	119.48	126.73

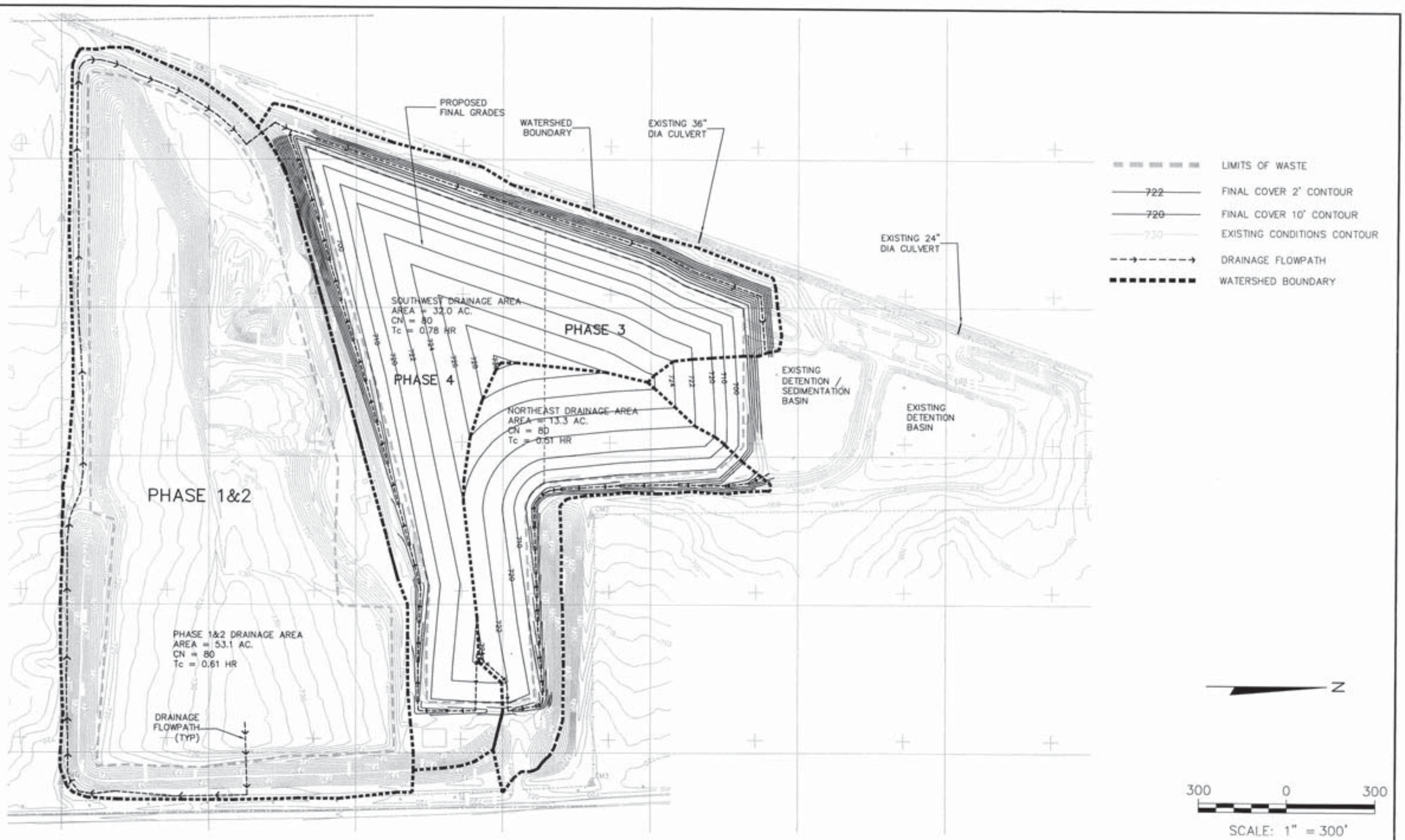
170' = 7.66

*Calculated from

$$LS = \left(\frac{65.41 \times s^2}{s^2 + 10{,}000} + \frac{4.56 \times s}{\sqrt{s^2 + 10{,}000}} + 0.065\right)\left(\frac{l}{72.5}\right)^m$$

LS = topographic factor
l = slope length, ft (m × 0.3048)
s = slope steepness,
m = exponent dependent upon slope steepness (0.2 for slopes < 1%, 0.3 for slopes 1 to 3%, 0.4 for slopes 3.5 to 4.5%, and 0.5 for slopes > 5%)

73 end



PROJECT NO.	3391	DRAWN BY:	KRG	ENGINEER	BT² inc. 2830 DAIRY DRIVE MADISON, WI 53718-6751 PHONE: (608) 224-2830 FAX: (608) 224-2839	CLIENT: WISCONSIN POWER AND LIGHT EDGEWATER GENERATING STATION 3739 LAKESHORE DRIVE SHEBOYGAN, WI 53081	SITE: PLAN OF OPERATION PHASES 3 AND 4 EDGEWATER I-43 ASH DISPOSAL FACILITY WILSON, WISCONSIN	WATERSHED AND DRAINAGE PATH LOCATIONS
DRAWN:	11/27/07	CHECKED BY:	TR					FIGURE
REVISED:		APPROVED BY:						G1

I:\3391\Drawings General\Drainage.dwg, 12/4/2007 9:01:00 AM

Storm Water Management Calculations

Purpose:
The purpose of the storm water runoff calculations is to demonstrate that the proposed landfill surface water management system design meets the requirements of the Wisconsin Administrative Code, 504.09.

Existing Features:
Currently Phase 1 and 2 of the landfill have final cover in place. The final cover includes a grass surface. Phase 3, Module 1 has been constructed and is full of ash but does not have final cover in place. Phase 4, Module 1 was constructed in the summer of 2014 and is accepting ash.

Surface water runoff from final cover areas discharges to an existing sedimentation basin at the north end of the landfill. Surface water runoff that comes in contact with ash discharges to the contact water basin located along the western side of the facility, which is managed separately from the non-contact runoff (refer to Section 2.7 of the Plan Modification report). An additional existing detention basin is located north of the landfill detention/sedimentation basin to treat off-site runon. Because the plan modification does not affect off-site runon or the existing detention basin, these storm water management calculations do not include modeling of these areas/features.

From the discharge of the existing detention/sedimentation basins, runoff ultimately discharges off-site via two culverts: 1) a 36-inch diameter culvert under the railroad tracks to the west of the site and 2) a 24-inch diameter culvert under the railroad tracks to the west of the site. The culverts are shown on **Figure F1**.

Approach:
Final Cover Soil Loss
The Universal Soil Loss Equation (USLE) was used to estimate soil loss along the final cover slopes. The USLE estimates the final cover soil erosion based on the erodibility of the soil, the rainfall and runoff erosivity, the slope steepness, cover management, and soil practice factors. A maximum soil loss of 3 tons per acre is considered acceptable.

Hydrograph Generation
To properly size the storm water management features, runoff hydrographs for the 25-year, 24-hour, and 100-year, 24-hour, storm events were developed. HydroCAD was used to model the storm water management system and develop the hydrographs using TR-20 methodologies. The model is designed to simulate the surface runoff response of a watershed to a precipitation event. Input parameters for the model include precipitation depth for the design storm event, contributing drainage areas, runoff curve numbers, time of concentration, and travel time.

The final cover watersheds are shown on **Figures F-1** and **F-2**.

Perimeter Ditch and Diversion Berm Sizing
Perimeter ditches and diversion berms were sized for the 25-year, 24-hour storm event using the Manning's equation to determine the depth of flow and velocity in the berm/ditch based on the berm/ditch geometry and peak flow in the berm/ditch (as determined by the Hydrograph Generation calculations). The drainage areas for the diversion berms are included in **Figure F2**.

Downslope Flume and Energy Dissipator Sizing
The downslope flume inlets were sized for the 25-year, 24-hour storm event using the orifice equation. The downslope flume pipes were sized based on the peak flow conditions in the pipe using Manning's

equation. Energy dissipators were sized using tables from the reference book "Hydraulic Design of Energy Dissipators for Culvert and Channels," US Department of Transportation, Federal Highway Administration, July 2006.

Culvert Sizing
The culverts were sized for the 25-year, 24-hour storm event using the HY-8 computer model developed by the US Department of Transportation, Federal Highway Administration. Culvert outlet protection was sized using guidance from the Wisconsin DOT Permissible Velocities for Riprap Lined Ditches, Procedure 13-30-10.

Sedimentation Basin Sizing
The sedimentation basin sizing process involved determining an appropriate ratio of surface area to flow rate that would allow particles to settle out during a design storm event. The sedimentation basins were sized for the 25-year, 24-hour storm event. The sedimentation basin emergency spillway were sized for the 100-year, 24-hour storm event.

A table presented in the "Erosion and Sediment Control Handbook" (Goldman, et. Al., 1986) provides the surface area-to-discharge ratio required to achieve settlement of the desired particle sizes.

The HydroCAD model was used in conjunction with accepted formulas and engineering calculations to evaluate the ability of the sedimentation basin to meet the requirements of NR 504.09.

Key Assumptions:

- Runoff curve numbers were based on tables presented in Urban Hydrology for Small Watersheds, and were assumed as follows

Cover Type	CN
Landfill final cover	79 – Open spaces (lawns, parks, etc) in fair condition with hydrologic soil group C
Sedimentation basin	98 – Water surface

- A Type II rainfall distribution was used, based on The NOAA Atlas 14, Precipitation Frequency Data Server for Sheboygan Falls, WI (page 4). The following precipitation depths were assumed.

Storm Event	Precipitation Depth (inches)
25-year, 24-hour	4.79
100-year, 24-hour	6.55

- Other assumptions are included with the calculations attached to this appendix.

Results:
The proposed landfill surface water management system design meets the requirements of the Wisconsin Administrative Code, 504.09. Further details are provided below.

Soil Loss
The USLE calculations indicate a minimal soil loss rate along the 3% and 4:1 final cover sideslopes. Although the calculations indicate no diversion berms are needed, berms have been designed upslope of the final cover slope transition. Experience has shown these transition points are sometimes more susceptible to erosion, so the added berms provide protection. Refer to the USLE Calculations section of this appendix for the detailed calculations.

Hydrograph Generation

The hydrograph modeling results for the 25-year and 100-year, 24-hour storm events are included the Hydrograph Generation section of this appendix.

Perimeter Ditch and Diversion Berm Sizing

The diversion berms will be constructed as shown on the plan set. The diversion berms will maintain a minimum 0.5 foot freeboard. Refer to the Diversion Berm and Ditch Sizing section of this appendix for the detailed calculations.

The perimeter ditches will be constructed as shown on the plan set. The perimeter ditches will contain the runoff from the 25-year, 24-hour storm event and maintain a minimum 0.5 foot of freeboard. Erosion matting will be used where ditch velocities exceed 5 feet per second. Refer to the Diversion Berm and Ditch Sizing section of this appendix for the detailed calculations.

Downslope Flume and Energy Dissipator Sizing

The downslope flumes will be constructed as shown on the plan set. The downslope flumes are designed to accommodate the surface water runoff from the final cover for a 25-year, 24-hour storm event. Energy dissipators at the bottom of the downslope flumes have been designed to handle the peak velocities, and additional riprap protection has been sized for the energy dissipator outlets. Refer to the Downslope Flume and Energy Dissipator Sizing section of this appendix for the detailed calculations.

Culvert Sizing

The culverts are designed to accommodate the flows from the perimeter ditches for the 25-year, 24-hour storm event. Riprap outlet protection has been sized based on the discharge rates and outlet velocities. Refer to the Culvert Sizing section of this appendix for the detailed calculations.

Sedimentation Basin Sizing

The outlet structure for the detention/sedimentation basin is sized to control runoff from the 25-year, 24-hour storm event, assuming the starting water elevation is at the bottom of the lowest outlet structure opening. The sedimentation basin is designed to settle out particles 0.01 microns and larger in diameter. Refer to the Sedimentation Basin Sizing section of this appendix for the detailed calculations. The emergency spillways have been designed to pass the 100-year, 24-hour storm event.

4

NOAA Atlas 14, Volume 8, Version 2
Location name: Sheboygan Falls, Wisconsin, US*
Latitude: 43.6942°, Longitude: -87.7645°
Elevation: 718 ft*
* source: Google Maps

POINT PRECIPITATION FREQUENCY ESTIMATES

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

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

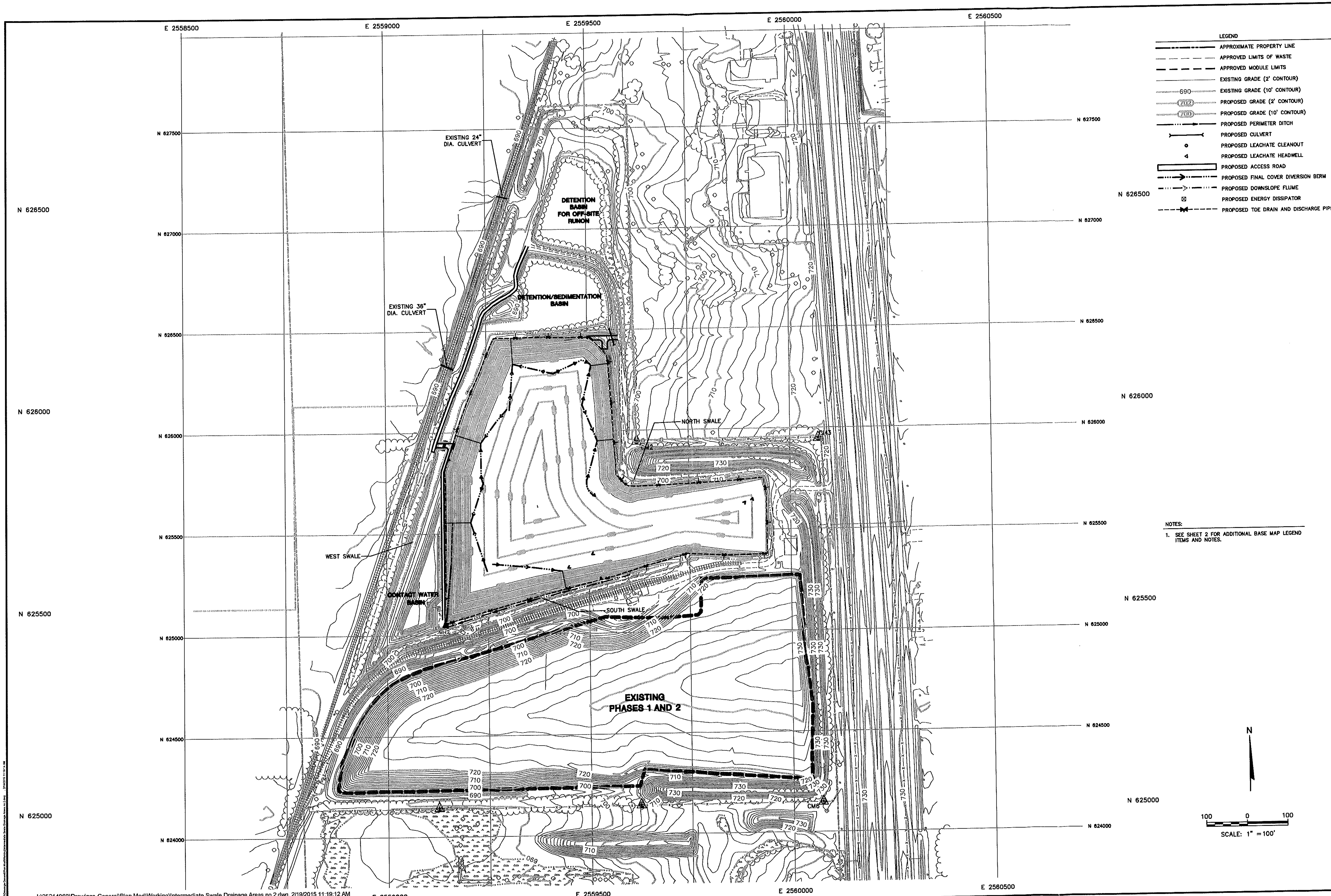
PF tabular

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

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.325 (0.258-0.409)	0.388 (0.307-0.488)	0.488 (0.385-0.615)	0.568 (0.447-0.717)	0.674 (0.514-0.858)	0.753 (0.565-0.966)	0.829 (0.607-1.07)	0.903 (0.641-1.19)	0.997 (0.688-1.33)	1.06 (0.722-1.43)
10-min	0.476 (0.377-0.599)	0.568 (0.450-0.715)	0.714 (0.564-0.900)	0.832 (0.654-1.05)	0.987 (0.753-1.26)	1.10 (0.828-1.41)	1.21 (0.889-1.57)	1.32 (0.939-1.74)	1.46 (1.01-1.94)	1.56 (1.06-2.10)
15-min	0.581 (0.460-0.730)	0.693 (0.549-0.872)	0.871 (0.688-1.10)	1.01 (0.798-1.28)	1.20 (0.918-1.53)	1.34 (1.01-1.72)	1.48 (1.08-1.92)	1.61 (1.15-2.12)	1.78 (1.23-2.37)	1.90 (1.29-2.56)
30-min	0.805 (0.638-1.01)	0.963 (0.763-1.21)	1.21 (0.959-1.53)	1.41 (1.11-1.78)	1.68 (1.28-2.13)	1.87 (1.40-2.39)	2.05 (1.50-2.66)	2.23 (1.58-2.92)	2.45 (1.69-3.26)	2.60 (1.77-3.51)
60-min	1.04 (0.823-1.31)	1.24 (0.978-1.55)	1.55 (1.23-1.96)	1.81 (1.43-2.29)	2.16 (1.66-2.76)	2.43 (1.83-3.13)	2.69 (1.98-3.50)	2.96 (2.10-3.90)	3.30 (2.28-4.41)	3.56 (2.42-4.79)
2-hr	1.27 (1.02-1.58)	1.51 (1.21-1.87)	1.89 (1.51-2.35)	2.21 (1.76-2.75)	2.65 (2.06-3.36)	3.00 (2.28-3.82)	3.34 (2.48-4.31)	3.69 (2.65-4.83)	4.16 (2.90-5.52)	4.51 (3.08-6.04)
3-hr	1.42 (1.15-1.75)	1.67 (1.35-2.06)	2.09 (1.69-2.58)	2.45 (1.97-3.03)	2.97 (2.33-3.75)	3.38 (2.60-4.30)	3.81 (2.85-4.90)	4.25 (3.08-5.55)	4.86 (3.41-6.44)	5.34 (3.66-7.11)
6-hr	1.69 (1.39-2.05)	1.96 (1.61-2.39)	2.45 (2.00-2.98)	2.89 (2.35-3.52)	3.54 (2.83-4.46)	4.09 (3.19-5.17)	4.67 (3.54-5.99)	5.30 (3.88-6.90)	6.19 (4.39-8.18)	6.91 (4.77-9.15)
12-hr	1.97 (1.64-2.36)	2.27 (1.89-2.73)	2.83 (2.34-3.40)	3.35 (2.76-4.04)	4.16 (3.38-5.21)	4.85 (3.84-6.10)	5.61 (4.31-7.15)	6.44 (4.77-8.34)	7.63 (5.46-10.0)	8.60 (5.98-11.3)
24-hr	2.26 (1.90-2.67)	2.59 (2.18-3.07)	3.23 (2.71-3.82)	3.84 (3.20-4.56)	4.79 (3.95-5.96)	5.63 (4.51-7.01)	6.55 (5.09-8.28)	7.57 (5.66-9.73)	9.04 (6.52-11.8)	10.3 (7.18-13.4)
2-day	2.57 (2.20-3.00)	2.93 (2.50-3.42)	3.63 (3.08-4.23)	4.30 (3.63-5.04)	5.37 (4.48-6.60)	6.31 (5.12-7.79)	7.36 (5.78-9.22)	8.52 (6.43-10.9)	10.2 (7.43-13.3)	11.6 (8.18-15.1)
3-day	2.82 (2.43-3.26)	3.18 (2.73-3.67)	3.87 (3.31-4.48)	4.55 (3.88-5.29)	5.65 (4.75-6.90)	6.62 (5.41-8.11)	7.70 (6.08-9.60)	8.90 (6.76-11.3)	10.7 (7.80-13.8)	12.1 (8.58-15.7)
4-day	3.03 (2.63-3.48)	3.40 (2.93-3.90)	4.10 (3.53-4.72)	4.79 (4.11-5.54)	5.91 (4.99-7.17)	6.89 (5.66-8.40)	7.99 (6.34-9.92)	9.22 (7.02-11.7)	11.0 (8.07-14.2)	12.5 (8.86-16.1)
7-day	3.55 (3.10-4.03)	3.98 (3.48-4.53)	4.80 (4.18-5.46)	5.57 (4.82-6.36)	6.77 (5.75-8.09)	7.81 (6.46-9.39)	8.95 (7.14-11.0)	10.2 (7.81-12.8)	12.0 (8.84-15.4)	13.5 (9.62-17.3)
10-day	4.01 (3.54-4.52)	4.52 (3.98-5.10)	5.43 (4.76-6.14)	6.27 (5.47-7.11)	7.54 (6.42-8.90)	8.61 (7.14-10.3)	9.77 (7.82-11.9)	11.0 (8.46-13.7)	12.8 (9.46-16.3)	14.3 (10.2-18.2)
20-day	5.45 (4.87-6.05)	6.09 (5.44-6.77)	7.20 (6.41-8.02)	8.16 (7.21-9.12)	9.54 (8.18-11.0)	10.7 (8.91-12.4)	11.8 (9.53-14.1)	13.0 (10.1-16.0)	14.7 (10.9-18.5)	16.0 (11.6-20.4)
30-day	6.71 (6.05-7.38)	7.47 (6.73-8.23)	8.74 (7.84-9.65)	9.80 (8.74-10.9)	11.3 (9.71-12.9)	12.4 (10.4-14.4)	13.6 (11.0-16.1)	14.8 (11.5-17.9)	16.4 (12.2-20.4)	17.6 (12.7-22.2)
45-day	8.35 (7.59-9.11)	9.29 (8.44-10.1)	10.8 (9.78-11.8)	12.0 (10.8-13.2)	13.7 (11.8-15.4)	14.9 (12.6-17.0)	16.1 (13.1-18.8)	17.2 (13.4-20.7)	18.7 (14.0-23.1)	19.8 (14.4-24.9)
60-day	9.78 (8.94-10.6)	10.9 (9.96-11.8)	12.7 (11.5-13.8)	14.0 (12.7-15.3)	15.8 (13.7-17.7)	17.1 (14.5-19.4)	18.3 (15.0-21.3)	19.5 (15.2-23.3)	20.9 (15.6-25.7)	21.9 (15.9-27.5)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).
Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.
Please refer to NOAA Atlas 14 document for more information.

Back to Top



PROJECT NO.	25214060	DRAWN BY:	KRG
DRAWN:	02/06/15	CHECKED BY:	CHECKEDBY
REVISED:		APPROVED BY:	

WISCONSIN POWER AND LIGHT COMPANY
EDGEWATER GENERATING STATION
3739 LAKESHORE DRIVE
SHEBOYGAN, WI 53081

CLIENT

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

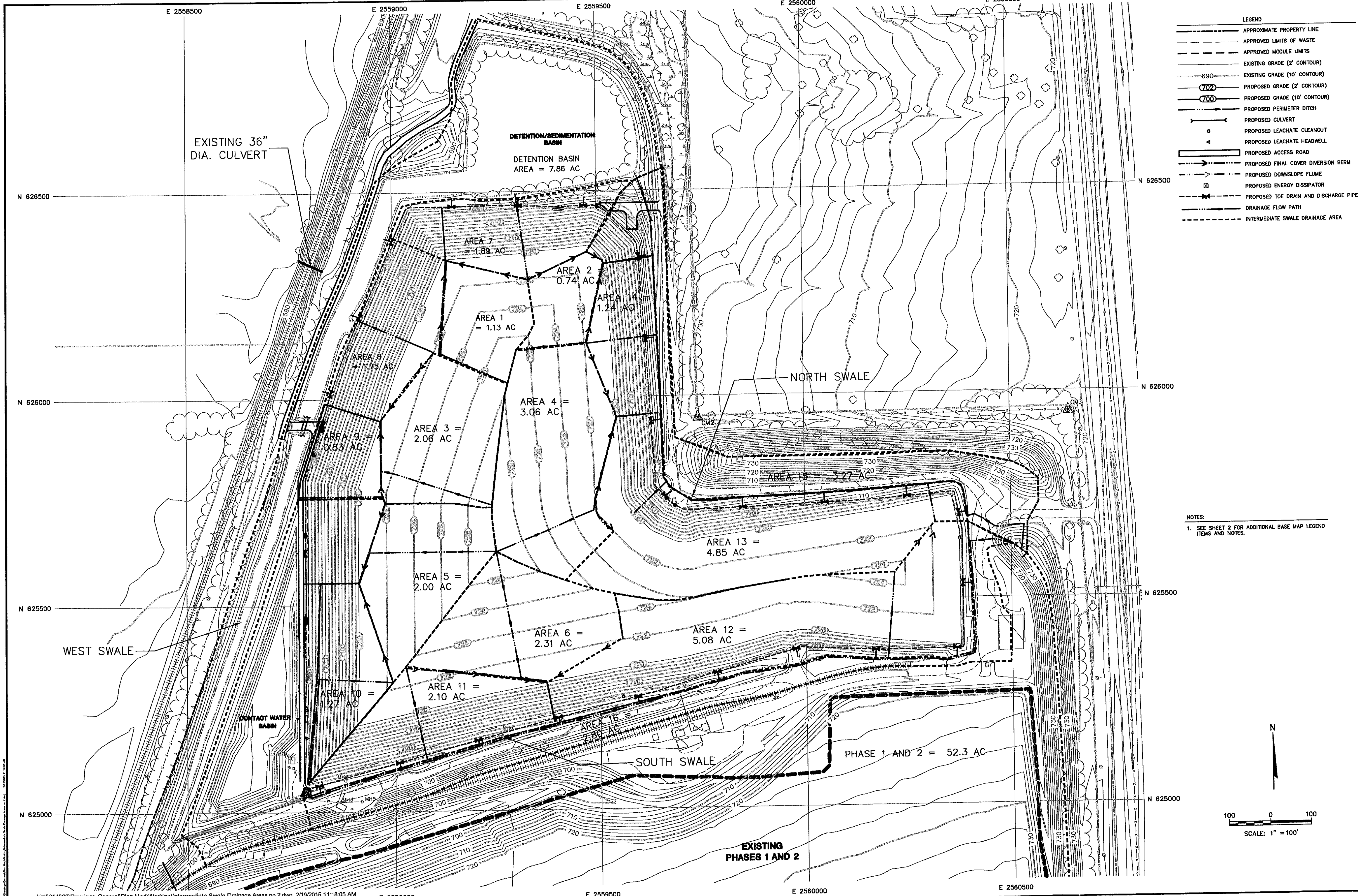
ENGINEER

PLAN MODIFICATION
EDGEWATER I-43 ASH DISPOSAL FACILITY
TOWN OF WILSON, WISCONSIN

SITE

PROPOSED FINAL GRADES AND DRAINAGE FEATURES

SHEET
F1



PROJECT NO.	25214060
DRAWN:	02/06/15
REVISED:	
DRAWN BY:	KRG
CHECKED BY:	CHECKEDBY
APPROVED BY:	

WISCONSIN POWER AND LIGHT COMPANY
EDGEWATER GENERATING STATION
3739 LAKESHORE DRIVE
SHEBOYGAN, WI 53081

CLIENT

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

ENGINEER

PLAN MODIFICATION
EDGEWATER I-43 ASH DISPOSAL FACILITY
TOWN OF WILSON, WISCONSIN

SITE

DRAINAGE AREAS AND FLOWPATHS

SHEET F2

USLE Calculation

SCS ENGINEERS

		Sheet No.	1 of 6
		Calc. No.	
		Rev. No.	
Job No. 25214060	Job: I-43 Landfill Plan Modification	By: KRG	Date: 1/30/15
Client: Alient Energy	Subject: Soil Loss Along Final Cover	Chk'd:	Date:

Universal Soil Loss Equation (USLE) Calculation

Use USLE to estimate soil loss along the 3% final cover slope, with the goal of maintaining ≤ 3 ton/acre of soil loss along the final cover.

USLE Equation:

A = R * K * LS * C * P

where: A = Average annual soil loss, ton/acre
R = Rainfall and runoff erosivity index
K = Soil erodibility factor, tons/acre
LS = Slope length and steepness factor
C = Cover management factor
P = Practice factor

The LS factor is a function of the slope and flow length.

LS = L * S

where: L = Slope length factor = (l/72.6)^m
where: l = Slope length, feet
m = Slope-length exponent (m = 0.3 for slopes of 1% to 3%
m = 0.4 for slopes of 3.5% to 4.5%
m = 0.5 for slopes greater than 5%)

S = Slope steepness factor = (65.41s^2/(s^2 + 10,000)) + (4.56s/(SQRT(s^2 + 10,000))) + 0.065
where: s = Slope, in percent

The soil type chosen for selecting the appropriate K factor is an estimate of silt loam for the topsoil.

Data Entered		**Data Computed**	
Slope (%), s =	3	S =	0.26
l =	340	L =	1.6
m =	0.3	LS =	0.4

Calculate Average Annual Soil Loss, A:

R = 100 *
K = 0.42 *
LS = 0.4
C = 0.004 *
P = 1.0 *

A = R * K * LS * C * P = 0.1 tons/acre

* See attached references for R, K, C, and P factors

Soil loss along the 3% slope of the final cover results in minimal soil loss.

Universal Soil Loss Equation (USLE) Calculation

Use USLE to estimate soil loss along the 4:1 final cover slope, with the goal of maintaining ≤ 3 ton/acre of soil loss along the final cover.

USLE Equation:

A = R * K * LS * C * P

where: A = Average annual soil loss, ton/acre
R = Rainfall and runoff erosivity index
K = Soil erodibility factor, tons/acre
LS = Slope length and steepness factor
C = Cover management factor
P = Practice factor

The LS factor is a function of the slope and flow length.

LS = L * S

where: L = Slope length factor = (l/72.6)^m
where: l = Slope length, feet
m = Slope-length exponent (m = 0.3 for slopes of 1% to 3%
m = 0.4 for slopes of 3.5% to 4.5%
m = 0.5 for slopes greater than 5%)

S = Slope steepness factor = (65.41s^2/(s^2 + 10,000)) + (4.56s/(SQRT(s^2 + 10,000))) + 0.065
where: s = Slope, in percent

The soil type chosen for selecting the appropriate K factor is an estimate of silt loam for the topsoil.

Data Entered		**Data Computed**	
Slope (%), s =	25	S =	5.02
l =	136	L =	1.4
m =	0.5	LS =	6.9

Calculate Average Annual Soil Loss, A:

R =	100	*
K =	0.42	*
LS =	6.9	
C =	0.004	*
P =	1.0	*

A = R * K * LS * C * P = 1.2 tons/acre

* See attached references for R, K, C, and P factors

Soil loss along the 4:1 slope of the final cover results in minimal soil loss.

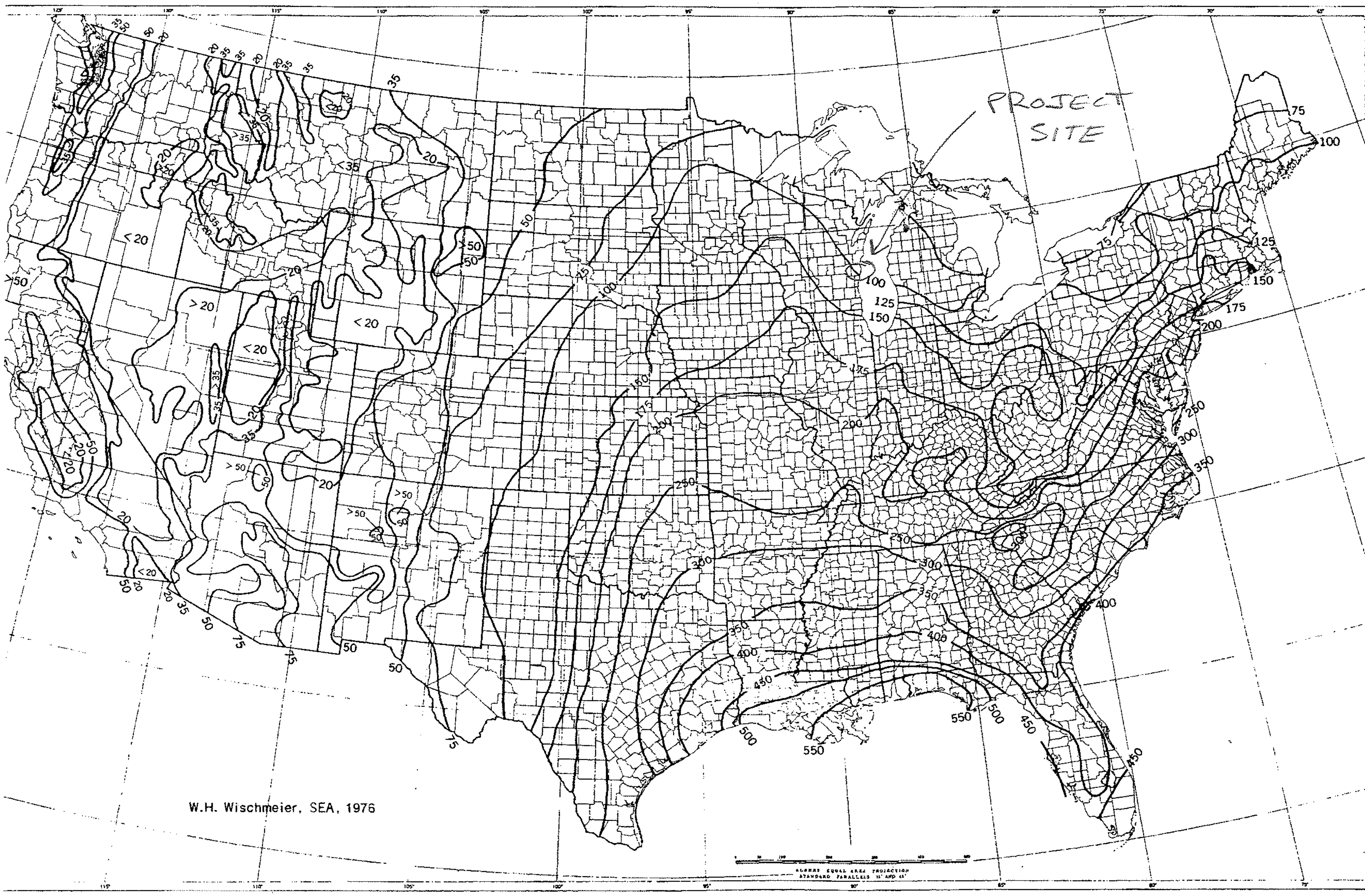


FIGURE 1.—Average annual values of the rainfall erosion index.

3

4

soil in a unit plot, pinpoints differences in erosion according to differences in soil type. Long-term plot studies under natural rainfall have produced K values generalized in Table 5 for the USDA soil types.

TABLE 5. APPROXIMATE VALUES OF FACTOR K FOR USDA TEXTURAL CLASSES[11]

Texture class	Organic matter content		
	<0.5%	2%	4%
	K	K	K
Sand	0.05	0.03	0.02
Fine sand	.16	.14	.10
Very fine sand	.42	.36	.28
Loamy sand	.12	.10	.08
Loamy fine sand	.24	.20	.16
Loamy very fine sand	.44	.38	.30
Sandy loam	.27	.24	.19
Fine sandy loam	.35	.30	.24
Very fine sandy loam	.47	.41	.33
Loam	.38	.34	.29
Silt loam	.48	.42	.33
Silt	.60	.52	.42
Sandy clay loam	.27	.25	.21
Clay loam	.28	.25	.21
Silty clay loam	.37	.32	.26
Sandy clay	.14	.13	.12
Silty clay	.25	.23	.19
Clay		0.13-0.29	

The values shown are estimated averages of broad ranges of specific-soil values. When a texture is near the borderline of two texture classes, use the average of the two K values.

The evaluator must next consider the shape of the slope in terms of length and inclination. The appropriate LS factor is obtained from Table 6. A nonlinear slope may have to be evaluated as a series of segments, each with uniform gradient. Two or three segments should be sufficient for most engineered landfills, provided the segments are selected so that they are also of equal length (Table 6 can be used, with certain adjustments). Enter Table 6 with the total slope length and read LS values corresponding to the percent slope of each segment. For three segments, multiply the chart LS values for the upper, middle, and lower segments by 0.58, 1.06, and 1.37, respectively. The average of the three products is a good estimate of the

5

TABLE 7. GENERALIZED VALUES OF FACTOR C FOR STATES EAST OF THE ROCKY MOUNTAINS[11]

Crop, rotation, and management	Productivity level	
	High	Mod.
	C value	
Base value: continuous fallow, tilled up and down slope	1.00	1.00
CORN		
C, RdR, fall TP, conv	0.54	0.62
C, RdR, spring TP, conv	.50	.59
C, RdL, fall TP, conv	.42	.52
C, RdR, wc seeding, spring TP, conv	.40	.49
C, RdL, standing, spring TP, conv	.38	.48
C-W-M-M, RdL, TP for C, disk for W	.039	.074
C-W-M-M-M, RdL, TP for C, disk for W	.032	.061
C, no-till pl in c-k sod, 95-80% rc	.017	.053
COTTON		
Cot, conv (Western Plains)	0.42	0.49
Cot, conv (South)	.34	.40
MEADOW		
Grass & Legume mix	0.004	0.01
Alfalfa, lespedeza or Sericia	.020	
Sweet clover	.025	
SORGHUM, GRAIN (Western Plains)		
RdL, spring TP, conv	0.43	0.53
No-till pl in shredded 70-50% rc	.11	.18
SOYBEANS		
B, RdL, spring TP, conv	0.48	0.54
C-B, TP annually, conv	.43	.51
B, no-till pl	.22	.28
C-B, no-till pl, fall shred C stalks	.18	.22
WHEAT		
W-F, fall TP after W	0.38	
W-F, stubble mulch, 500 lbs rc	.32	
W-F, stubble mulch, 1000 lbs rc	.21	

Abbreviations defined:

B - soybeans
C - corn
c-k - chemically killed
conv - conventional
cot - cotton
F - fallow
M - grass & legume hay
pl - plant
W - wheat
wc - winter cover

lbs rc - pounds of crop residue per acre remaining on surface after new crop seeding
% rc - percentage of soil surface covered by residue mulch after new crop seeding
70-50% rc - 70% cover for C values in first column; 50% for second column
RdR - residues (corn stover, straw, etc.) removed or burned
RdL - all residues left on field (on surface or incorporated)
TP - turn plowed (upper 5 or more inches of soil inverted, covering residues)

6

are listed in Table 8. These values are based on rather limited field data, but P has a narrower range of possible values than the other five factors.

TABLE 8. VALUES OF FACTOR P[11]

Practice	Land slope (percent)				
	1.1-2	2.1-7	7.1-12	12.1-18	18.1-24
	(Factor P)				
Contouring (P_c)	0.60	0.50	0.60	0.80	0.90
Contour strip cropping (P_{sc})					
R-R-M-M[1]	0.30	0.25	0.30	0.40	0.45
R-W-M-M	0.30	0.25	0.30	0.40	0.45
R-R-W-M	0.45	0.38	0.45	0.60	0.68
R-W	0.52	0.44	0.52	0.70	0.90
R-O	0.60	0.50	0.60	0.80	0.90
Contour listing or ridge planting (P_{c1})	0.30	0.25	0.30	0.40	0.45
Contour terracing (P_t)[2]	[3] $0.6/\sqrt{n}$	$0.5/\sqrt{n}$	$0.6/\sqrt{n}$	$0.8/\sqrt{n}$	$0.9/\sqrt{n}$
No support practice	1.0	1.0	1.0	1.0	1.0

[1] R = rowcrop, W = fall-seeded grain, O = spring-seeded grain, M = meadow. The crops are grown in rotation and so arranged on the field that rowcrop strips are always separated by a meadow or winter-grain strip.

[2] These P_t values estimate the amount of soil eroded to the terrace channels and are used for conservation planning. For prediction of off-field sediment, the P_t values are multiplied by 0.2.

[3] n = number of approximately equal-length intervals into which the field slope is divided by the terraces. Tillage operations must be parallel to the terraces.

Example: An owner/operator proposes to close one section of his small landfill with a sandy clay subsoil cover having the surface configuration shown in Figure 21. The factor R has been established as 200 for this locality. The evaluator questions anticipated erosion along the steep side and assigns the following values to the other factors in the USLE after inspecting Tables 5 through 8:

$$K = 0.14 \quad LS = 8.3 \quad C = 1.00 \quad P = 0.90$$

The rate of erosion for the steep slope of the landfill is calculated as follows:

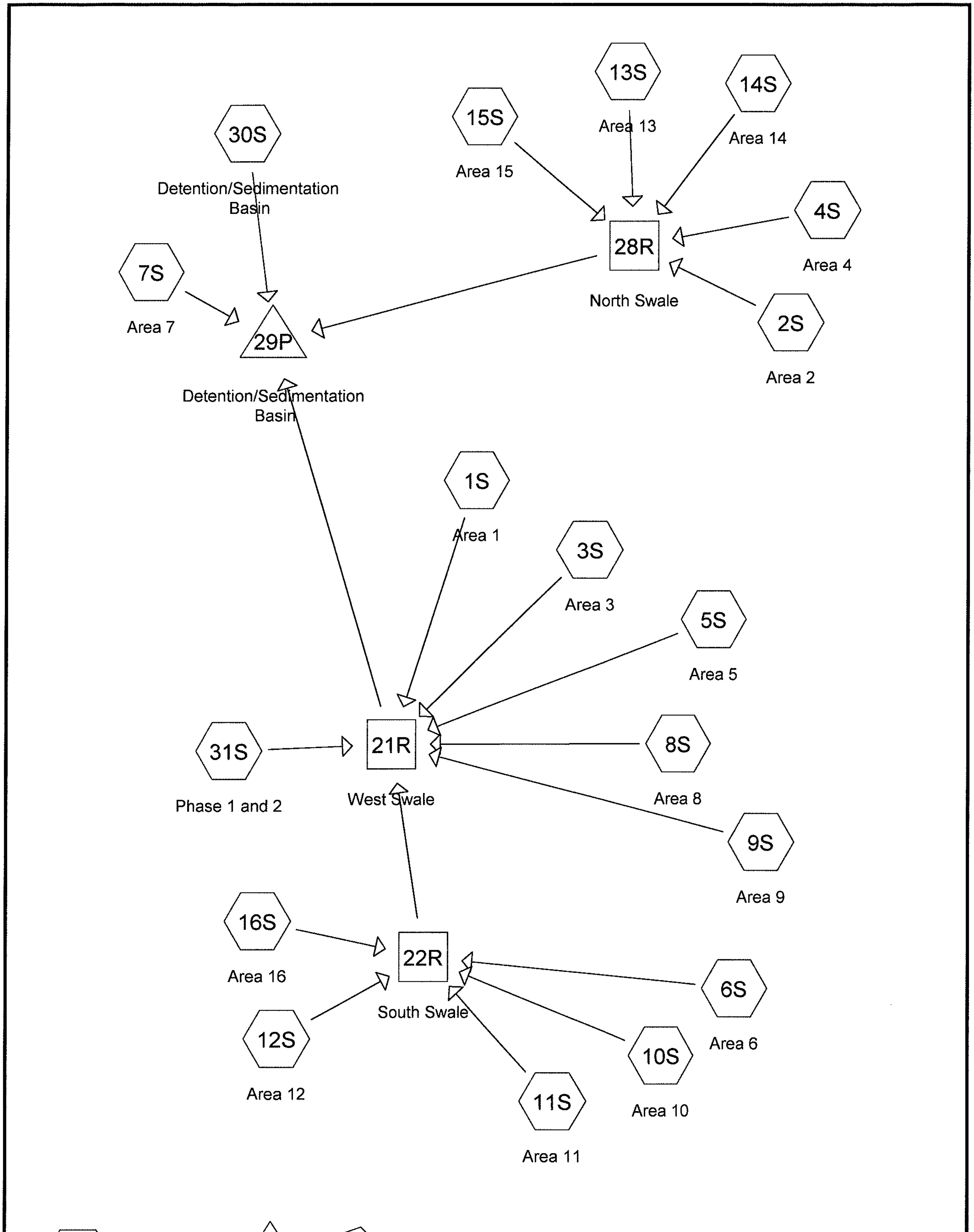
$$A = 200\ (0.14\ \text{tons/acre})\ (8.3)\ (1.00)\ (0.90)$$
$$= 209\ \text{tons/acre}$$

This erosion not only exceeds a limit recommended by the permitting authority but also indicates a potential

Hydrograph Generation

- 25-year, 24-hour Storm Event
- 100-year, 24-hour Storm Event

25-year, 24-hour Storm



Drainage Diagram for I-43 Landfill 2
Prepared by SCS Engineering, Printed 2/19/2015
HydroCAD® 8.50 s/n 005804 © 2007 HydroCAD Software Solutions LLC

Summary for Subcatchment 1S: Area 1

Runoff = 3.71 cfs @ 12.08 hrs, Volume= 0.227 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	1.130	79	
	1.130		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
1.1	78	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	223	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
15.8	401	Total			

Summary for Subcatchment 2S: Area 2

Runoff = 2.45 cfs @ 12.08 hrs, Volume= 0.149 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	0.740	79	
	0.740		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
1.0	70	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	196	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
15.5	366	Total			

Summary for Subcatchment 3S: Area 3

Runoff = 6.61 cfs @ 12.09 hrs, Volume= 0.414 af, Depth> 2.41"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	2.060	79	
	2.060		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
2.5	182	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	120	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.6	402	Total			

Summary for Subcatchment 4S: Area 4

Runoff = 9.76 cfs @ 12.09 hrs, Volume= 0.616 af, Depth> 2.41"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	3.060	79	
	3.060		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
2.1	155	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	232	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.8	487	Total			

Summary for Subcatchment 5S: Area 5

Runoff = 6.38 cfs @ 12.09 hrs, Volume= 0.402 af, Depth> 2.41"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	2.000	79	
	2.000		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
2.9	208	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.4	77	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.8	385	Total			

Summary for Subcatchment 6S: Area 6

Runoff = 7.37 cfs @ 12.09 hrs, Volume= 0.465 af, Depth> 2.41"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	2.310	79	
	2.310		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
3.0	215	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.3	62	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.8	377	Total			

Summary for Subcatchment 7S: Area 7

Runoff = 7.41 cfs @ 12.02 hrs, Volume= 0.381 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	1.890	79	
	1.890		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	65	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.7	144	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.3	209	Total			

Summary for Subcatchment 8S: Area 8

Runoff = 6.83 cfs @ 12.02 hrs, Volume= 0.353 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	1.750	79	
	1.750		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	67	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.6	136	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.4	203	Total			

Summary for Subcatchment 9S: Area 9

Runoff = 3.33 cfs @ 12.01 hrs, Volume= 0.167 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	0.830	79	
	0.830		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	60	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.7	145	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.7	205	Total			

Summary for Subcatchment 10S: Area 10

Runoff = 4.41 cfs @ 12.06 hrs, Volume= 0.256 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	1.270	79	
	1.270		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.5	82	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.5	96	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
2.1	242	0.0100	1.93	1.93	**Trap/Vee/Rect Channel Flow, Intermediate Swale on 4:1 Slope** Bot.W=0.00' D=0.50' Z= 4.0 '/' Top.W=4.00' n= 0.030
14.1	420	Total			

Summary for Subcatchment 11S: Area 11

Runoff = 7.24 cfs @ 12.06 hrs, Volume= 0.423 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	2.100	79	
	2.100		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.2	12	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	120	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
14.3	232	Total			

Summary for Subcatchment 12S: Area 12

Runoff = 14.68 cfs @ 12.13 hrs, Volume= 1.021 af, Depth> 2.41"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	5.080	79	
	5.080		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.9	163	0.0300	0.14		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.2	46	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
20.1	209	Total			

Summary for Subcatchment 13S: Area 13

Runoff = 15.91 cfs @ 12.08 hrs, Volume= 0.976 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	4.850	79	
	4.850		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
1.8	133	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.5	108	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
15.8	341	Total			

Summary for Subcatchment 14S: Area 14

Runoff = 4.97 cfs @ 12.01 hrs, Volume= 0.250 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	1.240	79	
	1.240		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	62	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.5	111	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.7	173	Total			

Summary for Subcatchment 15S: Area 15

[49] Hint: Tc<2dt may require smaller dt

Runoff = 15.87 cfs @ 11.95 hrs, Volume= 0.661 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	3.270	79	
	3.270		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	58	0.2700	0.27		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.6	145	0.0600	3.94		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
4.2	203	Total			

Summary for Subcatchment 16S: Area 16

Runoff = 10.90 cfs @ 12.03 hrs, Volume= 0.579 af, Depth> 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	2.870	79	
	2.870		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	44	0.0100	0.07		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.4	55	0.0200	2.28		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
11.3	99	Total			

Summary for Subcatchment 30S: Detention/Sedimentation Basin

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 60.20 cfs @ 11.89 hrs, Volume= 2.833 af, Depth> 4.33"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

Area (ac)	CN	Description
7.860	98	Water Surface
7.860		Impervious Area

Summary for Subcatchment 31S: Phase 1 and 2

Runoff = 121.30 cfs @ 12.23 hrs, Volume= 10.476 af, Depth> 2.40"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 25-yr Rainfall=4.79"

	Area (ac)	CN	Description
*	52.300	79	Closed Landfill
	52.300		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.0	100	0.0400	0.14		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
4.8	400	0.0400	1.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
12.1	2,976	0.0120	4.10	55.37	**Channel Flow, Perimeter Swale** Area= 13.5 sf Perim= 16.3' r= 0.83' n= 0.035 Earth, dense weeds
28.9	3,476	Total			

Summary for Reach 21R: West Swale

[62] Warning: Exceeded Reach 22R OUTLET depth by 1.93' @ 12.40 hrs

Inflow Area = 73.700 ac, 0.00% Impervious, Inflow Depth > 2.40" for 25-yr event
Inflow = 167.13 cfs @ 12.24 hrs, Volume= 14.740 af
Outflow = 146.77 cfs @ 12.51 hrs, Volume= 14.486 af, Atten= 12%, Lag= 16.4 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.67 fps, Min. Travel Time= 9.8 min
Avg. Velocity = 0.98 fps, Avg. Travel Time= 26.7 min

Peak Storage= 86,617 cf @ 12.35 hrs, Average Depth at Peak Storage= 2.46'
Bank-Full Depth= 3.00', Capacity at Bank-Full= 214.18 cfs

15.00' x 3.00' deep channel, n= 0.030 Earth, dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 33.00'
Length= 1,570.0' Slope= 0.0013 '/'
Inlet Invert= 684.08', Outlet Invert= 682.00'

Summary for Reach 22R: South Swale

Inflow Area =	13.630 ac,	0.00% Impervious,	Inflow Depth > 2.41"	for 25-yr event	
Inflow =	42.53 cfs @	12.07 hrs, Volume=	2.743 af		
Outflow =	35.46 cfs @	12.29 hrs, Volume=	2.699 af,	Atten= 17%,	Lag= 13.1 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.03 fps, Min. Travel Time= 8.0 min
Avg. Velocity = 1.27 fps, Avg. Travel Time= 25.2 min

Peak Storage= 17,162 cf @ 12.16 hrs, Average Depth at Peak Storage= 0.71'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 242.67 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, dense weeds
Side Slope Z-value= 4.0 3.0 '/' Top Width= 24.00'
Length= 1,925.0' Slope= 0.0135 '/'
Inlet Invert= 710.00', Outlet Invert= 684.08'

Summary for Reach 28R: North Swale

Inflow Area = 13.160 ac, 0.00% Impervious, Inflow Depth > 2.42" for 25-yr event
Inflow = 39.81 cfs @ 12.00 hrs, Volume= 2.652 af
Outflow = 35.67 cfs @ 12.18 hrs, Volume= 2.620 af, Atten= 10%, Lag= 10.7 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.31 fps, Min. Travel Time= 6.0 min
Avg. Velocity = 1.37 fps, Avg. Travel Time= 19.0 min

Peak Storage= 12,884 cf @ 12.08 hrs, Average Depth at Peak Storage= 0.67'
Bank-Full Depth= 3.00', Capacity at Bank-Full= 609.75 cfs

10.00' x 3.00' deep channel, n= 0.030 Earth, dense weeds
Side Slope Z-value= 4.0 3.0 '/' Top Width= 31.00'
Length= 1,560.0' Slope= 0.0167 '/'
Inlet Invert= 708.00', Outlet Invert= 682.00'

100-year, 24-hour Storm

Summary for Subcatchment 1S: Area 1

Runoff = 5.86 cfs @ 12.08 hrs, Volume= 0.365 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	1.130	79	
	1.130		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
1.1	78	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	223	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
15.8	401	Total			

Summary for Subcatchment 2S: Area 2

Runoff = 3.88 cfs @ 12.07 hrs, Volume= 0.239 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	0.740	79	
	0.740		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
1.0	70	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.0	196	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
15.5	366	Total			

Summary for Subcatchment 3S: Area 3

Runoff = 10.45 cfs @ 12.09 hrs, Volume= 0.665 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	2.060	79	
	2.060		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
2.5	182	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	120	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.6	402	Total			

Summary for Subcatchment 4S: Area 4

Runoff = 15.43 cfs @ 12.09 hrs, Volume= 0.987 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	3.060	79	
	3.060		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
2.1	155	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
1.2	232	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.8	487	Total			

Summary for Subcatchment 5S: Area 5

Runoff = 10.09 cfs @ 12.09 hrs, Volume= 0.645 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	2.000	79	
	2.000		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
2.9	208	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.4	77	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.8	385	Total			

Summary for Subcatchment 6S: Area 6

Runoff = 11.65 cfs @ 12.09 hrs, Volume= 0.745 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	2.310	79	
	2.310		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
3.0	215	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.3	62	0.0100	3.11	57.58	**Trap/Vee/Rect Channel Flow, Intermediate Swale** Bot.W=0.00' D=1.00' Z= 4.0 & 33.0 '/' Top.W=37.00' n= 0.030 Short grass
16.8	377	Total			

Summary for Subcatchment 7S: Area 7

Runoff = 11.66 cfs @ 12.02 hrs, Volume= 0.611 af, Depth> 3.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	1.890	79	
	1.890		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.6	65	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.7	144	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.3	209	Total			

Summary for Subcatchment 8S: Area 8

Runoff = 10.75 cfs @ 12.02 hrs, Volume= 0.566 af, Depth> 3.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	1.750	79	
	1.750		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.8	67	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.6	136	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
10.4	203	Total			

Summary for Subcatchment 9S: Area 9

Runoff = 5.23 cfs @ 12.01 hrs, Volume= 0.268 af, Depth> 3.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	0.830	79	
	0.830		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	60	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.7	145	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.7	205	Total			

Summary for Subcatchment 10S: Area 10

Runoff = 6.96 cfs @ 12.06 hrs, Volume= 0.410 af, Depth> 3.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	1.270	79	
	1.270		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.5	82	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.5	96	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
2.1	242	0.0100	1.93	1.93	**Trap/Vee/Rect Channel Flow, Intermediate Swale on 4:1 Slope** Bot.W=0.00' D=0.50' Z= 4.0 '/' Top.W=4.00' n= 0.030
14.1	420	Total			

Summary for Subcatchment 11S: Area 11

Runoff = 11.43 cfs @ 12.06 hrs, Volume= 0.678 af, Depth> 3.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	2.100	79	
	2.100		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.2	12	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.6	120	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
14.3	232	Total			

Summary for Subcatchment 12S: Area 12

Runoff = 23.32 cfs @ 12.12 hrs, Volume= 1.638 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	5.080	79	
	5.080		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.9	163	0.0300	0.14		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.2	46	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
20.1	209	Total			

Summary for Subcatchment 13S: Area 13

Runoff = 25.14 cfs @ 12.08 hrs, Volume= 1.566 af, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	4.850	79	
	4.850		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.5	100	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
1.8	133	0.0300	1.21		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.5	108	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
15.8	341	Total			

Summary for Subcatchment 14S: Area 14

Runoff = 7.82 cfs @ 12.01 hrs, Volume= 0.401 af, Depth> 3.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	1.240	79	
	1.240		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	62	0.0300	0.11		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.5	111	0.2500	3.50		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
9.7	173	Total			

Summary for Subcatchment 15S: Area 15

[49] Hint: Tc<2dt may require smaller dt

Runoff = 24.79 cfs @ 11.95 hrs, Volume= 1.059 af, Depth> 3.89"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	3.270	79	
	3.270		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	58	0.2700	0.27		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.6	145	0.0600	3.94		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
4.2	203	Total			

Summary for Subcatchment 16S: Area 16

Runoff = 17.15 cfs @ 12.03 hrs, Volume= 0.928 af, Depth> 3.88"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	2.870	79	
	2.870		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.9	44	0.0100	0.07		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
0.4	55	0.0200	2.28		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
11.3	99	Total			

Summary for Subcatchment 30S: Detention/Sedimentation Basin

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 82.51 cfs @ 11.89 hrs, Volume= 3.928 af, Depth> 6.00"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

Area (ac)	CN	Description
7.860	98	Water Surface
7.860		Impervious Area

Summary for Subcatchment 31S: Phase 1 and 2

Runoff = 193.11 cfs @ 12.23 hrs, Volume= 16.809 af, Depth> 3.86"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Type II 24-hr 100-yr Rainfall=6.55"

	Area (ac)	CN	Description
*	52.300	79	Closed Landfill
	52.300		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.0	100	0.0400	0.14		**Sheet Flow,** Grass: Dense n= 0.240 P2= 2.59"
4.8	400	0.0400	1.40		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
12.1	2,976	0.0120	4.10	55.37	**Channel Flow, Perimeter Swale** Area= 13.5 sf Perim= 16.3' r= 0.83' n= 0.035 Earth, dense weeds
28.9	3,476	Total			

Summary for Reach 21R: West Swale

[91] Warning: Storage range exceeded by 0.22'
[55] Hint: Peak inflow is 126% of Manning's capacity
[62] Warning: Exceeded Reach 22R OUTLET depth by 2.51' @ 12.35 hrs

Inflow Area = 73.700 ac, 0.00% Impervious, Inflow Depth > 3.85" for 100-yr event
Inflow = 270.76 cfs @ 12.22 hrs, Volume= 23.663 af
Outflow = 242.71 cfs @ 12.46 hrs, Volume= 23.342 af, Atten= 10%, Lag= 14.5 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.08 fps, Min. Travel Time= 8.5 min
Avg. Velocity = 1.09 fps, Avg. Travel Time= 23.9 min

Peak Storage= 124,154 cf @ 12.32 hrs, Average Depth at Peak Storage= 3.22'
Bank-Full Depth= 3.00', Capacity at Bank-Full= 214.18 cfs

15.00' x 3.00' deep channel, n= 0.030 Earth, dense weeds
Side Slope Z-value= 3.0 '/' Top Width= 33.00'
Length= 1,570.0' Slope= 0.0013 '/'
Inlet Invert= 684.08', Outlet Invert= 682.00'

Summary for Reach 22R: South Swale

Inflow Area = 13.630 ac, 0.00% Impervious, Inflow Depth > 3.87" for 100-yr event
Inflow = 67.37 cfs @ 12.07 hrs, Volume= 4.399 af
Outflow = 58.27 cfs @ 12.26 hrs, Volume= 4.345 af, Atten= 14%, Lag= 11.3 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.71 fps, Min. Travel Time= 6.8 min
Avg. Velocity = 1.43 fps, Avg. Travel Time= 22.5 min

Peak Storage= 24,052 cf @ 12.14 hrs, Average Depth at Peak Storage= 0.94'
Bank-Full Depth= 2.00', Capacity at Bank-Full= 242.67 cfs

10.00' x 2.00' deep channel, n= 0.030 Earth, dense weeds
Side Slope Z-value= 4.0 3.0 '/' Top Width= 24.00'
Length= 1,925.0' Slope= 0.0135 '/'
Inlet Invert= 710.00', Outlet Invert= 684.08'

Summary for Reach 28R: North Swale

Inflow Area = 13.160 ac, 0.00% Impervious, Inflow Depth > 3.88" for 100-yr event
Inflow = 63.20 cfs @ 12.00 hrs, Volume= 4.252 af
Outflow = 57.58 cfs @ 12.16 hrs, Volume= 4.213 af, Atten= 9%, Lag= 9.3 min

Routing by Stor-Ind+Trans method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.04 fps, Min. Travel Time= 5.2 min
Avg. Velocity = 1.53 fps, Avg. Travel Time= 17.0 min

Peak Storage= 17,962 cf @ 12.07 hrs, Average Depth at Peak Storage= 0.88'
Bank-Full Depth= 3.00', Capacity at Bank-Full= 609.75 cfs

10.00' x 3.00' deep channel, n= 0.030 Earth, dense weeds
Side Slope Z-value= 4.0 3.0 '/' Top Width= 31.00'
Length= 1,560.0' Slope= 0.0167 '/'
Inlet Invert= 708.00', Outlet Invert= 682.00'

Perimeter Ditch and Diversion Berm Sizing

I-43 Landfill
Sheboygan, WI

Lining Type: Vegetation

Project ID: I-43 Landfill - Plan Modification		
Location: Sheboygan, WI		
Designer/Checker: KRG		
Date: 1/6/15		

	South Swale Q=25-yr	North Swale Q=25-yr	Int. Swale Q=25-yr
Channel/Ditch Geometry			
Channel Slope, S_o (ft/ft)	**0.013**	**0.025**	**0.01**
Channel Bottom Width, B (ft)	**10**	**6**	**0**
Channel Side Slope, z_1	**4**	**3**	**2**
Channel Side Slope, z_2	**3**	**2**	**0.03**
Flow Depth, d (ft) Solve iteratively	**0.89**	**0.86**	**1.65**
Safety Factor, SF	**1.5**	**1.5**	**1.5**
Vegetation/Soil Parameters			
Vegetation Retardance Class	**D**	**D**	**D**
Vegetation Condition	**good**	**good**	**good**
Vegetation Growth Form	**turf**	**turf**	**turf**
Soil Type	**cohesive**	**cohesive**	**cohesive**
D_{75} (in) (Set at 0.00 for cohesive soils)			
ASTM Soil Class	**SC**	**SC**	**SC**
Plasticity Index, PI	**16**	**16**	**16**
Results Summary			
Design Q (ft^3/s)	**35.5**	**35.7**	**4.9**
Calculated Q (ft^3/s)	35.8	35.7	4.8
Difference Between Design & Calc. Flow (%)	0.9%	0.0%	-0.5%
Stable (Yes or No)	YES	YES	YES
Channel Parameters			
Vegetation Height, h (ft)	0.33	0.33	0.33
Grass Roughness Coefficient, C_n	0.165	0.165	0.165
Cover Factor, C_f	0.90	0.90	0.90
Noncohesive Soil			
Soil Grain Roughness, n_s	0.016	0.016	0.016
Permissible Soil Shear Stress, τ_p (lb/ft^2)	N/A	N/A	N/A
Cohesive Soil			
Porosity, e	0.35	0.35	0.35
Soil Coefficient 1, c_1	1.0700	1.0700	1.0700
Soil Coefficient 2, c_2	14.30	14.30	14.30
Soil Coefficient 3, c_3	47.700	47.700	47.700
Soil Coefficient 4, c_4	1.42	1.42	1.42
Soil Coefficient 5, c_5	-0.61	-0.61	-0.61
Soil Coefficient 6, c_6	0.00010	0.00010	0.00010
Permissible Soil Shear Stress, τ_p (lb/ft^2)	0.080	0.080	0.080
Total Permissible Shear Stress, τ_p (lb/ft^2)	0.080	0.080	0.080
Cross Sectional Area, A (ft^2)	11.672	7.009	2.763
Wetted Perimeter, P (ft)	16.48	10.64	5.34
Hydraulic Radius, R (ft)	0.708	0.659	0.517
Top Width, T (ft)	16.23	10.30	3.35
Hydraulic Depth, D (ft)	0.719	0.680	0.825
Froude Number (Q design)	0.637	1.088	0.339
Channel Shear Stress, τ_o (lb/ft^2)	0.57	1.03	0.32
Actual Sheer Stress, τ_d (lb/ft^2)	0.72	1.34	1.03
Mannings n	0.044	0.035	0.055
Average Velocity, V (ft/s)	3.04	5.09	1.76
Calculated Flow, Q (ft^3/s)	35.8	35.7	4.8
Difference Between Design & Calc. Flow (%)	0.9%	0.0%	-0.5%
Effective Shear on Soil Surface, τ_e (lb/ft^2)	0.010	0.028	0.009
Total Permissible Shear on Veg., $\tau_{p\,veg}$ (lb/ft^2)	6.06	3.83	9.47
Stable (Y or N)	YES	YES	YES

SCS ENGINEERS

		Sheet No. 1/3	
		Calc. No.	
		Rev. No.	
Job No. 25214060	Job: I-43 Landfill	By: KRG	Date: 01/14/15
Client: Alliant Energy	Subject: Downslope Flume Sizing	Chk'd: ZB	Date: 02/09/15

Purpose: To size the downslope flume pipes to accommodate the flows expected from a 25-year, 24-hour storm event.

Approach: Use the orifice equation to size the downslope pipe inlet and Manning's equation to size the downslope pipes.

Calculations:

The runoff must first get into the down slope flume
The entrance to the flume is a Y with an open pipe on each branch of the Y.
1/2 of the flowrate of the 25-yr storm event for each drainage area will enter each branch of the flume.
An orifice equation calculates the flowrate of water that can enter the pipe.

Orifice Equation: $Q = C \times A \times (2 \times g \times h)^{0.5}$

Q = flow rate (cfs)
C = orifice coefficent = 0.63
A = area of orifice = 0.78 sf for 12" dia. pipe, 10" = 0.54 sf, 8" = 0.35 sf
g = acceleration due to gravity = 32.2 ft/sec^2
h = orifice head acting on centerline = 1.5 x pipe diameter = 1.5' for 12" dia. pipe, 1.25' for 10", 1.0
$Q_{12\text{" pipe}} = 0.63 \times .78 \times (2 \times 32.2 \times 1.5)^{0.5} =$ 4.83 cfs
$Q_{10\text{" pipe}} = 0.63 \times .54 \times (2 \times 32.2 \times 1.25)^{0.5} =$ 3.05 cfs

The downslope flume pipes have the following flow capacities at the designated slopes:

	Flow Capacity of Pipe*
Flume Size	25% slope
12" dia.	19.3 cfs
10" dia.	11.8 cfs

* See Sheets 2 - 3 for the Manning's flow calculations.

Results:

The downslope flumes will consist of the following sizes, as indicated on Plan Sheet 14.

Flume Number	Flow Rate (cfs)	1/2 the Flowrate (cfs)	Flume Size
Flume 1 (Area 1)	3.7	1.9	10 inch
Flume 2 (Area 2)	2.5	1.3	10 inch
Flume 3 (Area 3)	6.6	3.3	12 inch
Flume 4 (Area 4)	9.7	4.9	12 inch
Flume 5 (Area 5)	6.4	3.2	12 inch
Flume 6 (Area 6)	7.4	3.7	12 inch

Free Online Manning Pipe Flow Calculator

List of Calculators Hydraulics Language

Manning Formula Uniform Pipe Flow at Given Slope and Depth

Can you help me translate this calculator to your language or host this calculator at your web site?

I-43 Landfill

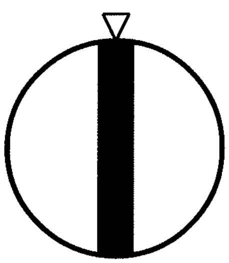
Down Slope Flumes

Set units: m mm ft inches

Pipe diameter, d_0	10 inches
Manning roughness, n ?	.012
Pressure slope (possibly ? equal to pipe slope), S_0	.25 rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	100 %

Results:

Flow, q	11.8668	cfs
Velocity, v	21.7580	ft/sec
Velocity head, h_v	88.2918	inches
Flow area	78.5400	sq. in.
Wetted perimeter	31.4159	inches
Hydraulic radius	2.5000	inches
Top width, T	0.0000	inches
Froude number, F	0.00	
Shear stress (tractive force), tau	13.0078	psf



Please give us your valued words of suggestion or praise. Did this free calculator exceed your expectations in every way?

Home | Support | FreeSoftware | Engineering Services | Engineering Calculators | Technical Documents | Blog (new in 2009) | Personal essays | Collaborative Family Trees | Contact

Last Modified 01/14/2015 13:51:46

3

Free Online Manning Pipe Flow Calculator

List of Calculators   Hydraulics   Language

Manning Formula Uniform Pipe Flow at Given Slope and Depth

Can you help me translate this calculator to your language or host this calculator at your web site?

I-43 Landfill

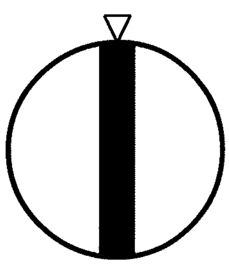
Down Slope Flumes

Set units: m mm ft inches

Pipe diameter, d_0	12	inches
Manning roughness, n ?	.012	
Pressure slope (possibly ? equal to pipe slope), S_0	.25	rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	100	%

Results:

Flow, q	19.2967	cfs
Velocity, v	24.5700	ft/sec
Velocity head, h_v	112.5889	inches
Flow area	113.0976	sq. in.
Wetted perimeter	37.6991	inches
Hydraulic radius	3.0000	inches
Top width, T	0.0000	inches
Froude number, F	0.00	
Shear stress (tractive force), tau	15.6094	psf



Please give us your valued words of suggestion or praise. Did this free calculator exceed your expectations in every way?

Home | Support | FreeSoftware | Engineering Services | Engineering Calculators | Technical Documents | Blog (new in 2009) | Personal essays | Collaborative Family Trees | Contact

Downslope Flume and Energy Dissipator Sizing

Energy Dissipator Design

Design the Energy Dissipators located at the end of each downslope flume using the US Dept. of Transportation, Hydraulic Engineering Circular No. 14, "Hydraulic Design of Energy dissipators for Culverts and Channels", July 2006.

Pipe/Culvert: Flume 3, 4, 5, 6, and 7

* Peak flow in this flume from 25-year, 24-hour event is 9.7 cfs.

Flow is in a 12" dia. Flume

From an on-line Mannings Equation Calculator (see page 3)

Q = 9.7 cfs

n = 0.01

V = 28.2 ft/sec

A = 49.64 sq. in. = 0.34 sq. ft.

Fr = 8.58

Compute Equivalent Depth of Flow Entering Dissipator:

$Y_e = (A/2)^{1/2}$ where: Ye = Equivalent depth

A = Area (from above)

$Y_e =$ 0.42 ft

Compute Energy at End of Pipe:

$H_o = Y_e + V^2/2g$ where: H_o = Energy

Y_e = Equivalent depth (from above)

V = Velocity (from above)

g = Gravity constant (32.2 ft/sec)

Ho = 12.76 ft

Determine Width of Dissipator:

Use Froude Number computed above and Figure 9.14 (see page 5) from "Hydraulic Design of Energy Dissipators for Culverts and Channels" to obtain value for H_o/W. Given H_o above, compute W (width of dissipator).

From Figure 9.14, $H_o/W_B =$ 3.9 (interpolated)

$W_B =$ 3.3 ft

Determine Remaining Dimensions of the Dissipator:

Based on W determined above, use Table 9.2 (CU) (page 6) to determine the remaining dissipator dimensions. Round the value of W_B to the nearest entry in the table (interpolation is not necessary).

Note: the smallest W_B on Table 9.2 is 4.0 ft, so this dimension is used.

Energy Dissipator Design

Pipe/Culvert: Flume 1 and 2

* Peak flow in this flume from 25-year, 24-hour event is 4.0 cfs.

Flow is in a 10" dia. Flume

From an on-line Mannings Equation Calculator (see page 4)

Q = 4 cfs

n = 0.01

V = 22.4 ft/sec

A = 25.7 sq. in. = 0.18 sq. ft.

Fr = 8.5

Compute Equivalent Depth of Flow Entering Dissipator:

$Y_e = (A/2)^{1/2}$ where: Ye = Equivalent depth

A = Area (from above)

Y_e = 0.30 ft

Compute Energy at End of Pipe:

$H_o = Y_e + V^2/2g$ where: H_o = Energy

Y_e = Equivalent depth (from above)

V = Velocity (from above)

g = Gravity constant (32.2 ft/sec)

Ho = 8.09 ft

Determine Width of Dissipator:

Use Froude Number computed above and Figure 9.14 from "Hydraulic Design of Energy Dissipators for Culverts and Channels" to obtain value for H_o/W. Given H_o above, compute W (width of dissipator).

From Figure 9.14, H_o/W_B = 3.9 (interpolated)

W_B = 2.1 ft

Determine Remaining Dimensions of the Dissipator:

Based on W determined above, use Table 9.2 (CU) to determine the remaining dissipator dimensions. Round the value of W_B to the nearest entry in the table (interpolation is not necessary).

Note: the smallest W_B on Table 9.2 is 4.0 ft, so this dimension is used.

4

Free Online Manning Pipe Flow Calculator

List of Calculators   Hydraulics   Language

Manning Formula Uniform Pipe Flow at Given Slope and Depth

Can you help me translate this calculator to your language or host this calculator at your web site?

I-43 Landfill

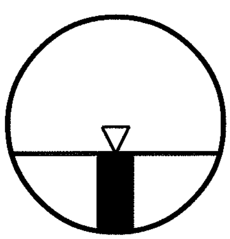
Down Slope Flumes 1,2,8,9,10

Set units: m | mm | ft | inches

Pipe diameter, d_0	10 inches
Manning roughness, n ?	.01
Pressure slope (possibly ? equal to pipe slope), S_0	.25 rise/run
Percent of (or ratio to) full depth (100% or 1 if flowing full)	36.3 %

Results:

Flow, q	4.0097	cfs
Velocity, v	22.4299	ft/sec
Velocity head, h_v	93.8297	inches
Flow area	25.7434	sq. in.
Wetted perimeter	12.9325	inches
Hydraulic radius	1.9906	inches
Top width, T	9.6173	inches
Froude number, F	8.50	
Shear stress (tractive force), tau	4.7218	psf



Please give us your valued words of suggestion or praise. Did this free calculator exceed your expectations in every way?

Home | Support | FreeSoftware | Engineering Services | Engineering Calculators | Technical Documents | Blog (new in 2009) | Personal essays | Collaborative Family Trees | Contact

Last Modified 01/28/2015 10:15:55

shows the relationship of the Froude number to the ratio of the energy entering the dissipator to the width of dissipator required. The Los Angeles tests indicate that limited extrapolation of this curve is permissible.

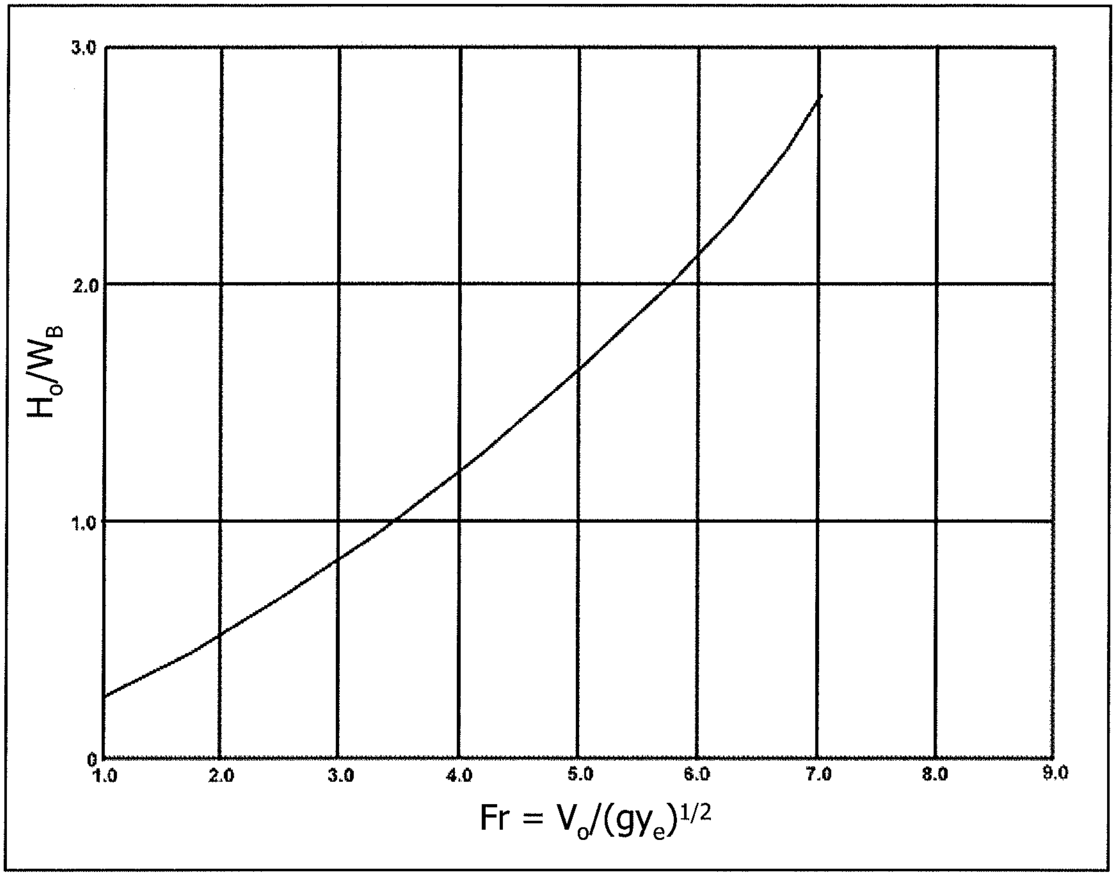


Figure 9.14. Design Curve for USBR Type VI Impact Basin

Once the basin width, W_B, has been determined, many of the other dimensions shown in Figure 9.13 follow according to Table 9.2. To use Table 9.2, round the value of W_B to the nearest entry in the table to determine the other dimensions. Interpolation is not necessary.

In calculating the energy and the Froude number, the equivalent depth of flow, $y_e = (A/2)^{1/2}$, entering the dissipator from a pipe or irregular-shaped conduit must be computed. In other words, the cross section flow area in the pipe is converted into an equivalent rectangular cross section in which the width is twice the depth of flow. The conduit preceding the dissipator can be open, closed, or of any cross section.

The effectiveness of the basin is best illustrated by comparing the energy losses within the structure to those in a natural hydraulic jump, Figure 9.15. The energy loss was computed based on depth and velocity measurements made in the approach pipe and also in the downstream channel with no tailwater. Compared with the natural hydraulic jump, the USBR Type VI impact basin shows a greater capacity for dissipating energy.

6

Table 9.2 (CU). USBR Type VI Impact Basin Dimensions (ft) (AASHTO, 2005)

W_B	h_1	h_2	h_3	h_4	L	L_1	L_2
4.	3.08	1.50	0.67	1.67	5.42	2.33	3.08
5.	3.83	1.92	0.83	2.08	6.67	2.92	3.83
6.	4.58	2.25	1.00	2.50	8.00	3.42	4.58
7.	5.42	2.58	1.17	2.92	9.42	4.00	5.42
8.	6.17	3.00	1.33	3.33	10.67	4.58	6.17
9.	6.92	3.42	1.50	3.75	12.00	5.17	6.92
10.	7.58	3.75	1.67	4.17	13.42	5.75	7.67
11.	8.42	4.17	1.83	4.58	14.58	6.33	8.42
12.	9.17	4.50	2.00	5.00	16.00	6.83	9.17
13.	10.17	4.92	2.17	5.42	17.33	7.42	10.00
14.	10.75	5.25	2.33	5.83	18.67	8.00	10.75
15.	11.50	5.58	2.50	6.25	20.00	8.50	11.50
16.	12.25	6.00	2.67	6.67	21.33	9.08	12.25
17.	13.00	6.33	2.83	7.08	21.50	9.67	13.00
18.	13.75	6.67	3.00	7.50	23.92	10.25	13.75
19.	14.58	7.08	3.17	7.92	25.33	10.83	14.58
20.	15.33	7.50	3.33	8.33	26.58	11.42	15.33

W_B	W_1	W_2	t_1	t_2	t_3	t_4	t_5
4.	0.33	1.08	0.50	0.50	0.50	0.50	0.25
5.	0.42	1.42	0.50	0.50	0.50	0.50	0.25
6.	0.50	1.67	0.50	0.50	0.50	0.50	0.25
7.	0.50	1.92	0.50	0.50	0.50	0.50	0.25
8.	0.58	2.17	0.50	0.58	0.58	0.50	0.25
9.	0.67	2.50	0.58	0.58	0.67	0.58	0.25
10.	0.75	2.75	0.67	0.67	0.75	0.67	0.25
11.	0.83	3.00	0.67	0.75	0.75	0.67	0.33
12.	0.92	3.00	0.67	0.83	0.83	0.75	0.33
13.	1.00	3.00	0.67	0.92	0.83	0.83	0.33
14.	1.08	3.00	0.67	1.00	0.92	0.92	0.42
15.	1.17	3.00	0.67	1.00	1.00	1.00	0.42
16.	1.25	3.00	0.75	1.00	1.00	1.00	0.50
17.	1.33	3.00	0.75	1.08	1.00	1.00	0.50
18.	1.33	3.00	0.75	1.08	1.08	1.08	0.58
19.	1.42	3.00	0.83	1.17	1.08	1.08	0.58
20.	1.50	3.00	0.83	1.17	1.17	1.17	0.67

Culvert Sizing

HY-8 Culvert Analysis Report

Crossing Discharge Data

Discharge Selection Method: Specify Minimum, Design, and Maximum Flow

Minimum Flow: 0 cfs

Design Flow: 146 cfs

Maximum Flow: 270 cfs

Table 1 - Summary of Culvert Flows at Crossing: I-43 Landfill

Headwater Elevation (ft)	Total Discharge (cfs)	West Swale Culverts Discharge (cfs)	Roadway Discharge (cfs)	Iterations
678.70	0.00	0.00	0.00	1
680.07	27.00	27.00	0.00	1
680.67	54.00	54.00	0.00	1
681.15	81.00	81.00	0.00	1
681.63	108.00	108.00	0.00	1
682.07	135.00	135.00	0.00	1
682.23	146.00	146.00	0.00	1
683.11	189.00	189.00	0.00	1
683.47	216.00	216.00	0.00	1
683.81	243.00	243.00	0.00	1
684.16	270.00	270.00	0.00	1
686.00	392.66	392.66	0.00	Overtopping

Table 2 - Culvert Summary Table: West Swale Culverts

Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
	0.00	0.00	678.70	0.000	0.000	0-NF	0.000	0.000	0.300	0.000	0.000
	27.00	27.00	680.07	1.369	0.951	1-JS1t	0.985	1.006	1.238	0.938	3.542
	54.00	54.00	680.67	1.973	1.427	1-JS1t	1.408	1.437	1.674	1.374	4.669
	81.00	81.00	681.15	2.451	1.828	1-JS1t	1.739	1.772	2.008	1.708	5.484
	108.00	108.00	681.63	2.934	2.200	1-JS1t	2.031	2.060	2.287	1.987	6.168
	135.00	135.00	682.07	3.369	2.563	1-JS1t	2.308	2.317	2.531	2.231	6.769
	146.00	146.00	682.23	3.535	2.322	1-JS1t	2.413	2.415	2.622	2.322	7.000
	189.00	189.00	683.11	4.141	4.412	3-M1t	2.822	2.760	2.947	2.647	7.847
	216.00	216.00	683.47	4.506	4.766	3-M1t	3.076	2.960	3.131	2.831	8.348
	243.00	243.00	683.81	4.872	5.114	3-M2t	3.341	3.145	3.301	3.001	8.834
	270.00	270.00	684.16	5.250	5.459	3-M2t	3.614	3.324	3.461	3.161	9.308

****

Straight Culvert

Inlet Elevation (invert): 678.70 ft, Outlet Elevation (invert): 678.40 ft

Culvert Length: 100.00 ft, Culvert Slope: 0.0030

****

Site Data - West Swale Culverts

Site Data Option: Culvert Invert Data

Inlet Station: 0.00 ft

Inlet Elevation: 678.70 ft

Outlet Station: 100.00 ft

Outlet Elevation: 678.40 ft

Number of Barrels: 2

Culvert Data Summary - West Swale Culverts

Barrel Shape: Circular

Barrel Diameter: 5.00 ft

Barrel Material: Smooth HDPE

Embedment: 0.00 in

Barrel Manning's n: 0.0120

Culvert Type: Straight

Inlet Configuration: Square Edge with Headwall

Inlet Depression: NONE

Table 3 - Downstream Channel Rating Curve (Crossing: I-43 Landfill)

Flow (cfs)	Water Surface Elev (ft)	Depth (ft)	Velocity (ft/s)	Shear (psf)	Froude Number
0.00	678.70	0.00	0.00	0.00	0.00
27.00	679.64	0.94	2.25	0.18	0.45
54.00	680.07	1.37	2.78	0.26	0.48
81.00	680.41	1.71	3.13	0.32	0.49
108.00	680.69	1.99	3.40	0.37	0.50
135.00	680.93	2.23	3.63	0.42	0.51
146.00	681.02	2.32	3.71	0.43	0.51
189.00	681.35	2.65	3.98	0.50	0.52
216.00	681.53	2.83	4.13	0.53	0.52
243.00	681.70	3.00	4.26	0.56	0.53
270.00	681.86	3.16	4.38	0.59	0.53

Tailwater Channel Data - I-43 Landfill

Tailwater Channel Option: Trapezoidal Channel

Bottom Width: 10.00 ft

Side Slope (H:V): 3.00 (_:1)

Channel Slope: 0.0030

Channel Manning's n: 0.0300

Channel Invert Elevation: 678.70 ft

Roadway Data for Crossing: I-43 Landfill

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 50.00 ft

Crest Elevation: 686.00 ft

Roadway Surface: Gravel

Roadway Top Width: 20.00 ft

Sedimentation Basin Sizing

Sheet No.	1 of 3
Calc. No.	
Rev. No.	

SCS ENGINEERS

Job No. 25214060	Job: I-43 Landfill Plan Modification	By: KRG	Date: 02/06/15
Client: Alliant Energy	Subject: Sed Basin Sizing	Chk'd: ZB	Date: 02/10/15

Sedimentation Basin Sizing

Performance Criteria

* Sedimentation basin is designed to settle out particles 15 microns and greater for the 25-year, 24-hour storm event
* Principal spillway is designed to pass the 25-year, 24-hour storm event.
* Emergency spillway is designed to pass the 100-yr, 24-hour storm event.

Use the Table 8.1 presented in Erosion and Sediment Control Handbook (Goldman, *et al*., 1986) that provides the surface area to discharge ratios required to achieve settlement of the desired particle sizes. The table is included below. From this table, use the surface area to flow ratio for the sedimentation to determine the maximum particle size settled.

The table below summarized the surface area to flow ratios for sedimentation basins. It also summarizes the free board for the 100-year, 24-hour storm event. The information is based on the HydroCAD model output included in this appendix.

TABLE 8.1 Surface Area Requirements of Sediment Traps and Basins

Particle size, mm	Settling velocity, ft/sec (m/sec)	Surface area requirements, ft^2 per ft^3/sec discharge	(m^2 per m^3/sec discharge)
0.5 (coarse sand)	0.19 (0.058)	6.3	(20.7)
0.2 (medium sand)	0.067 (0.020)	17.9	(58.7)
0.1 (fine sand)	0.023 (0.0070)	52.2	(171.0)
0.05 (coarse silt)	0.0062 (0.0019)	193.6	(635.0)
0.02 (medium silt)	0.00096 (0.00029)	1,250.0	(4,101.0)
0.01 (fine silt)	0.00024 (0.000073)	5,000.0	(16,404.0)
0.005 (clay)	0.00006 (0.000018)	20,000.0	(65,617.0)

The output from the HydroCAD model for the 25 and 100-yr storm event is included on Pages 2 - 3.

25-year, 24 hour Storm			Surface Area at Peak Water Surface Elevation, SA (sf)	SA/Q Ratio	Maximum Particle Size Settled (mm)	100-yr, 24-hr Storm Peak Water Surface Elevation	Top of Berm Elevation (Freeboard)	Basin Freeboard for 100-yr Storm (feet)
Peak Inflow (cfs)	Peak Discharge Q (cfs)	Peak Water Surface Elevation						
165.09	17.1	684.74	230,955	13,506	< 0.01	685.90	686.50	0.6

I:\25214060\Calculations\Stormwater\[Sed Basin Sizing.xls]Sheet1

Summary for Pond 29P: Detention/Sedimentation Basin

[63] Warning: Exceeded Reach 21R INLET depth by 0.10' @ 15.40 hrs
[62] Warning: Exceeded Reach 28R OUTLET depth by 2.62' @ 14.55 hrs

Inflow Area = 96.610 ac, 8.14% Impervious, Inflow Depth > 2.52" for 25-yr event
Inflow = 165.09 cfs @ 12.49 hrs, Volume= 20.321 af
Outflow = 17.07 cfs @ 14.38 hrs, Volume= 10.223 af, Atten= 90%, Lag= 113.9 min
Primary = 17.07 cfs @ 14.38 hrs, Volume= 10.223 af
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 684.74' @ 14.38 hrs Surf.Area= 5.302 ac Storage= 13.038 af

Plug-Flow detention time= 247.0 min calculated for 10.223 af (50% of inflow)
Center-of-Mass det. time= 161.9 min (963.6 - 801.6)

Volume	Invert	Avail.Storage	Storage Description
#1	681.46'	20.170 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
681.46	2.750	0.000	0.000
682.00	2.880	1.520	1.520
684.00	4.860	7.740	9.260
686.00	6.050	10.910	20.170

Device	Routing	Invert	Outlet Devices
#1	Primary	681.50'	**24.0" x 50.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 681.00' S= 0.0100 '/' Cc= 0.900 n= 0.025 Corrugated metal
#2	Device 1	681.75'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#3	Device 1	682.25'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#4	Device 1	682.75'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#5	Device 1	683.25'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#6	Device 1	684.00'	**36.0" Horiz. Orifice/Grate** Limited to weir flow C= 0.600
#7	Secondary	685.00'	**10.0' long x 30.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=17.07 cfs @ 14.38 hrs HW=684.74' (Free Discharge)
└─**1=Culvert** (Barrel Controls 17.07 cfs @ 5.43 fps)
  ├─**2=Orifice/Grate** (Passes < 6.26 cfs potential flow)
  ├─**3=Orifice/Grate** (Passes < 5.66 cfs potential flow)
  ├─**4=Orifice/Grate** (Passes < 4.99 cfs potential flow)
  ├─**5=Orifice/Grate** (Passes < 4.22 cfs potential flow)
  └─**6=Orifice/Grate** (Passes < 19.76 cfs potential flow)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=681.46' (Free Discharge)
└─**7=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond 29P: Detention/Sedimentation Basin

[63] Warning: Exceeded Reach 21R INLET depth by 0.92' @ 14.35 hrs
[62] Warning: Exceeded Reach 28R OUTLET depth by 3.71' @ 13.60 hrs

Inflow Area = 96.610 ac, 8.14% Impervious, Inflow Depth > 3.99" for 100-yr event
Inflow = 272.92 cfs @ 12.44 hrs, Volume= 32.094 af
Outflow = 44.56 cfs @ 13.47 hrs, Volume= 18.380 af, Atten= 84%, Lag= 62.0 min
Primary = 22.02 cfs @ 13.47 hrs, Volume= 13.215 af
Secondary = 22.55 cfs @ 13.47 hrs, Volume= 5.165 af

Routing by Stor-Ind method, Time Span= 1.00-20.00 hrs, dt= 0.05 hrs
Peak Elev= 685.90' @ 13.47 hrs Surf.Area= 5.991 ac Storage= 19.576 af

Plug-Flow detention time= 214.7 min calculated for 18.331 af (57% of inflow)
Center-of-Mass det. time= 138.1 min (930.0 - 791.9)

Volume	Invert	Avail.Storage	Storage Description
#1	681.46'	20.170 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
681.46	2.750	0.000	0.000
682.00	2.880	1.520	1.520
684.00	4.860	7.740	9.260
686.00	6.050	10.910	20.170

Device	Routing	Invert	Outlet Devices
#1	Primary	681.50'	**24.0" x 50.0' long Culvert** CMP, square edge headwall, Ke= 0.500 Outlet Invert= 681.00' S= 0.0100 '/' Cc= 0.900 n= 0.025 Corrugated metal
#2	Device 1	681.75'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#3	Device 1	682.25'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#4	Device 1	682.75'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#5	Device 1	683.25'	**6.0" Vert. Orifice/Grate X 4.00** C= 0.600
#6	Device 1	684.00'	**36.0" Horiz. Orifice/Grate** Limited to weir flow C= 0.600
#7	Secondary	685.00'	**10.0' long x 30.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=22.02 cfs @ 13.47 hrs HW=685.90' (Free Discharge)
└─**1=Culvert** (Barrel Controls 22.02 cfs @ 7.01 fps)
  ├─**2=Orifice/Grate** (Passes < 7.47 cfs potential flow)
  ├─**3=Orifice/Grate** (Passes < 6.97 cfs potential flow)
  ├─**4=Orifice/Grate** (Passes < 6.44 cfs potential flow)
  ├─**5=Orifice/Grate** (Passes < 5.86 cfs potential flow)
  └─**6=Orifice/Grate** (Passes < 46.93 cfs potential flow)

Secondary OutFlow Max=22.54 cfs @ 13.47 hrs HW=685.90' (Free Discharge)
└─**7=Broad-Crested Rectangular Weir** (Weir Controls 22.54 cfs @ 2.50 fps)

SCS ENGINEERS

		Sheet No.	
		Calc. No.	
		Rev. No.	
Job No. 25214179	Job I-43 Ash Landfill	By KRG	Date 5/17/16
Client Wisconsin P&L	Subject Contact Water Basin	Chk'd BLP	Date 5/23/16

Purpose:

The contact water basin at the I-43 landfill accommodates runoff pumped from contact water handling areas within each module and from other areas directly dischargin into the contact water basin during storm events. The purpose of this calculation is to determine the maximum starting water elevation in the contact water basin prior to a 25-year, 24-hour storm event in order to accommodate the volume of runoff from these two contributing sources.

Approach:

Determine the 25-year, 24-hour storm event runoff volumes contributing to the contact water basin for each phase of development, starting with Phase 3, Module 2. Use the HydroCAD model to calculate volumes. Drainage areas during each stage of development are shown on the attached figures.

Determine the remaining capacity of the contact water basin, assuming the basin has standing water at various intervals prior to the start of the storm event. One foot intervals were used.

Assumptions

A 25-year, 24-hour storm event = 4.80 inches, based on NOAA Atlas 14.

Assume a MSE4 storm distribution.

Assume 1' of freeboard will be maintained in the contact water basin.

Ash has a runoff curve number of 98.

Assume other site areas draining into the contact water basin are bare soil.

Results:

Phase 3 Module 2 Active

To accommodate the runoff volume (269,114 cf) resulting from a 25-year, 24-hour storm event, the starting water elevation in the pond should be 682.5 or lower.

Phase 4 Module 2

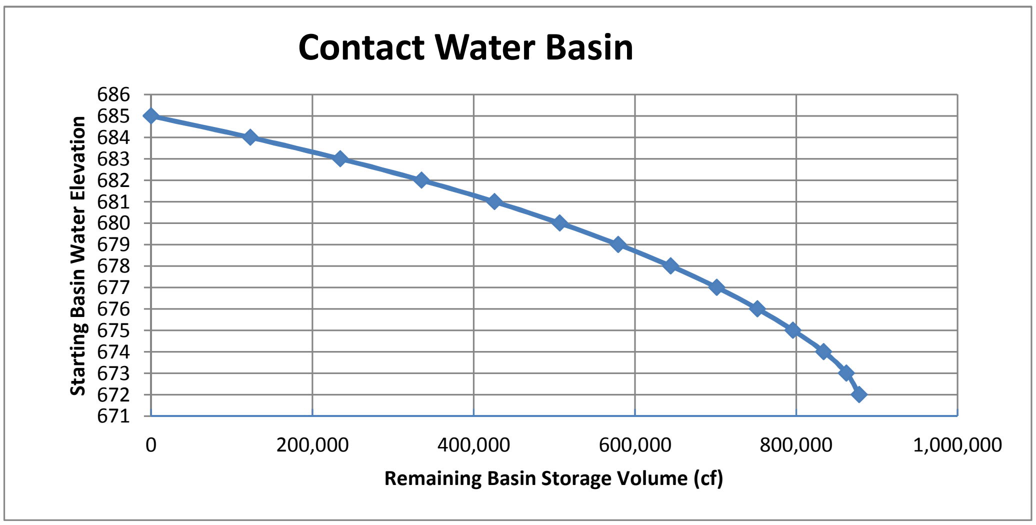
To accommodate the runoff volume (257,352 cf) resulting from a 25-year, 24-hour storm event, the starting water elevation in the pond should be 681.5 or lower.

Phase 4 Module 3

To accommodate the runoff volume (237,141 cf) resulting from a 25-year, 24-hour storm event, the starting water elevation in the pond should be 681.5 or lower.

Table 1
Operational Chart
Phase 3 Module 2
Contact Water Basin Outside Limits of Waste

Basin Elevation	Starting Water Depth (ft)	Area (sf)	Incremental Storage Volume (cf)	Cumulative Volume to Reach Basin Elevation 685 (cf)	Notes
686	14	140,337	-	-	Basin is full
685	13	128,481	0	0	Peak Elevation (1' freeboard)
684	12	117,241	122,861	122,861	
683	11	105,982	111,611	234,473	Elev 682.5 Cumulative Volume = 284,811 cf
682	10	95,370	100,676	335,149	
681	9	85,538	90,454	425,603	
680	8	76,769	81,154	506,756	
679	7	68,768	72,768	579,525	
678	6	60,958	64,863	644,388	
677	5	53,735	57,347	701,734	
676	4	47,129	50,432	752,166	
675	3	40,929	44,029	796,195	
674	2	35,173	38,051	834,246	
673	1	21,330	28,252	862,498	
672	0	10,036	15,683	878,181	Basin is empty

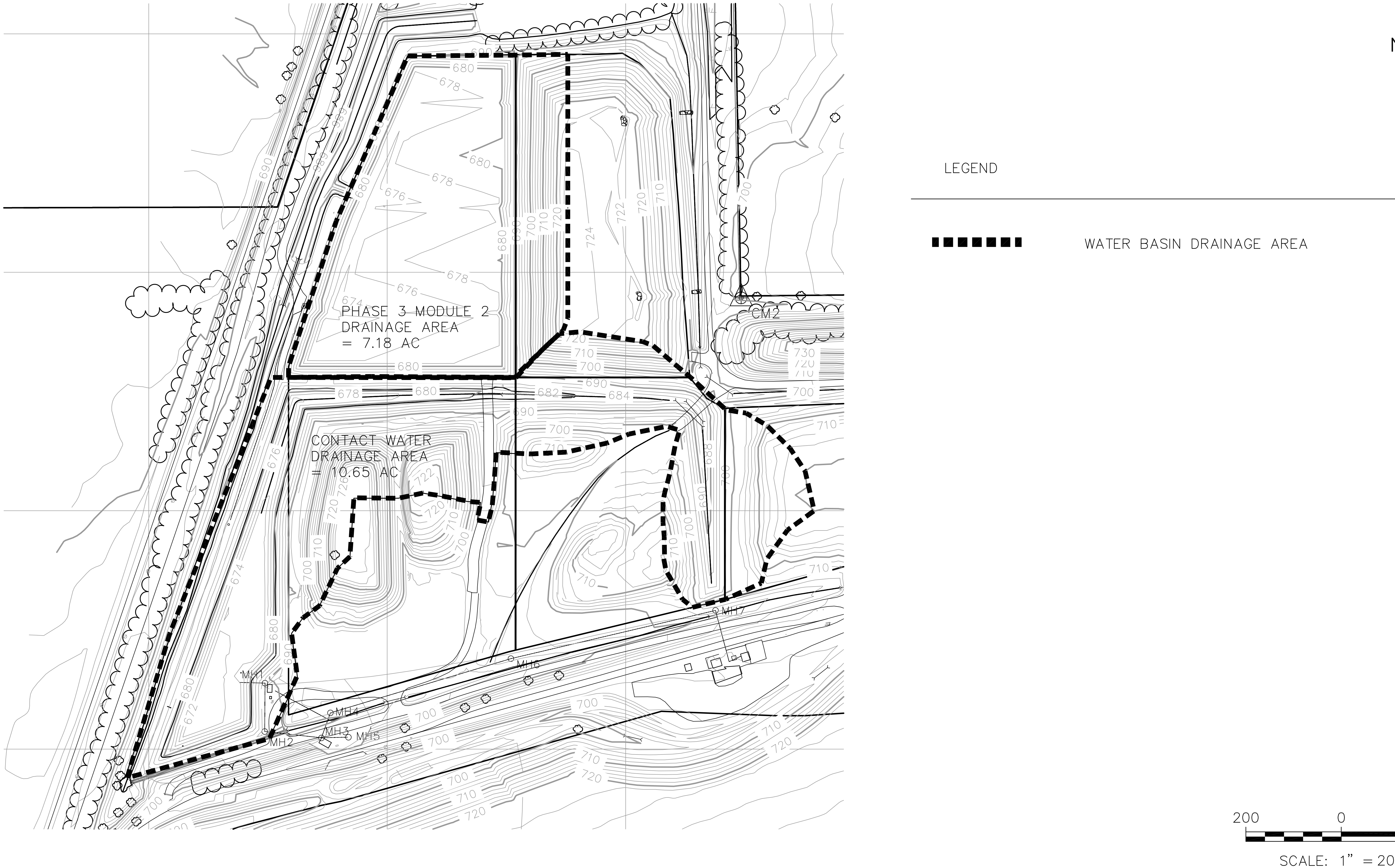


Before pumping water from any of the contact water holding features located within each module into the Contact Water Basin, make sure there is adaquate storage available.

Phase 3 Module 2 Runoff Volume:		112,733	cf (from HydroCAD model, 2.588 ac-ft)
Other Runoff Volume to Basin		156,380	cf (from HydroCAD model, 3.590 ac-ft)
	Total:	269,114	cf

Based on the above runoff volume to the contact water basin, the starting water level in the basin should not be higher than 682.5 to accommodate the runoff from a 25-year, 24-hour storm event.

KRG/ 5/16/16



PROJECT NO.	25216090	DRAWN BY:	KRG
DRAWN:	05/16/16	CHECKED BY:	??
REVISED:	??/??/??	APPROVED BY:	

ENGINEER

SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

CLIENT

WISCONSIN POWER AND LIGHT COMPANY
EDGEWATER GENERATING STATION
3739 LAKESHORE DRIVE
SHEBOYGAN, WISCONSIN

SITE

EDGEWATER I-43 ASH DISPOSAL FACILITY
TOWN OF WILSON, WISCONSIN

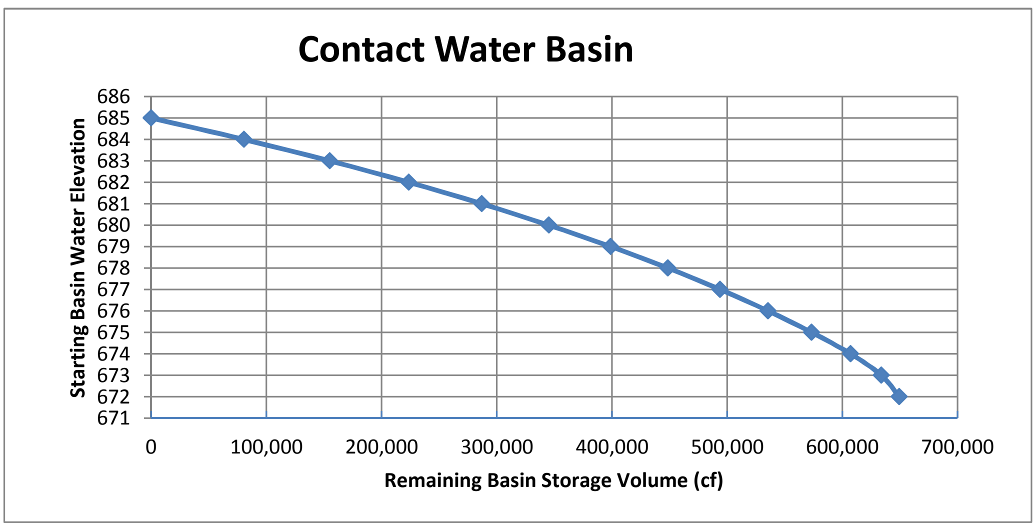
PHASE 3 MODULE 2 CONTACT
WATER BASIN DRAINAGE AREAS

FIGURE
1

I:\25214060\Drawings-General\Plan Mod\Working\Phase 3 Module 2 Contact Water Storage - 2.dwg, 5/23/2016 3:27:19 PM

Table 2
Operational Chart
Phase 4 Module 2
Contact Water Basin Outside Limits of Waste

Basin Elevation	Starting Water Depth (ft)	Area (sf)	Incremental Storage Volume (cf)	Cumulative Volume to Reach Basin Elevation 685 (cf)	Notes
686	14	89,741	-	-	Basin is full
685	13	83,468	0	0	Peak Elevation (1' freeboard)
684	12	77,379	80,424	80,424	
683	11	71,511	74,445	154,869	
682	10	65,875	68,693	223,562	Elev 681.5 Cumulative Volume = 255,195 cf
681	9	60,657	63,266	286,828	
680	8	56,021	58,339	345,167	
679	7	51,631	53,826	398,994	
678	6	47,444	49,538	448,531	
677	5	43,448	45,446	493,977	
676	4	39,620	41,534	535,511	
675	3	35,881	37,751	573,262	
674	2	31,974	33,928	607,190	
673	1	21,330	26,652	633,841	
672	0	10,036	15,683	649,524	Basin is empty

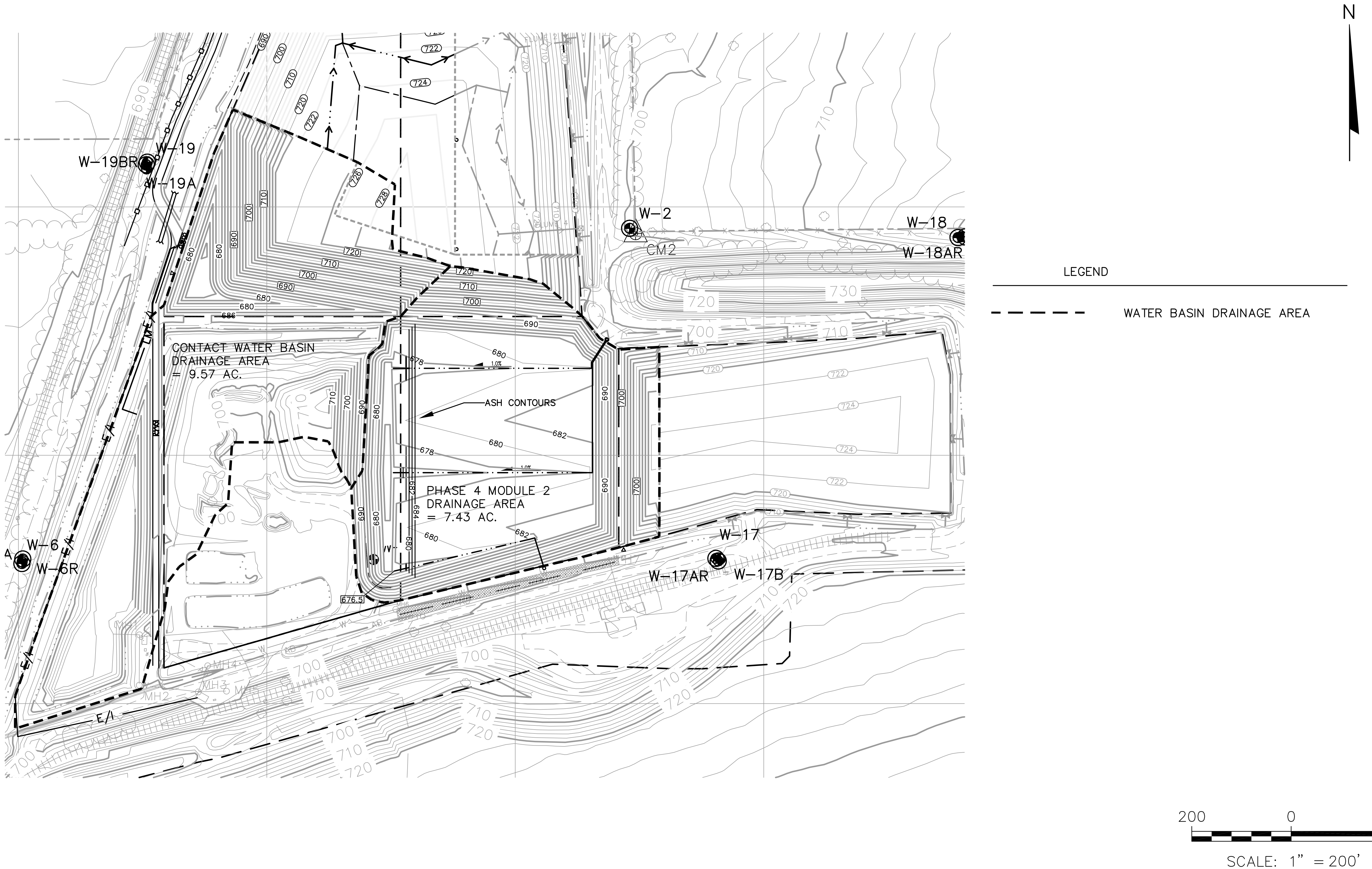


Before pumping water from any of the contact water holding features located within each module into the Contact Water Basin, make sure there is adaquate storage available:

Phase 4 Module 2 Runoff Volume:	116,697	cf (from HydroCAD model, 2.679 ac-ft)
Other Ruoff Volume to Basin:	140,655	cf (from HydroCAD model, 3.229 ac-ft)
Total:	257,352	cf

Based on the above runoff volume to the contact water basin, the starting water level in the basin should not be higher than 681.5 to accommodate the runoff from a 25-year, 24-hour storm event.

KRG/ 5/16/16



PROJECT NO.	25214060	DRAWN BY:	KRG
DRAWN:	02/25/15	CHECKED BY:	
REVISED:	05/16/16	APPROVED BY:	

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

CLIENT: WISCONSIN POWER AND LIGHT COMPANY
EDGEWATER GENERATING STATION
3739 LAKESHORE DRIVE
SHEBOYGAN, WI 53081

SITE: PLAN MODIFICATION
EDGEWATER I-43 ASH DISPOSAL FACILITY
TOWN OF WILSON, WISCONSIN

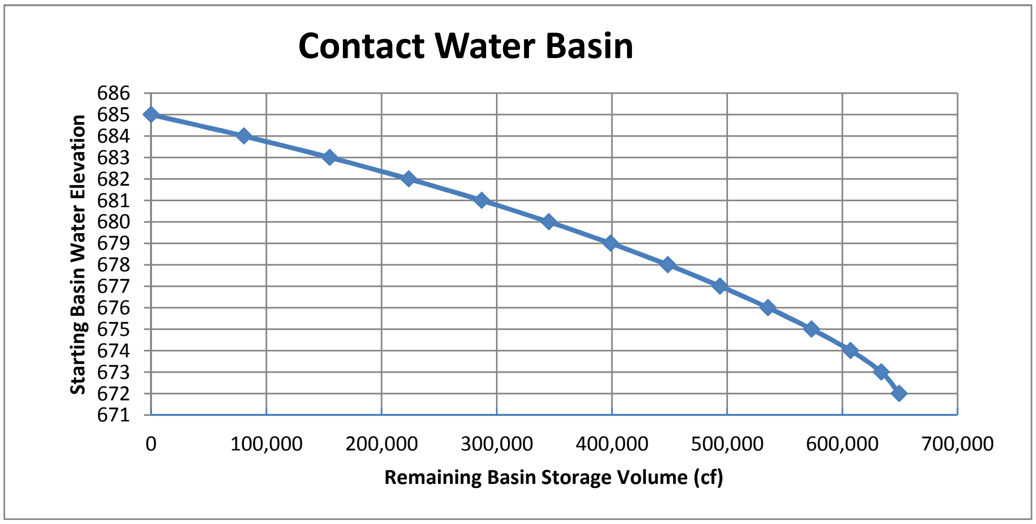
PHASE 4 MODULE 2 CONTACT WATER BASIN DRAINAGE AREA

FIGURE 2

I:\25214060\Drawings-General\Plan Mod\Working\Phase 4 Module 2 Contact Water Storage - 2.dwg, 5/23/2016 3:42:12 PM

Table 3
Operational Chart
Phase 4 Module 3
Contact Water Basin Outside Limits of Waste

Basin Elevation	Starting Water Depth (ft)	Area (sf)	Incremental Storage Volume (cf)	Cumulative Volume to Reach Basin Elevation 685 (cf)	Notes
686	14	89,751	-	-	Basin is full
685	13	83,469	0	0	Peak Elevation (1' freeboard)
684	12	77,379	80,424	80,424	
683	11	71,512	74,446	154,870	
682	10	65,875	68,694	223,563	Elev 681.5 Cumulative Volume = 255,197 cf
681	9	60,658	63,266	286,830	
680	8	56,021	58,339	345,169	
679	7	51,632	53,827	398,996	
678	6	47,444	49,538	448,534	
677	5	43,458	45,451	493,985	
676	4	39,619	41,539	535,524	
675	3	35,880	37,750	573,274	
674	2	31,974	33,927	607,201	
673	1	21,330	26,652	633,853	
672	0	10,036	15,683	649,536	Basin is empty

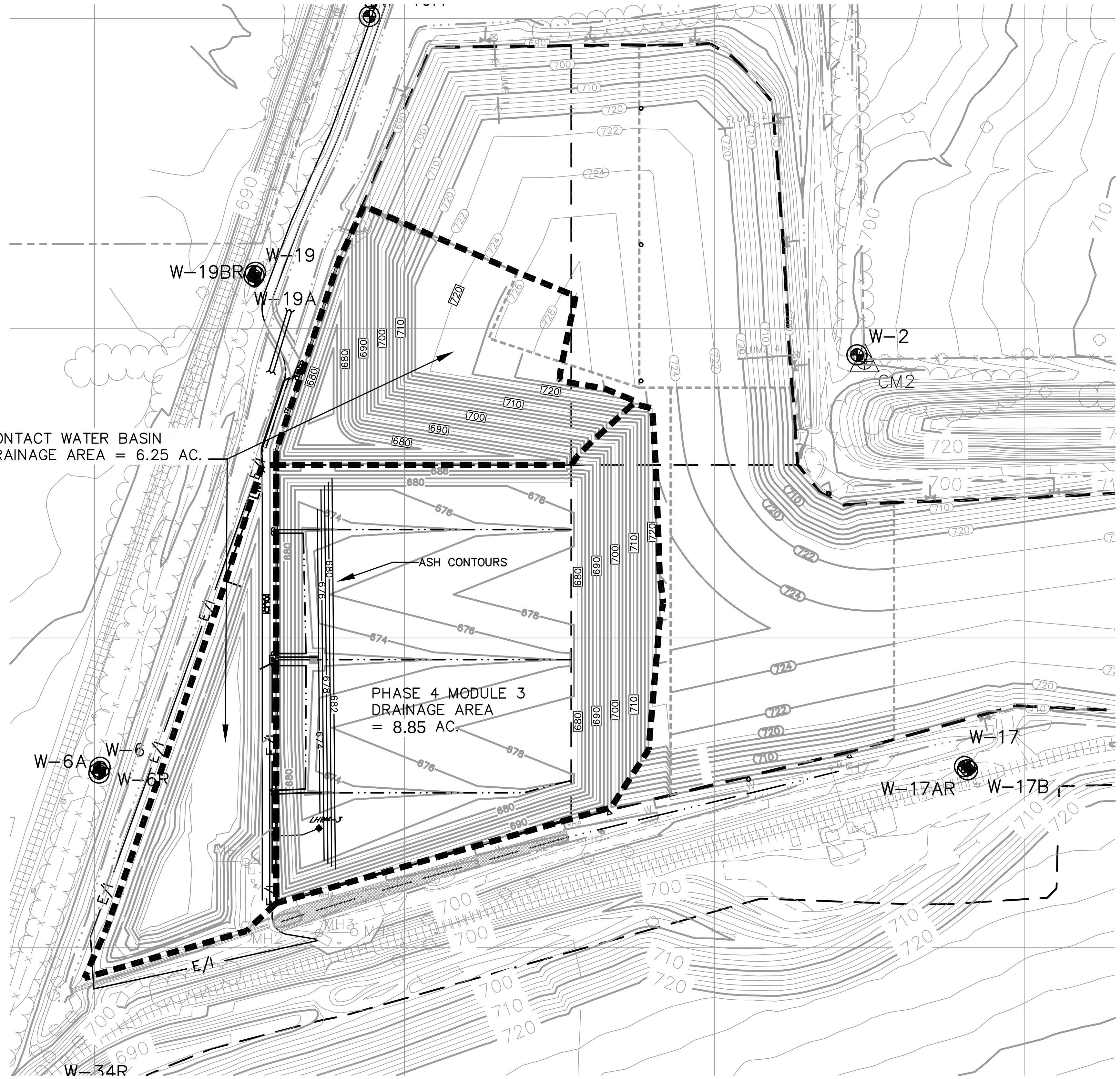


Before pumping water from any of the contact water holding features located within each module into the Contact Water Basin, make sure there is adaquate storage available:

Phase 4 Module 3 Runoff Volume:	139,000	cf (from HydroCAD model, 3.191 ac-ft)
Other Runoff Volume to Basin:	98,141	cf (from HydroCAD model, 2.253 ac-ft)
Total:	237,141	cf

Based on the above runoff volume to the contact water basin, the starting water level in the basin should not be higher than 681.5 to accommodate the runoff from a 25-year, 24-hour storm event.

KRG/ 5/16/16



N

LEGEND

BASIN DRAINAGE AREA

200 0 200

SCALE: 1" = 200'

PROJECT NO.	25214060	DRAWN BY:	KRG
DRAWN:	02/25/15	CHECKED BY:	
REVISED:		APPROVED BY:	

ENGINEER: SCS ENGINEERS
2830 DAIRY DRIVE MADISON, WI 53718-6751
PHONE: (608) 224-2830

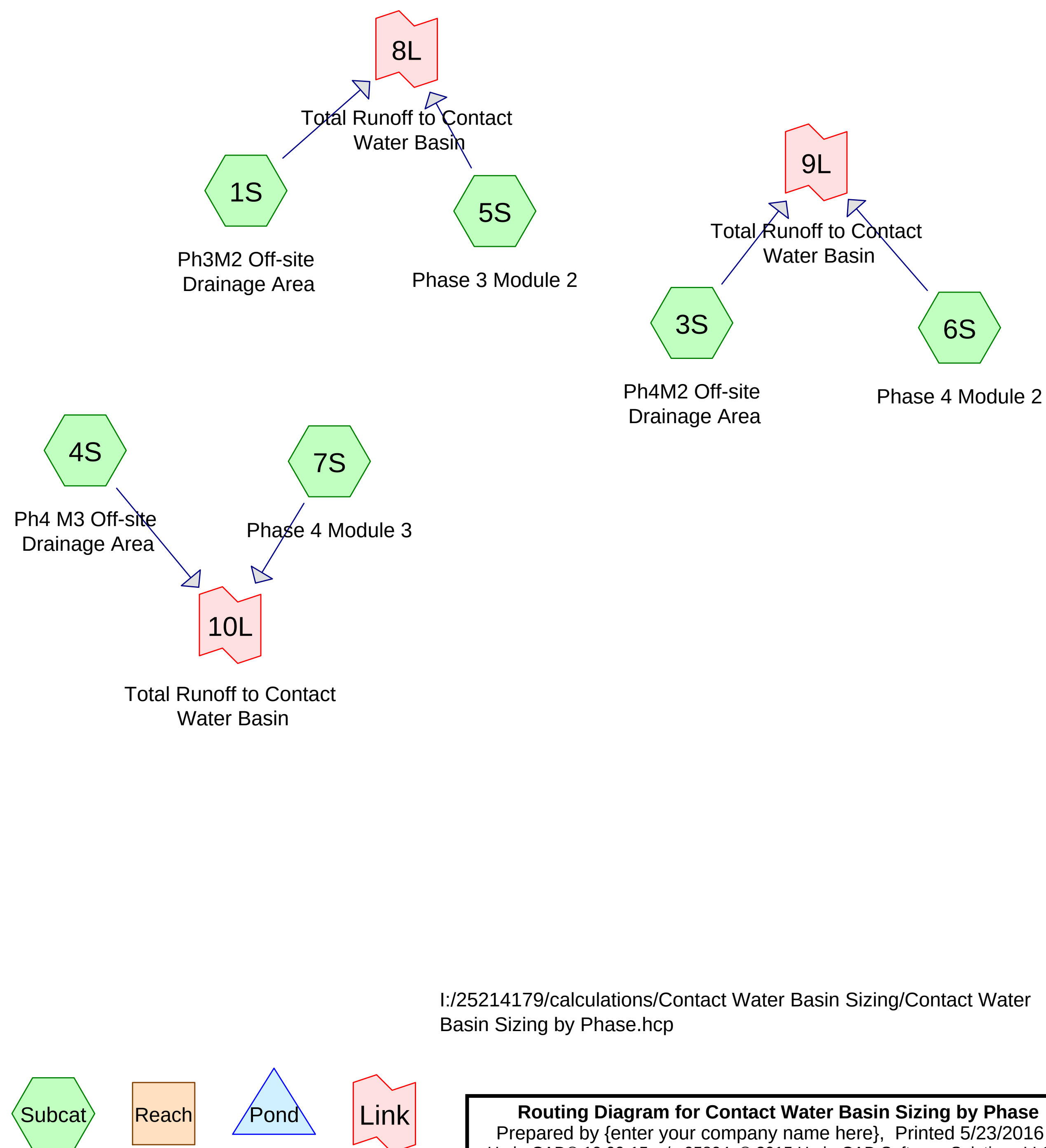
CLIENT: WISCONSIN POWER AND LIGHT COMPANY
EDGEWATER GENERATING STATION
3739 LAKESHORE DRIVE
SHEBOYGAN, WI 53081

SITE: PLAN MODIFICATION
EDGEWATER I-43 ASH DISPOSAL FACILITY
TOWN OF WILSON, WISCONSIN

PHASE 4 MODULE 3 CONTACT WATER BASIN DRAINAGE AREA

FIGURE
3

I:\25214060\Drawings-General\Plan Mod\Working\Phase 4 Module 3 Contact Water Storage - 2.dwg, 5/23/2016 3:38:44 PM



I:/25214179/calculations/Contact Water Basin Sizing/Contact Water Basin Sizing by Phase.hcp

Routing Diagram for Contact Water Basin Sizing by Phase
Prepared by {enter your company name here}, Printed 5/23/2016

Summary for Subcatchment 1S: Ph3M2 Off-site Drainage Area

[49] Hint: Tc<2dt may require smaller dt

Runoff = 69.57 cfs @ 12.09 hrs, Volume= 3.590 af, Depth> 4.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr Rainfall=4.80"

	Area (sf)	CN	Description
	323,363	94	Fallow, bare soil, HSG D
*	140,337	98	Water Surface (area of top of contact water basin)
	463,700	95	Weighted Average
	323,363		69.74% Pervious Area
	140,337		30.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	100	0.3300	3.80		**Sheet Flow, Phase 4 Mod 1** Smooth surfaces n= 0.011 P2= 2.59"
0.2	80	0.3300	5.74		**Shallow Concentrated Flow, Phase 4 Mod 1** Nearly Bare & Untilled Kv= 10.0 fps
2.8	980	0.0100	5.80	75.44	**Trap/Vee/Rect Channel Flow, Swale** Bot.W=10.00' D=1.00' Z= 3.0 '/' Top.W=16.00' n= 0.022 Earth, clean & straight
3.4	1,160	Total			

Summary for Subcatchment 3S: Ph4M2 Off-site Drainage Area

[49] Hint: Tc<2dt may require smaller dt

Runoff = 64.63 cfs @ 12.05 hrs, Volume= 3.229 af, Depth> 4.05"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr Rainfall=4.80"

	Area (ac)	CN	Description
	7.510	94	Fallow, bare soil, HSG D
*	2.060	98	Water Surface (area at top of contact water basin)
	9.570	95	Weighted Average
	7.510		78.47% Pervious Area
	2.060		21.53% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	100	0.3300	3.80		**Sheet Flow, Off-site Stockpiles** Smooth surfaces n= 0.011 P2= 2.59"
0.2	80	0.3300	5.74		**Shallow Concentrated Flow, Off-site Stockpiles** Nearly Bare & Untilled Kv= 10.0 fps
0.6	180	Total			

Summary for Subcatchment 4S: Ph4 M3 Off-site Drainage Area

[46] Hint: Tc=0 (Instant runoff peak depends on dt)

Runoff = 43.43 cfs @ 12.04 hrs, Volume= 2.253 af, Depth> 4.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr Rainfall=4.80"

	Area (ac)	CN	Description
*	2.060	98	Water Surface (area at top of contact water basin)
*	4.190	98	Ash in Phase 3 Module 2
	6.250	98	Weighted Average
	6.250		100.00% Impervious Area

Summary for Subcatchment 5S: Phase 3 Module 2

[49] Hint: Tc<2dt may require smaller dt

Runoff = 50.45 cfs @ 12.08 hrs, Volume= 2.588 af, Depth> 4.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr Rainfall=4.80"

	Area (sf)	CN	Description
*	312,726	98	Open Cell
	312,726		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.6	100	0.2500	1.01		**Sheet Flow, Down Ash face in P3M1** Fallow n= 0.050 P2= 2.59"
0.1	33	0.2500	8.05		**Shallow Concentrated Flow, Down ash face in P3M1** Unpaved Kv= 16.1 fps
0.4	96	0.0500	3.60		**Shallow Concentrated Flow, Across Liner** Unpaved Kv= 16.1 fps
2.1	229	Total			

Summary for Subcatchment 6S: Phase 4 Module 2

[49] Hint: Tc<2dt may require smaller dt

Runoff = 51.57 cfs @ 12.06 hrs, Volume= 2.679 af, Depth> 4.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr Rainfall=4.80"

	Area (ac)	CN	Description
*	7.430	98	Ash
	7.430		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	100	0.3300	3.80		**Sheet Flow, Down ash face in P4M1** Smooth surfaces n= 0.011 P2= 2.59"
0.0	27	0.3300	9.25		**Shallow Concentrated Flow,** Unpaved Kv= 16.1 fps
0.3	68	0.0400	4.06		**Shallow Concentrated Flow, Base of Phase 4 Mod 2** Paved Kv= 20.3 fps
0.7	195	Total			

Summary for Subcatchment 7S: Phase 4 Module 3

[49] Hint: Tc<2dt may require smaller dt

Runoff = 61.61 cfs @ 12.06 hrs, Volume= 3.191 af, Depth> 4.33"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
MSE 24-hr 4 25-yr Rainfall=4.80"

	Area (ac)	CN	Description
*	8.850	98	
	8.850		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.4	100	0.3300	3.80		**Sheet Flow,** Smooth surfaces n= 0.011 P2= 2.59"
0.1	42	0.3300	11.66		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.5	78	0.0200	2.87		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
1.0	220	Total			

Summary for Link 8L: Total Runoff to Contact Water Basin

Inflow Area = 17.824 ac, 58.35% Impervious, Inflow Depth > 4.16" for 25-yr event
Inflow = 119.38 cfs @ 12.09 hrs, Volume= 6.178 af
Primary = 119.38 cfs @ 12.09 hrs, Volume= 6.178 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Link 9L: Total Runoff to Contact Water Basin

Inflow Area = 17.000 ac, 55.82% Impervious, Inflow Depth > 4.17" for 25-yr event
Inflow = 116.20 cfs @ 12.05 hrs, Volume= 5.907 af
Primary = 116.20 cfs @ 12.05 hrs, Volume= 5.907 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Link 10L: Total Runoff to Contact Water Basin

Inflow Area = 15.100 ac,100.00% Impervious, Inflow Depth > 4.33" for 25-yr event
Inflow = 104.32 cfs @ 12.05 hrs, Volume= 5.444 af
Primary = 104.32 cfs @ 12.05 hrs, Volume= 5.444 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs