



***Stormwater Control Plan  
Sunflower CCR Landfill  
KDHE Permit Number 420  
Holcomb, KS***

***Prepared for:  
Sunflower Electric Power Corporation***



***AEC File No. 21097:4908  
December 2021***

## **TABLE OF CONTENTS**

### **PROFESSIONAL ENGINEER STATEMENT**

**ii**

### **ATTACHMENTS**

ATTACHMENT 1 – STORMWATER CALCULATIONS

ATTACHMENT 2 – DISCUSSION

## PROFESSIONAL ENGINEERING STATEMENT

In accordance with our Professional Services Agreement with Sunflower Electric Power Corporation, Allied Environmental Consultants, Inc. (AEC) prepared the Stormwater Control Plan for the Sunflower Coal Combustion Residue (CCR) Landfill in Holcomb, Kansas. The Project included preparing design calculations of the stormwater controls for the current phase of landfill development. In accordance with the documentation listed as follows, our Statement of Professional Opinion shown below is stipulated.

- As documented by the Attached Stormwater Calculations and Discussion.

Therefore, as an officer of Allied Environmental Consultants, Inc., and in accordance with the above conditions and documentation, the following statement of Professional Opinion is hereby made: **It is my Professional Opinion that the Stormwater Control Plan completed for this Project substantially conforms with 40 CFR 257.81 entitled "Run-on and run-off controls for CCR Landfills," and provides stormwater controls for the 25 year 24 hour storm as stipulated therein.**



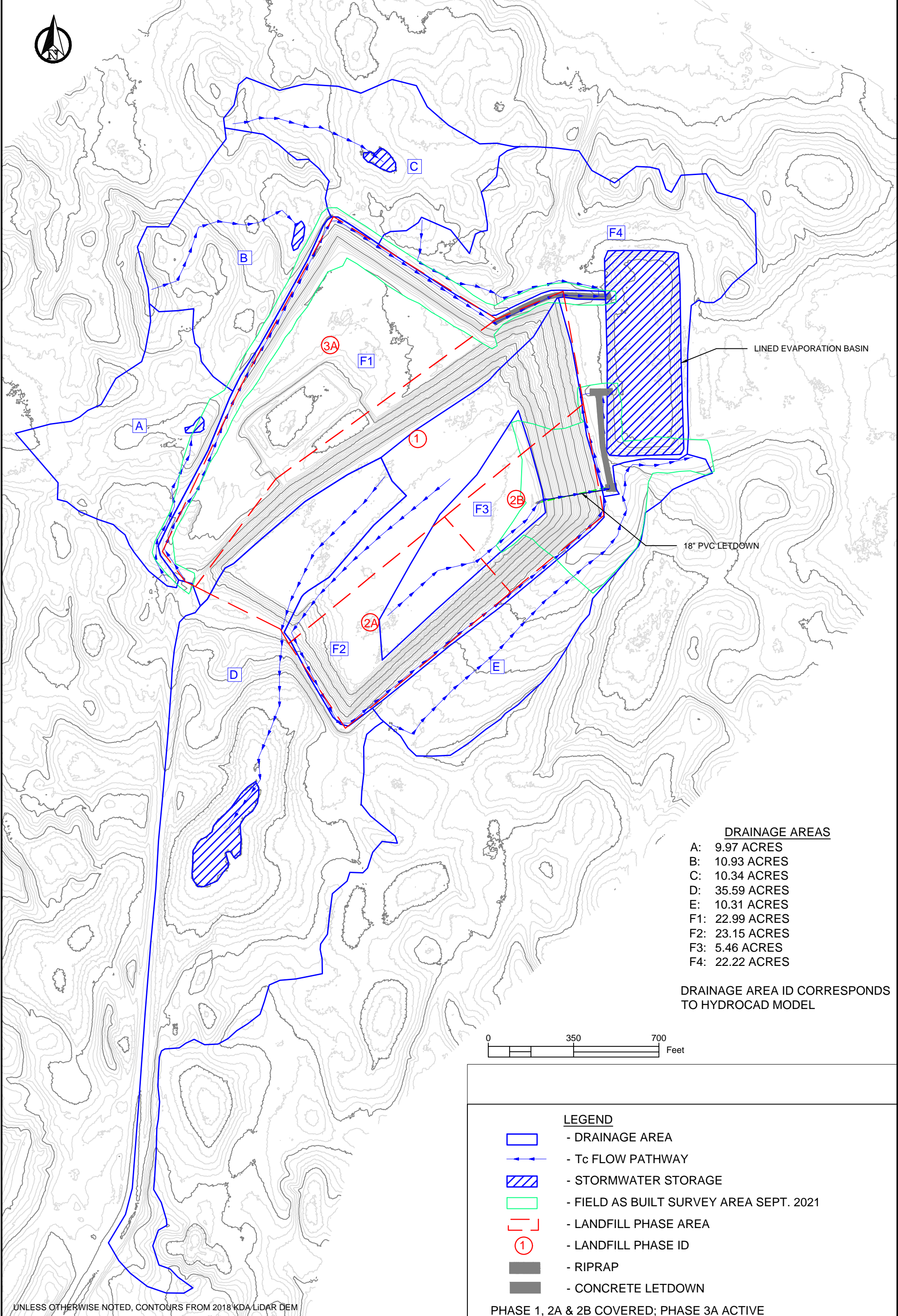
Engineer: \_\_\_\_\_  
Theodore B. Francis, P.E.

Date: December 29, 2021

\*\_\*\_\*\_\*\_\*

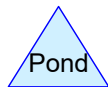
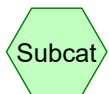
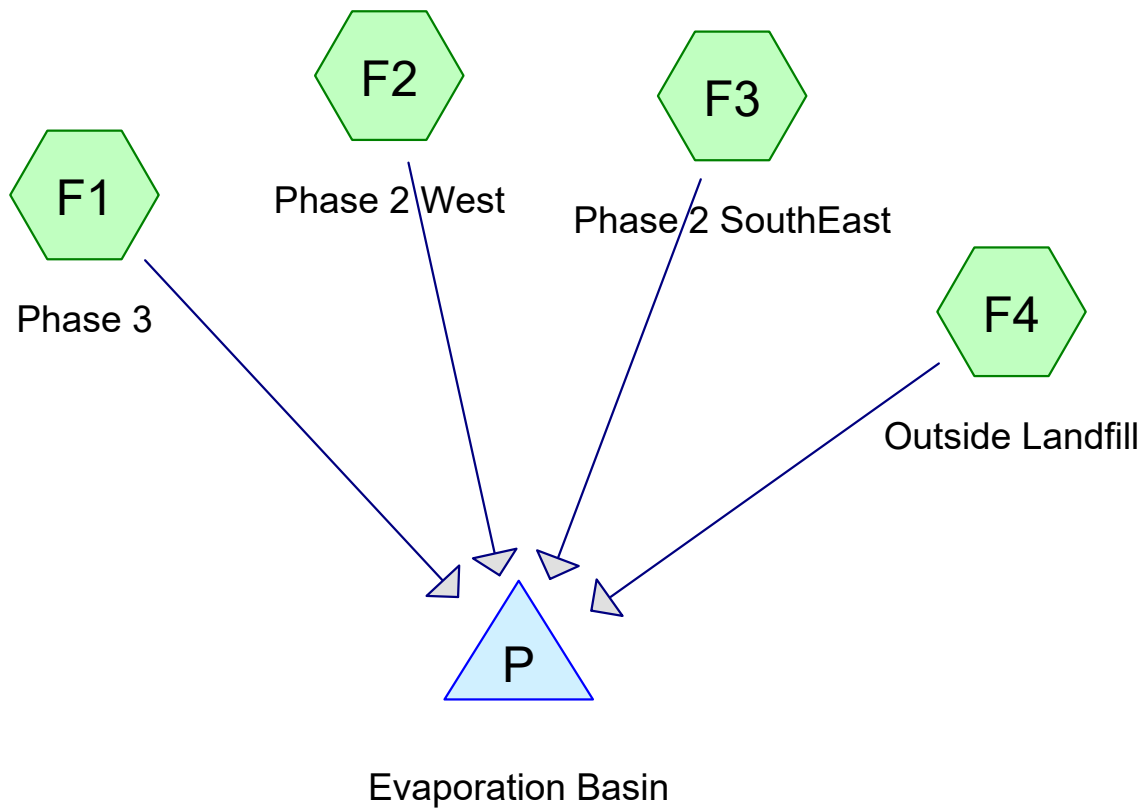
**ATTACHMENT 1**

**STORMWATER CALCULATIONS**



UNLESS OTHERWISE NOTED, CONTOURS FROM 2018 KDA LIDAR DEM

PHASE 1, 2A & 2B COVERED; PHASE 3A ACTIVE



**Routing Diagram for Evaporation Basin Drainage Area**  
 Prepared by Allied Environmental, Printed 12/15/2021  
 HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

**Evaporation Basin Drainage Area**

Prepared by Allied Environmental

Printed 12/15/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 2

**Area Listing (all nodes)**

Area (acres)	CN	Description (subcatchment-numbers)
17.840	86	Active Cell (F1)
33.763	69	Covered Landfill (F1, F2, F3)
5.898	100	Evaporation Basin (F4)
16.321	49	Outside Landfill (F4)
<b>73.822</b>	<b>71</b>	<b>TOTAL AREA</b>

## Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 3

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

### Subcatchment F1: Phase 3

Runoff Area=22.991 ac 0.00% Impervious Runoff Depth>2.29"  
Flow Length=3,204' Tc=9.6 min CN=82 Runoff=87.28 cfs 4.394 af

### Subcatchment F2: Phase 2 West

Runoff Area=23.151 ac 0.00% Impervious Runoff Depth>1.31"  
Flow Length=3,316' Tc=50.1 min CN=69 Runoff=19.37 cfs 2.528 af

### Subcatchment F3: Phase 2 SouthEast

Runoff Area=5.461 ac 0.00% Impervious Runoff Depth>1.33"  
Flow Length=1,494' Tc=22.5 min CN=69 Runoff=7.97 cfs 0.604 af

### Subcatchment F4: Outside Landfill

Runoff Area=22.219 ac 26.54% Impervious Runoff Depth>0.97"  
Flow Length=969' Tc=23.8 min CN=63 Runoff=21.45 cfs 1.793 af

### Pond P: Evaporation Basin

Peak Elev=2,888.22' Storage=9.313 af Inflow=105.18 cfs 9.320 af  
Outflow=0.00 cfs 0.000 af

**Total Runoff Area = 73.822 ac Runoff Volume = 9.320 af Average Runoff Depth = 1.51"**  
**92.01% Pervious = 67.924 ac 7.99% Impervious = 5.898 ac**

# Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 4

## Summary for Subcatchment F1: Phase 3

Runoff = 87.28 cfs @ 12.01 hrs, Volume= 4.394 af, Depth> 2.29"  
 Routed to Pond P : Evaporation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Area (ac)	CN	Description
* 17.840	86	Active Cell
* 5.151	69	Covered Landfill
22.991	82	Weighted Average
22.991		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.8	100	0.0350	0.44		<b>Sheet Flow,</b> Fallow n= 0.050 P2= 2.40"
0.5	280	0.3300	9.25		<b>Shallow Concentrated Flow,</b> Unpaved Kv= 16.1 fps
0.2	160	0.0470	16.41	307.61	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=2.50' Z= 3.0 '/' Top.W=15.00' n= 0.022
1.2	487	0.0080	6.77	126.91	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=2.50' Z= 3.0 '/' Top.W=15.00' n= 0.022 Earth, clean & straight
1.6	1,000	0.0180	10.15	190.37	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=2.50' Z= 3.0 '/' Top.W=15.00' n= 0.022 Earth, clean & straight
0.5	240	0.0130	8.63	161.78	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=2.50' Z= 3.0 '/' Top.W=15.00' n= 0.022 Earth, clean & straight
0.8	545	0.0200	10.70	200.66	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=2.50' Z= 3.0 '/' Top.W=15.00' n= 0.022 Earth, clean & straight
1.0	392	0.0200	6.73	126.13	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=2.50' Z= 3.0 '/' Top.W=15.00' n= 0.035 Riprap, 6-inch
9.6	3,204	Total			

# Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

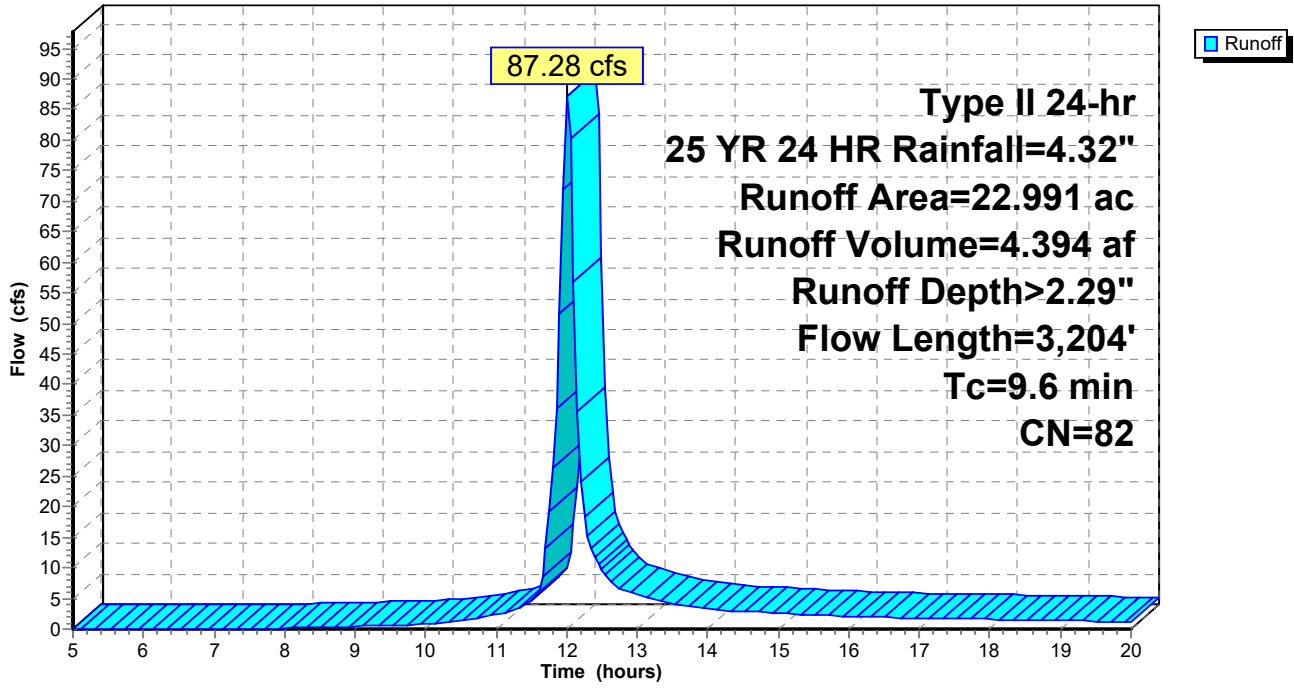
Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 5

## Subcatchment F1: Phase 3

Hydrograph



# Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 6

## Summary for Subcatchment F2: Phase 2 West

Runoff = 19.37 cfs @ 12.53 hrs, Volume= 2.528 af, Depth> 1.31"  
Routed to Pond P : Evaporation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Area (ac)	CN	Description
* 23.151	69	Covered Landfill
23.151		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.7	100	0.0020	0.12		<b>Sheet Flow,</b> Cultivated: Residue<=20% n= 0.060 P2= 2.40"
29.3	556	0.0010	0.32		<b>Shallow Concentrated Flow,</b> Nearly Bare & Untilled Kv= 10.0 fps
0.6	65	0.0320	1.79		<b>Shallow Concentrated Flow,</b> Nearly Bare & Untilled Kv= 10.0 fps
1.1	200	0.0950	3.08		<b>Shallow Concentrated Flow,</b> Nearly Bare & Untilled Kv= 10.0 fps
0.2	166	0.0480	11.79	79.61	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=1.50' Z= 3.0 '/' Top.W=9.00' n= 0.022 Earth, clean & straight
0.2	104	0.0270	8.85	59.71	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=1.50' Z= 3.0 '/' Top.W=9.00' n= 0.022 Earth, clean & straight
0.6	196	0.0090	5.11	34.47	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=1.50' Z= 3.0 '/' Top.W=9.00' n= 0.022 Earth, clean & straight
2.3	1,240	0.0270	8.85	59.71	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=1.50' Z= 3.0 '/' Top.W=9.00' n= 0.022 Earth, clean & straight
1.9	549	0.0080	4.81	32.50	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=1.50' Z= 3.0 '/' Top.W=9.00' n= 0.022 Earth, clean & straight
0.2	140	0.0490	11.92	80.44	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=1.50' Z= 3.0 '/' Top.W=9.00' n= 0.022 Earth, clean & straight
50.1	3,316	Total			

# Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

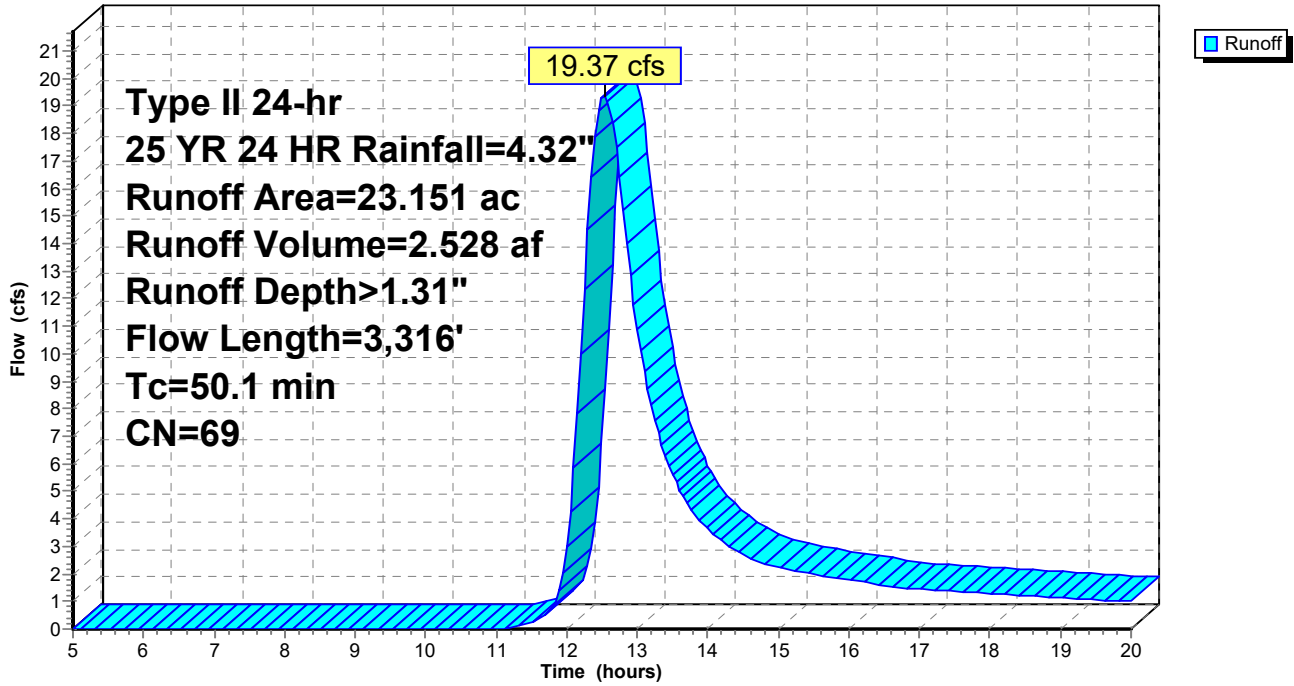
Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 7

## Subcatchment F2: Phase 2 West

Hydrograph



# Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 8

## Summary for Subcatchment F3: Phase 2 SouthEast

Runoff = 7.97 cfs @ 12.17 hrs, Volume= 0.604 af, Depth> 1.33"  
 Routed to Pond P : Evaporation Basin

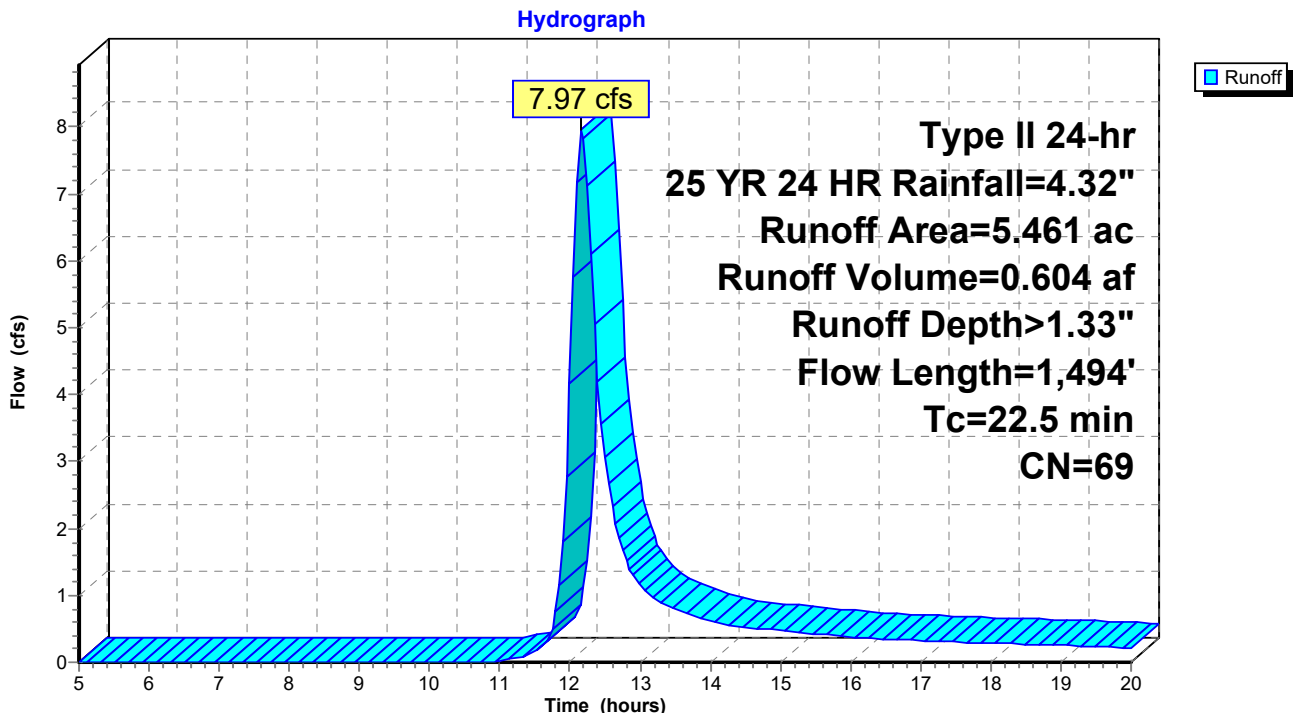
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Area (ac)	CN	Description
* 5.461	69	Covered Landfill
5.461		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.1	100	0.0070	0.23		<b>Sheet Flow,</b> Fallow n= 0.050 P2= 2.40"
13.9	699	0.0070	0.84		<b>Shallow Concentrated Flow,</b> Nearly Bare & Untilled Kv= 10.0 fps
0.1	295	0.3300	44.39	78.45	<b>Pipe Channel,</b> 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.010 PVC, smooth interior
1.4	400	0.0124	4.63	74.13	<b>Trap/Vee/Rect Channel Flow,</b> Bot.W=0.00' D=2.00' Z= 4.0 '/' Top.W=16.00' n= 0.035 Riprap, 6-inch
22.5	1,494	Total			

## Subcatchment F3: Phase 2 SouthEast



# Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 9

## Summary for Subcatchment F4: Outside Landfill

Runoff = 21.45 cfs @ 12.20 hrs, Volume= 1.793 af, Depth> 0.97"  
Routed to Pond P : Evaporation Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Area (ac)	CN	Description
* 5.898	100	Evaporation Basin
* 16.321	49	Outside Landfill
22.219	63	Weighted Average
16.321		73.46% Pervious Area
5.898		26.54% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	100	0.0340	0.20		<b>Sheet Flow,</b> Range n= 0.130 P2= 2.40"
6.2	402	0.0240	1.08		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
0.4	55	0.1270	2.49		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
9.0	412	0.0120	0.77		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
23.8	969	Total			

# Evaporation Basin Drainage Area

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

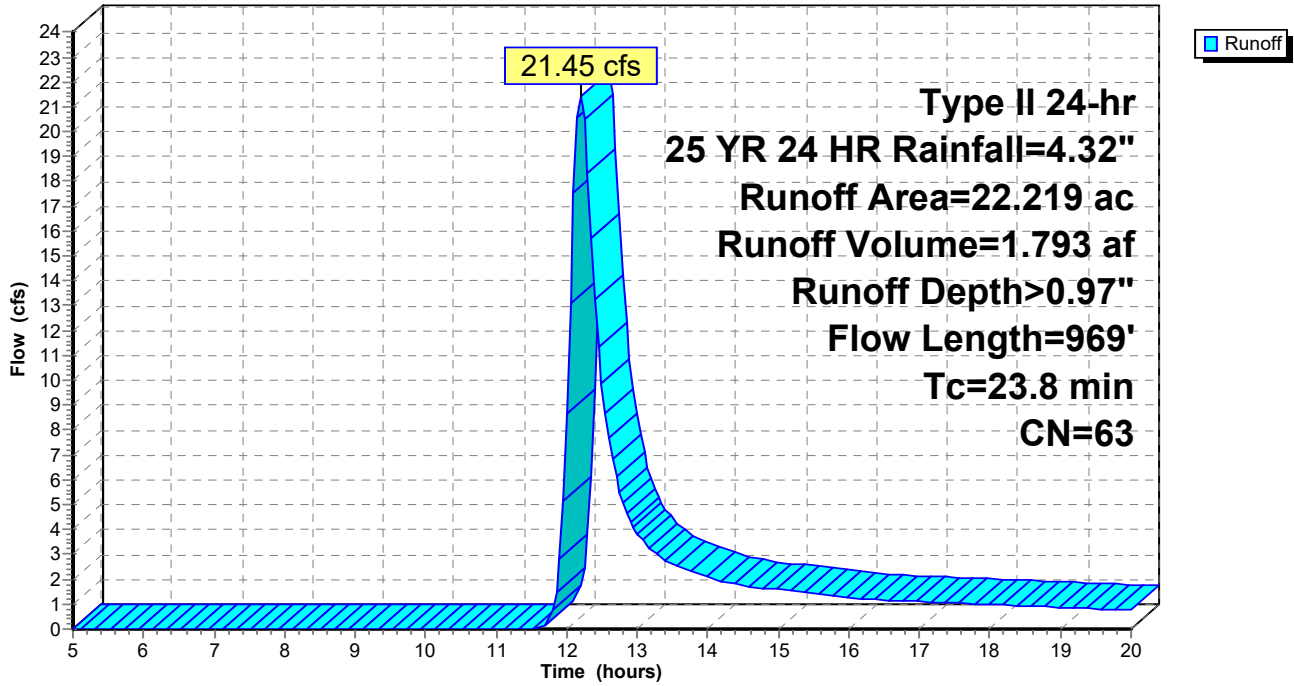
Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/15/2021

Page 10

## Subcatchment F4: Outside Landfill

Hydrograph



### Evaporation Basin Drainage Area

Prepared by Allied Environmental  
 HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

### Summary for Pond P: Evaporation Basin

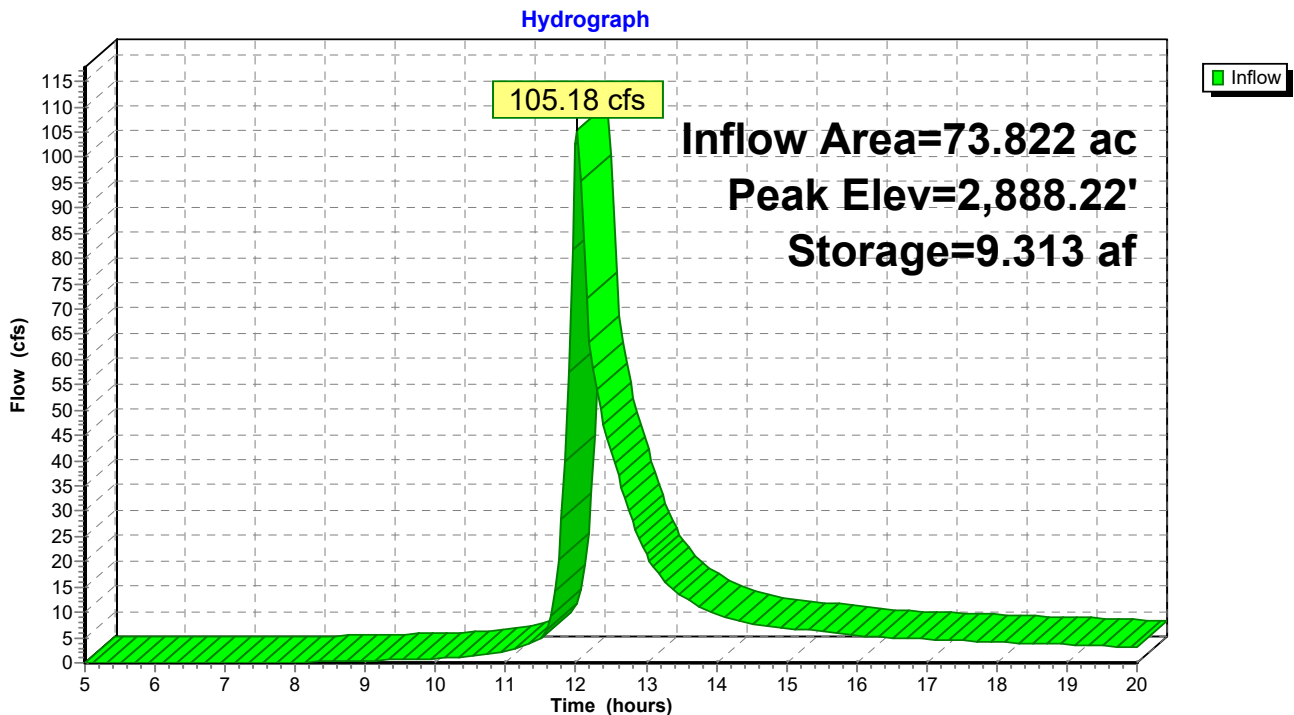
Inflow Area = 73.822 ac, 7.99% Impervious, Inflow Depth > 1.51" for 25 YR 24 HR event  
 Inflow = 105.18 cfs @ 12.03 hrs, Volume= 9.320 af  
 Outflow = 0.00 cfs @ 5.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min

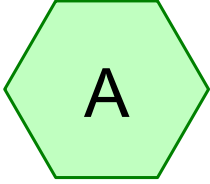
Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs  
 Peak Elev= 2,888.22' @ 20.00 hrs Surf.Area= 4.351 ac Storage= 9.313 af

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

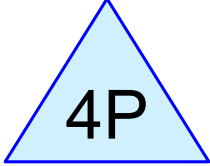
Volume	Invert	Avail.Storage	Storage Description	
#1	2,886.00'	58.826 af	<b>Custom Stage Data (Conic)</b> Listed below (Recalc)	
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
2,886.00	4.050	0.000	0.000	4.050
2,898.00	5.807	58.826	58.826	5.864

### Pond P: Evaporation Basin

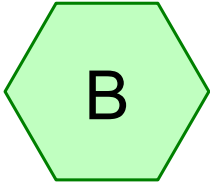




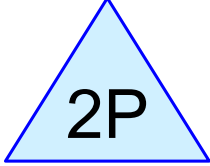
Outside Landfill 1



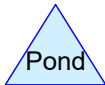
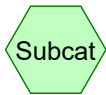
Depression



Outside Landfill 2



Depression



Routing Diagram for Outside Landfill Depression Drainage Areas  
Prepared by Allied Environmental, Printed 12/14/2021  
HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

**Outside Landfill Depression Drainage Areas**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 2

**Area Listing (all nodes)**

Area (acres)	CN	Description (subcatchment-numbers)
20.900	49	Desert shrub range, Good, HSG A (A, B)
<b>20.900</b>	<b>49</b>	<b>TOTAL AREA</b>

# Outside Landfill Depression Drainage Areas

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/14/2021

Page 3

Time span=0.00-40.00 hrs, dt=0.05 hrs, 801 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

## Subcatchment A: Outside Landfill 1

Runoff Area=9.974 ac 0.00% Impervious Runoff Depth=0.40"  
Flow Length=561' Tc=13.0 min CN=49 Runoff=2.65 cfs 0.329 af

## Subcatchment B: Outside Landfill 2

Runoff Area=10.926 ac 0.00% Impervious Runoff Depth=0.40"  
Flow Length=698' Tc=13.2 min CN=49 Runoff=2.88 cfs 0.361 af

## Pond 2P: Depression

Peak Elev=2,914.05' Storage=0.004 af Inflow=2.88 cfs 0.361 af  
Outflow=2.61 cfs 0.361 af

## Pond 4P: Depression

Peak Elev=2,926.07' Storage=0.005 af Inflow=2.65 cfs 0.329 af  
Outflow=2.35 cfs 0.329 af

**Total Runoff Area = 20.900 ac Runoff Volume = 0.690 af Average Runoff Depth = 0.40"**  
**100.00% Pervious = 20.900 ac 0.00% Impervious = 0.000 ac**

# Outside Landfill Depression Drainage Areas

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill

Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/14/2021

Page 4

## Summary for Subcatchment A: Outside Landfill 1

Runoff = 2.65 cfs @ 12.11 hrs, Volume= 0.329 af, Depth= 0.40"  
 Routed to Pond 4P : Depression

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

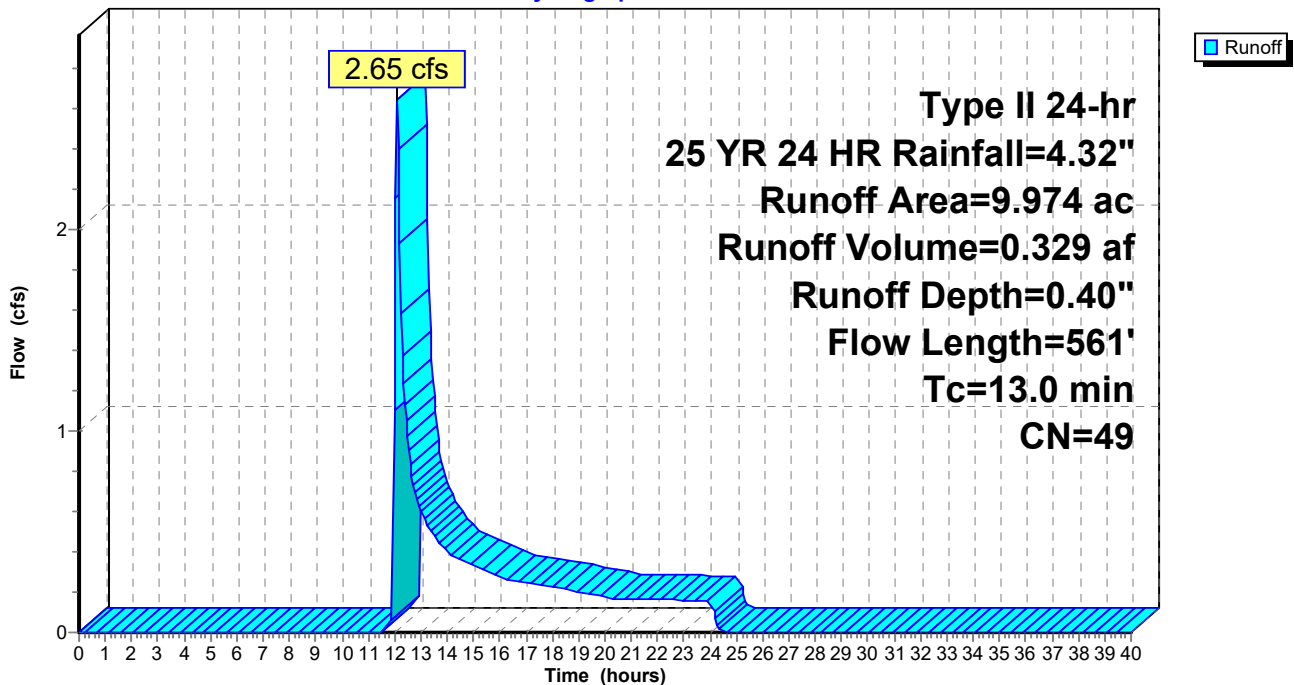
Area (ac)	CN	Description
9.974	49	Desert shrub range, Good, HSG A
9.974		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	98	0.0820	0.29		<b>Sheet Flow,</b> Range n= 0.130 P2= 2.40"
6.4	341	0.0160	0.89		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
1.0	122	0.0860	2.05		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
13.0	561	Total			

## Subcatchment A: Outside Landfill 1

Hydrograph



# Outside Landfill Depression Drainage Areas

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Holcomb Common Facilities CCR Landfill

Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/14/2021

Page 5

## Summary for Subcatchment B: Outside Landfill 2

Runoff = 2.88 cfs @ 12.11 hrs, Volume= 0.361 af, Depth= 0.40"  
 Routed to Pond 2P : Depression

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

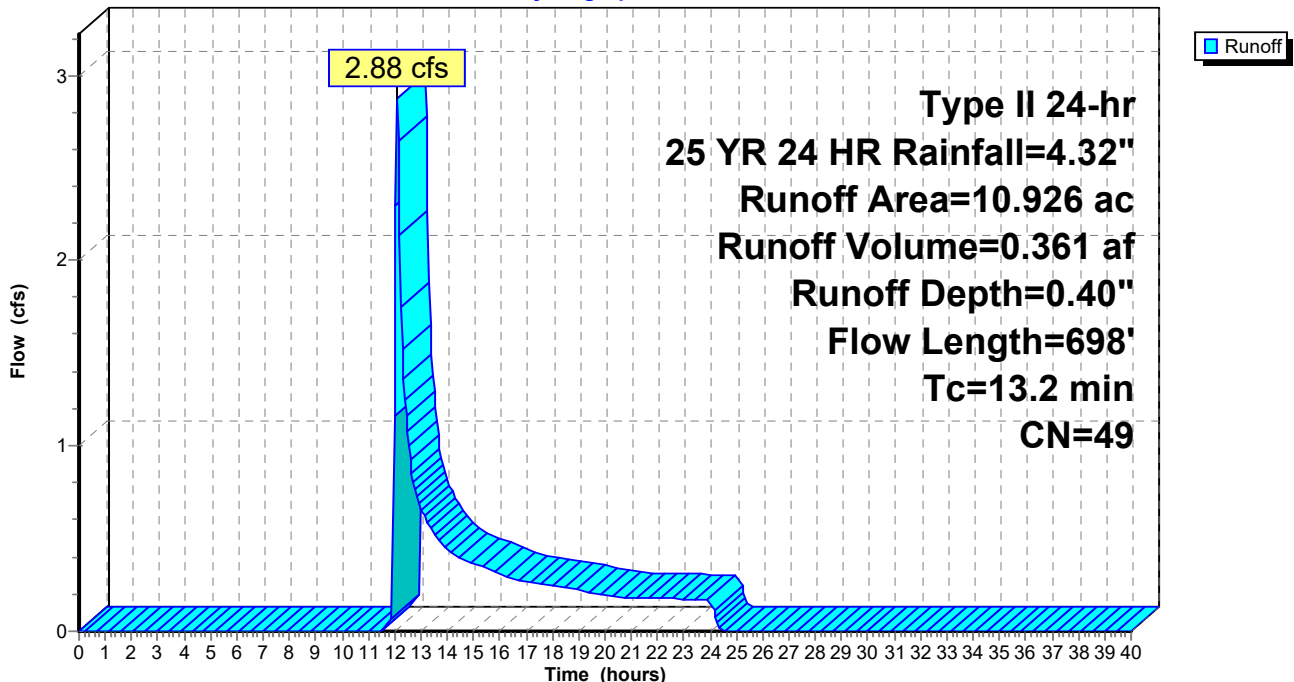
Area (ac)	CN	Description
10.926	49	Desert shrub range, Good, HSG A
10.926		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.3	100	0.1720	0.39		<b>Sheet Flow,</b> Range n= 0.130 P2= 2.40"
5.0	275	0.0170	0.91		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
1.5	178	0.0790	1.97		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
1.9	89	0.0130	0.80		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
0.5	56	0.0870	2.06		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
13.2	698	Total			

## Subcatchment B: Outside Landfill 2

Hydrograph



**Outside Landfill Depression Drainage Areas**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 6

**Summary for Pond 2P: Depression**

Inflow Area = 10.926 ac, 0.00% Impervious, Inflow Depth = 0.40" for 25 YR 24 HR event  
 Inflow = 2.88 cfs @ 12.11 hrs, Volume= 0.361 af  
 Outflow = 2.61 cfs @ 12.15 hrs, Volume= 0.361 af, Atten= 9%, Lag= 2.1 min  
 Discarded = 2.61 cfs @ 12.15 hrs, Volume= 0.361 af

Routing by Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Peak Elev= 2,914.05' @ 12.15 hrs Surf.Area= 0.086 ac Storage= 0.004 af

Plug-Flow detention time= 1.0 min calculated for 0.360 af (100% of inflow)  
 Center-of-Mass det. time= 1.0 min ( 951.6 - 950.7 )

Volume	Invert	Avail.Storage	Storage Description
#1	2,914.00'	2.323 af	<b>Custom Stage Data (Conic)</b> Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
2,914.00	0.081	0.000	0.000	0.081
2,915.00	0.215	0.143	0.143	0.215
2,916.00	0.624	0.402	0.544	0.624
2,917.00	0.906	0.761	1.305	0.907
2,918.00	1.134	1.018	2.323	1.135

Device	Routing	Invert	Outlet Devices
#1	Discarded	2,914.00'	<b>29.980 in/hr Exfiltration over Wetted area</b> Conductivity to Groundwater Elevation = 1.00'

**Discarded OutFlow** Max=2.61 cfs @ 12.15 hrs HW=2,914.05' (Free Discharge)  
 ↑1=Exfiltration ( Controls 2.61 cfs)

# Outside Landfill Depression Drainage Areas

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

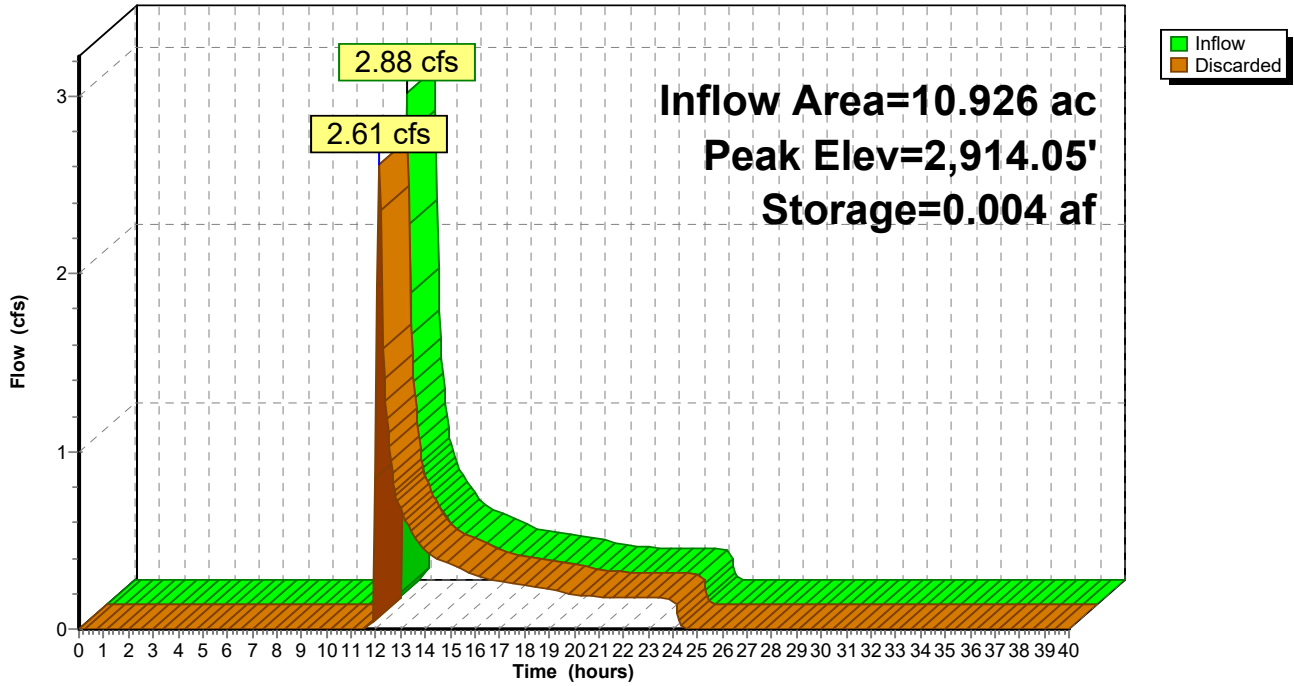
Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Printed 12/14/2021

Page 7

## Pond 2P: Depression

Hydrograph



**Outside Landfill Depression Drainage Areas**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 8

**Summary for Pond 4P: Depression**

Inflow Area = 9.974 ac, 0.00% Impervious, Inflow Depth = 0.40" for 25 YR 24 HR event  
 Inflow = 2.65 cfs @ 12.11 hrs, Volume= 0.329 af  
 Outflow = 2.35 cfs @ 12.15 hrs, Volume= 0.329 af, Atten= 11%, Lag= 2.6 min  
 Discarded = 2.35 cfs @ 12.15 hrs, Volume= 0.329 af

Routing by Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Peak Elev= 2,926.07' @ 12.15 hrs Surf.Area= 0.078 ac Storage= 0.005 af

Plug-Flow detention time= 1.2 min calculated for 0.329 af (100% of inflow)  
 Center-of-Mass det. time= 1.2 min ( 951.7 - 950.5 )

Volume	Invert	Avail.Storage	Storage Description		
#1	2,926.00'	2.622 af	<b>Custom Stage Data (Conic)</b> Listed below (Recalc)		
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)	
2,926.00	0.072	0.000	0.000	0.072	
2,927.00	0.177	0.121	0.121	0.177	
2,928.00	0.284	0.228	0.349	0.284	
2,929.00	0.403	0.342	0.691	0.404	
2,930.00	1.000	0.679	1.370	1.001	
2,931.00	1.523	1.252	2.622	1.524	

Device	Routing	Invert	Outlet Devices
#1	Discarded	2,926.00'	<b>29.980 in/hr Exfiltration over Wetted area</b> Conductivity to Groundwater Elevation = 1.00'

**Discarded OutFlow** Max=2.35 cfs @ 12.15 hrs HW=2,926.07' (Free Discharge)  
 ↑1=Exfiltration ( Controls 2.35 cfs)

# Outside Landfill Depression Drainage Areas

Prepared by Allied Environmental

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

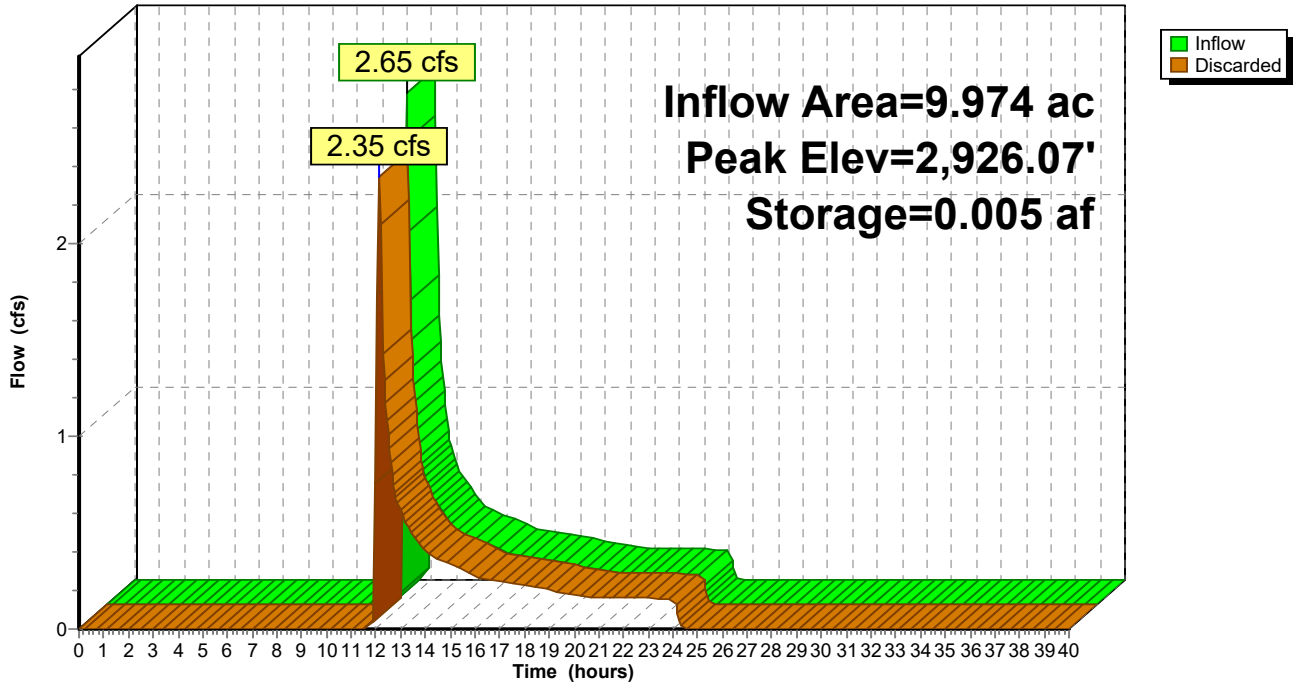
Holcomb Common Facilities CCR Landfill  
Type II 24-hr 25 YR 24 HR Rainfall=4.32"

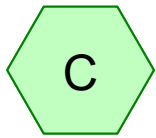
Printed 12/14/2021

Page 9

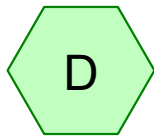
## Pond 4P: Depression

Hydrograph

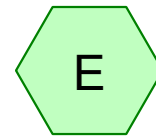




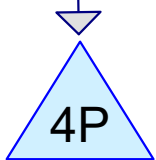
Outside Landfill 3



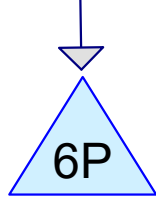
Phase 1 and Outside  
Landfill



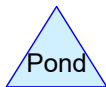
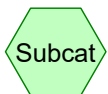
Outside Landfill 5



Depression



Depression



Routing Diagram for Phase 1 and Outside Landfill Depression Drainage Areas

Prepared by Allied Environmental, Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

**Phase 1 and Outside Landfill Depression Drainage Areas**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 2

**Area Listing (all nodes)**

Area (acres)	CN	Description (subcatchment-numbers)
5.619	69	(D)
50.620	49	Desert shrub range, Good, HSG A (C, D, E)
<b>56.239</b>	<b>51</b>	<b>TOTAL AREA</b>

**Phase 1 and Outside Landfill Depression Drains** *Type II 24-hr 25 YR 24 HR Rainfall=4.32"*

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 3

Time span=0.00-40.00 hrs, dt=0.05 hrs, 801 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

<b>Subcatchment C: Outside Landfill 3</b>	Runoff Area=10.340 ac 0.00% Impervious Runoff Depth=0.40" Flow Length=650' Tc=13.3 min CN=49 Runoff=2.71 cfs 0.341 af
<b>Subcatchment D: Phase 1 and Outside</b>	Runoff Area=35.591 ac 0.00% Impervious Runoff Depth=0.52" Flow Length=1,296' Tc=50.2 min CN=52 Runoff=6.60 cfs 1.551 af
<b>Subcatchment E: Outside Landfill 5</b>	Runoff Area=10.308 ac 0.00% Impervious Runoff Depth=0.40" Flow Length=1,875' Tc=45.1 min CN=49 Runoff=1.26 cfs 0.340 af
<b>Pond 4P: Depression</b>	Peak Elev=2,910.19' Storage=0.111 af Inflow=2.71 cfs 0.341 af Outflow=0.32 cfs 0.341 af
<b>Pond 6P: Depression</b>	Peak Elev=2,909.86' Storage=0.584 af Inflow=6.60 cfs 1.551 af Outflow=1.36 cfs 1.551 af

**Total Runoff Area = 56.239 ac Runoff Volume = 2.232 af Average Runoff Depth = 0.48"**  
**100.00% Pervious = 56.239 ac 0.00% Impervious = 0.000 ac**

**Phase 1 and Outside Landfill Depression Drains Type II 24-hr 25 YR 24 HR Rainfall=4.32"**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 4

**Summary for Subcatchment C: Outside Landfill 3**

Runoff = 2.71 cfs @ 12.11 hrs, Volume= 0.341 af, Depth= 0.40"  
 Routed to Pond 4P : Depression

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

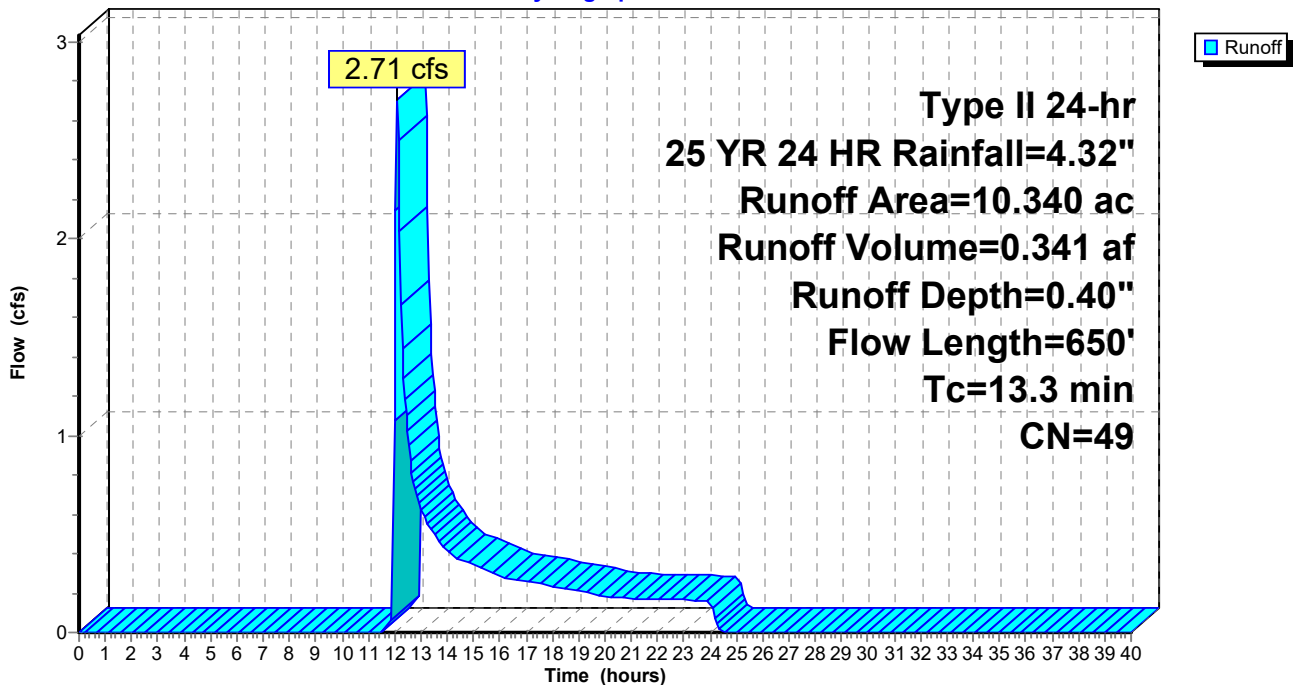
Area (ac)	CN	Description
10.340	49	Desert shrub range, Good, HSG A
10.340		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.6	100	0.0570	0.25		<b>Sheet Flow,</b> Range n= 0.130 P2= 2.40"
3.2	319	0.0570	1.67		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
1.0	111	0.0760	1.93		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
2.5	120	0.0130	0.80		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
13.3	650	Total			

**Subcatchment C: Outside Landfill 3**

Hydrograph



**Phase 1 and Outside Landfill Depression Drains Type II 24-hr 25 YR 24 HR Rainfall=4.32"**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 5

**Summary for Subcatchment D: Phase 1 and Outside Landfill**

Runoff = 6.60 cfs @ 12.66 hrs, Volume= 1.551 af, Depth= 0.52"  
 Routed to Pond 6P : Depression

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

Area (ac)	CN	Description
* 5.619	69	
29.972	49	Desert shrub range, Good, HSG A
35.591	52	Weighted Average
35.591		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.6	100	0.0030	0.08		<b>Sheet Flow,</b> Range n= 0.130 P2= 2.40"
13.5	571	0.0050	0.71		<b>Shallow Concentrated Flow,</b> Nearly Bare & Untilled Kv= 10.0 fps
0.4	102	0.1840	4.29		<b>Shallow Concentrated Flow,</b> Nearly Bare & Untilled Kv= 10.0 fps
4.9	231	0.0128	0.79		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
9.8	292	0.0050	0.49		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
50.2	1,296	Total			

**Phase 1 and Outside Landfill Depression Drains Type II 24-hr 25 YR 24 HR Rainfall=4.32"**

Prepared by Allied Environmental

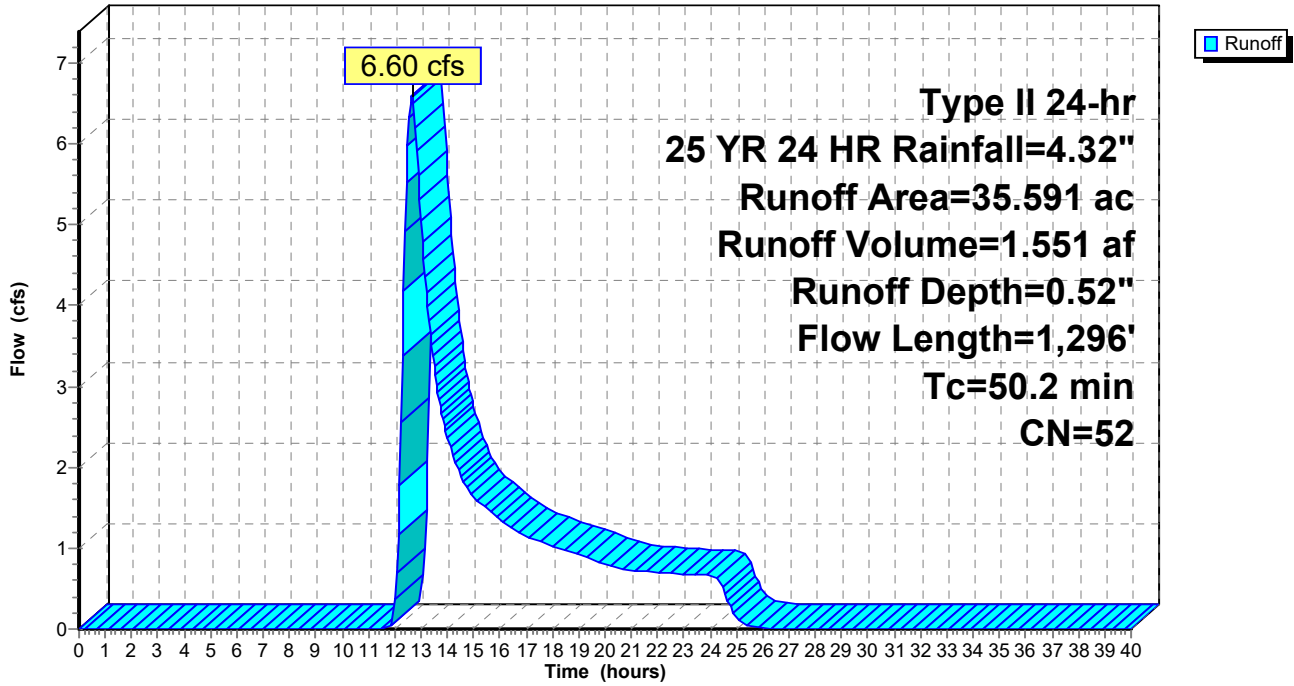
Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 6

**Subcatchment D: Phase 1 and Outside Landfill**

Hydrograph



**Phase 1 and Outside Landfill Depression Drains Type II 24-hr 25 YR 24 HR Rainfall=4.32"**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 7

**Summary for Subcatchment E: Outside Landfill 5**

Runoff = 1.26 cfs @ 12.63 hrs, Volume= 0.340 af, Depth= 0.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type II 24-hr 25 YR 24 HR Rainfall=4.32"

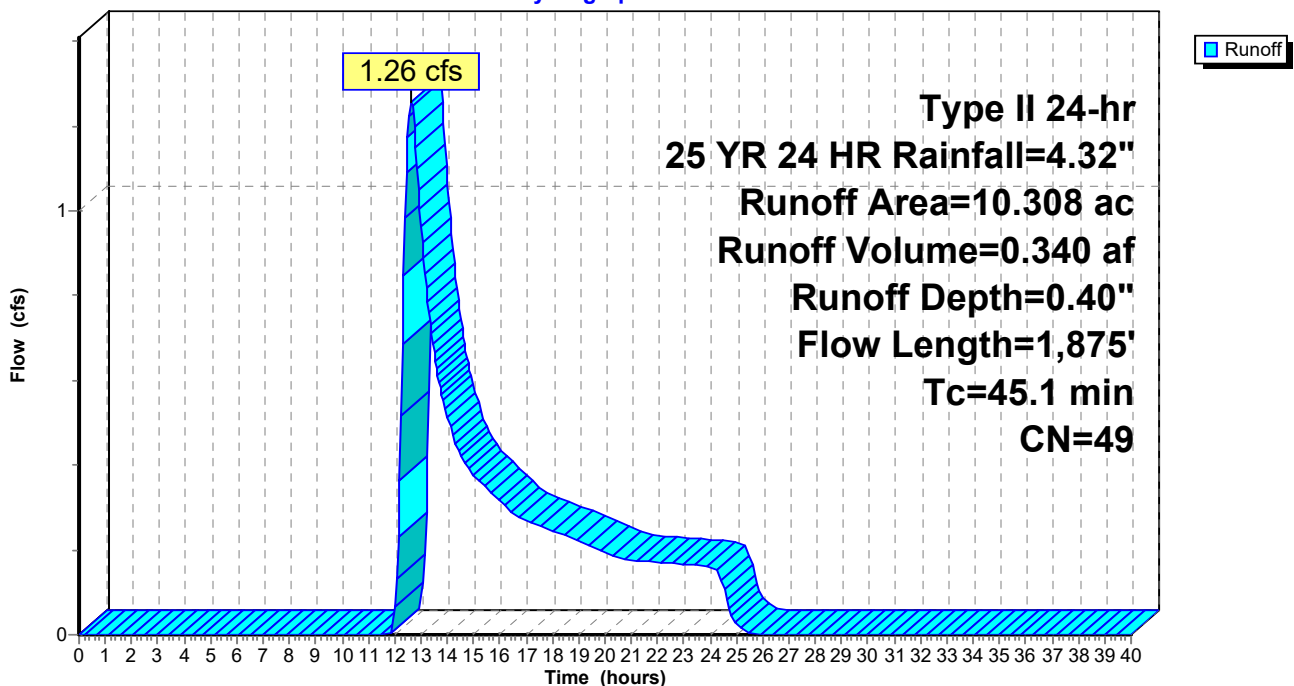
Area (ac)	CN	Description
10.308	49	Desert shrub range, Good, HSG A
10.308		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.0	100	0.0160	0.15		<b>Sheet Flow,</b> Range n= 0.130 P2= 2.40"
15.0	1,019	0.0260	1.13		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
7.7	419	0.0170	0.91		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
1.2	102	0.0420	1.43		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
10.2	235	0.0030	0.38		<b>Shallow Concentrated Flow,</b> Short Grass Pasture Kv= 7.0 fps
45.1	1,875	Total			

**Subcatchment E: Outside Landfill 5**

Hydrograph



**Phase 1 and Outside Landfill Depression Drains Type II 24-hr 25 YR 24 HR Rainfall=4.32"**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 8

**Summary for Pond 4P: Depression**

Inflow Area = 10.340 ac, 0.00% Impervious, Inflow Depth = 0.40" for 25 YR 24 HR event  
 Inflow = 2.71 cfs @ 12.11 hrs, Volume= 0.341 af  
 Outflow = 0.32 cfs @ 15.45 hrs, Volume= 0.341 af, Atten= 88%, Lag= 200.1 min  
 Discarded = 0.32 cfs @ 15.45 hrs, Volume= 0.341 af

Routing by Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Peak Elev= 2,910.19' @ 15.45 hrs Surf.Area= 0.225 ac Storage= 0.111 af

Plug-Flow detention time= 219.1 min calculated for 0.341 af (100% of inflow)  
 Center-of-Mass det. time= 219.4 min ( 1,170.2 - 950.8 )

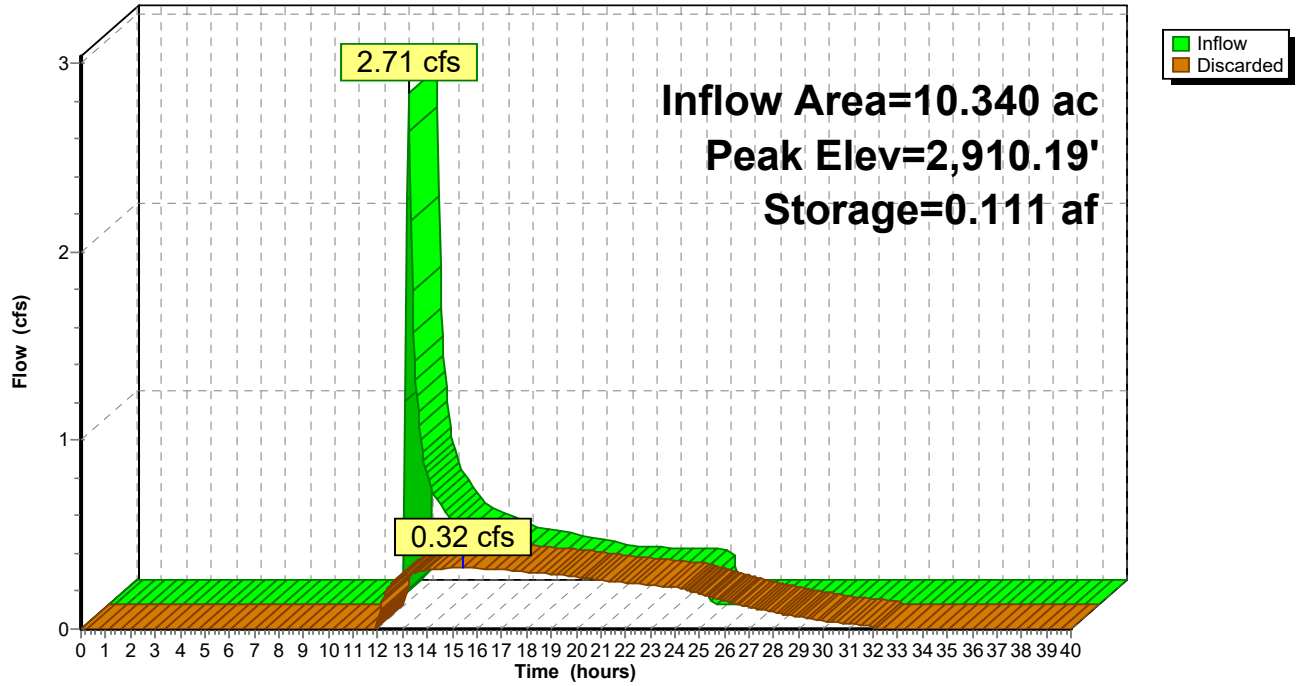
Volume	Invert	Avail.Storage	Storage Description		
#1	2,909.00'	0.415 af	<b>Custom Stage Data (Conic)</b> Listed below (Recalc)		
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)	
2,909.00	0.010	0.000	0.000	0.010	
2,910.00	0.171	0.074	0.074	0.171	
2,911.00	0.546	0.341	0.415	0.546	

Device	Routing	Invert	Outlet Devices
#1	Discarded	2,909.00'	<b>1.420 in/hr Exfiltration over Wetted area</b> Conductivity to Groundwater Elevation = 1.00'

**Discarded OutFlow** Max=0.32 cfs @ 15.45 hrs HW=2,910.19' (Free Discharge)  
 ↑1=Exfiltration ( Controls 0.32 cfs)

### Pond 4P: Depression

Hydrograph



**Phase 1 and Outside Landfill Depression Drains Type II 24-hr 25 YR 24 HR Rainfall=4.32"**

Prepared by Allied Environmental

Printed 12/14/2021

HydroCAD® 10.10-7a s/n 10443 © 2021 HydroCAD Software Solutions LLC

Page 10

**Summary for Pond 6P: Depression**

Inflow Area = 35.591 ac, 0.00% Impervious, Inflow Depth = 0.52" for 25 YR 24 HR event  
 Inflow = 6.60 cfs @ 12.66 hrs, Volume= 1.551 af  
 Outflow = 1.36 cfs @ 15.99 hrs, Volume= 1.551 af, Atten= 79%, Lag= 199.5 min  
 Discarded = 1.36 cfs @ 15.99 hrs, Volume= 1.551 af

Routing by Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Peak Elev= 2,909.86' @ 15.99 hrs Surf.Area= 0.950 ac Storage= 0.584 af

Plug-Flow detention time= 276.4 min calculated for 1.551 af (100% of inflow)  
 Center-of-Mass det. time= 276.3 min ( 1,240.4 - 964.1 )

Volume	Invert	Avail.Storage	Storage Description
#1	2,908.00'	13.597 af	<b>Custom Stage Data (Conic)</b> Listed below (Recalc)

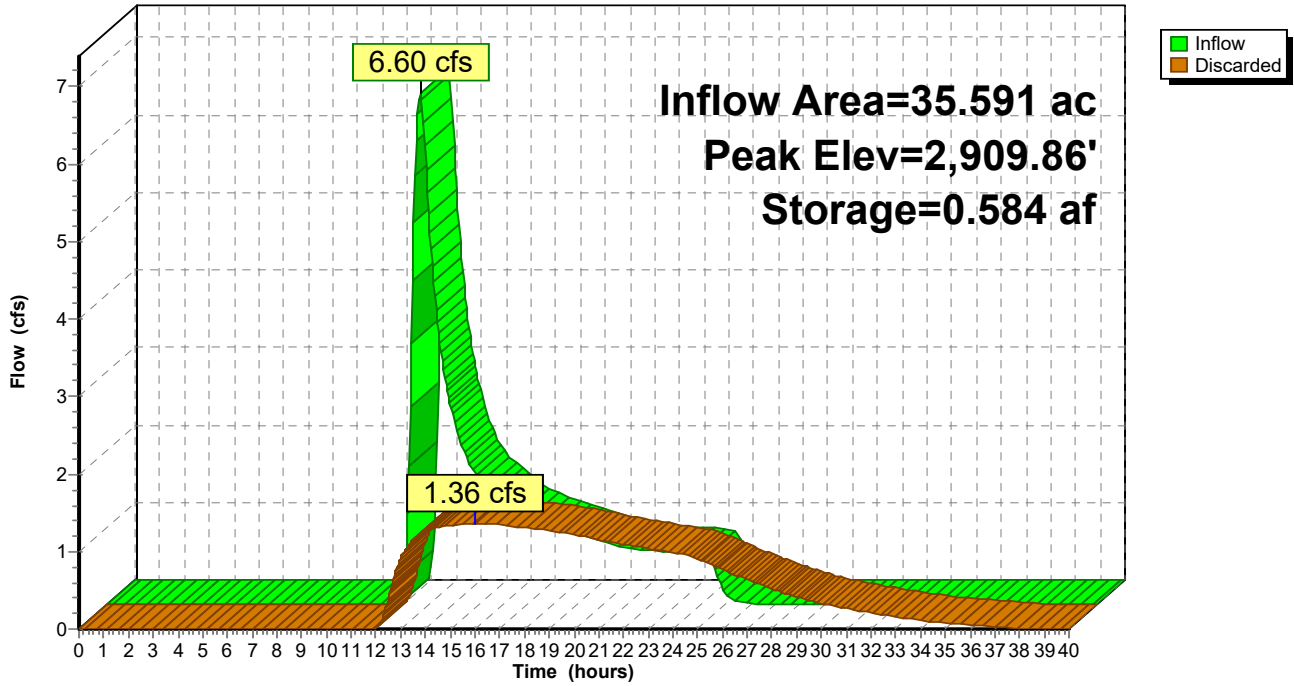
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)	Wet.Area (acres)
2,908.00	0.008	0.000	0.000	0.008
2,909.00	0.252	0.102	0.102	0.252
2,910.00	1.111	0.631	0.732	1.111
2,911.00	1.785	1.435	2.167	1.785
2,912.00	2.351	2.062	4.229	2.352
2,913.00	2.880	2.611	6.840	2.882
2,914.00	3.392	3.133	9.972	3.395
2,915.00	3.862	3.624	13.597	3.866

Device	Routing	Invert	Outlet Devices
#1	Discarded	2,908.00'	<b>1.420 in/hr Exfiltration over Wetted area</b> Conductivity to Groundwater Elevation = 1.00'

**Discarded OutFlow** Max=1.36 cfs @ 15.99 hrs HW=2,909.86' (Free Discharge)  
 ↑**1=Exfiltration** ( Controls 1.36 cfs)

### Pond 6P: Depression

Hydrograph





Project Name:	Sunflower Stormwater Control Plan
Project No.:	4908:21097
Date:	12/15/21
Estimate by:	Ted Francis

**Drainage Calculations**

AREAS AND CURVE NUMBERS	Drainage Area	Acres	CN	S	Ia
1	Drainage Area				
2	Areas F1 Through F4	73.822	71	4.08	0.82
3	Evaporation Basin	4.35			
4					

CLIMATE DATA	1	25 YR 24 HR RAIN DEPTH	4.32	Inches; Source: KDOT Rainfall Intensity Tables			
	2						
	3		Avg. Total Monthly Precipitation (Inches)		Avg. Daily Maximum Precipitation by Month (Inches)		
	4	January	0.40	January	0.40	January	0.30
	5	February	0.54	February	0.50	February	0.60
	6	March	1.22	March	0.80	March	0.60
	7	April	1.55	April	1.00	April	8.40
	8	May	3.02	May	1.60	May	10.30
	9	June	3.17	June	1.60	June	12.40
	10	July	2.75	July	1.50	July	13.40
	11	August	2.57	August	1.50	August	11.30
	12	September	1.47	September	1.10	September	8.90
	13	October	1.18	October	0.90	October	6.60
	14	November	0.62	November	0.50	November	0.10
	15	December	0.49	December	0.40	December	1.30
	16	Data From NOAA Garden City Experimental Station Dates 8/1/1948 through 5/20/2016					
	17						

EVAPORATION BASIN SIMULATION		Precipitation (in)	Runoff (in)	Runoff (AC-FT)	Evap (AC-FT)	dStorage (AC: FT)	Basin Volume (AC-FT)	Basin Depth (FT)
	1							
2	Start 25 Yr 24 Hr Storm	4.32	1.62	9.95	0.00	9.95	9.95	2.29
3	May	3.02	0.77	4.75	3.73	1.02	10.96	2.52
4	June	3.17	0.86	5.29	4.50	0.80	11.76	2.70
5	July	2.75	0.62	3.82	4.86	-1.04	10.72	2.47
6	August	2.57	0.53	3.24	4.10	-0.86	9.87	2.27
7	September	1.47	0.09	0.55	3.23	-2.67	7.19	1.65
8	October	1.18	0.03	0.18	2.39	-2.21	4.98	1.15
9	November	0.62	0.00	0.00	0.04	-0.04	4.95	1.14
10	December	0.49	0.00	0.00	0.47	-0.47	4.48	1.03
11	January	0.40	0.00	0.00	0.11	-0.11	4.37	1.00
12	February	0.54	0.00	0.00	0.22	-0.22	4.15	0.95
13	March	1.22	0.04	0.22	0.22	0.01	4.16	0.96
14	April	1.55	0.11	0.69	3.05	-2.36	1.80	0.41
15	Runoff Calculated Using SCS Curve Number Method							
16								
17								
18		$Q = \frac{(P - I_a)^2}{[(P - I_a) + S]}$						
19								
20	where:							
21	Q	=	cumulative direct runoff (in)					
22	P	=	cumulative rainfall (in)					
23	I <sub>a</sub>	=	initial abstraction including surface storage, interception, evaporation, and infiltration prior to any runoff occurring (in)					
24	S	=	(1000/CN) - 10 where CN = NRCS Curve Number					

$I_a = 0.2S$  (Note that for  $P \leq I_a$ ,  $Q = 0$ )

## **ATTACHMENT 2**

# **STORMWATER CALCULATION DISCUSSION**

## STORMWATER CALCULATION DISCUSSION

### General

The stormwater control system consists of berms, roads, ditches, and a non-discharging basin (evaporation basin) to limit stormwater run-on into the active landfill area and control run-off of stormwater that has come in contact with Coal Combustion Residuals (CCR), hereafter referred to as “contact water.”

Hydrologic and hydraulic calculations were performed to verify the sizing of the existing evaporation basin and the various site ditches using a 25-year 24-hour storm event referred to as the “design storm.” The calculations indicate that the existing evaporation basin is more than adequately sized to retain run-off from its entire drainage area with a 25-year 24-hour storm occurring during an average rainfall year. Off-site run-on will remain outside active portions of the landfill and will infiltrate quickly into depressions in the sand dune topography.

The Landfill and its immediate vicinity include six (6) separate drainage areas (A through F) based on the point of discharge. Drainage area F was further divided into four (4) additional areas (F1 through F4) to determine adequate ditch sizing. The drainage areas are shown on Figure 1 in Attachment 1.

Drainage areas A through D all drain into depressions in the topography, which is dominated by sand dunes. These depression areas were evaluated as infiltration basins, utilizing hydraulic conductivity values collected from soil borings in the area. The average hydraulic conductivity used in the simulation was  $1 \times 10^{-3}$  cm/sec or 1.42 inches/hour. Areas A through C are wholly located outside of the landfill while drainage area D consists of a portion of the covered and closed Phase 1 disposal cell. Drainage area E drains past the evaporation basin and off site to the east. Drainage areas F1 through F4 all drain into the evaporation basin. Perimeter access roads restrict drainage from entering active landfill areas. Landfill toe ditches direct contact water and stormwater into the evaporation basin restricting flow from leaving the site.

The Soil Conservation Service (SCS) Peak Run-off and volume estimation via HydroCAD (version 10.10-7a) hydrologic modeling software was utilized for ditch sizing and depression area infiltration capacity. The inputs and outputs from the model are shown in Attachment 1.

### Areas and Curve Numbers

The Areas and Curve Numbers provides the areas with different characteristics for run-off modeling purposes and the total weighted average for the entire drainage area. The areas were determined using the existing topography of the site and are shown on the HydroCAD reports (Attachment 1). The Soil Conservation Service TR-55, along with observation of the site was used to determine appropriate curve numbers for the various areas.

Until final closure, Phase 3A will receive deposits of hydrated/partially hydrated fly ash. AEC designated this unit with a curve number of 86 and is considered substantially similar to the Bare Soil with a hydrologic soil group of B (See TR-55 Table 2-2b). The compacted nature of the material limits the applicability of Type A soils; however, the partially hydrated nature of the fly ash and ability to retain water limits the applicability of Type C or D soils. The closed portion of the landfill (Phases 1, 2A, and 2B) were designated with a curve number of 69 in that they compare favorably to rangeland with a fair hydrologic condition and Type B soils (See TR-55 Table 2-2c). Outside the active landfill areas, AEC designated a curve number of 49 as the area compares favorably with rangeland in fair hydrologic condition (i.e., 50% to 75% ground cover) and Type A soils (Valent fine sand, 5 to 20 percent slopes – USDA Web Soil Survey). Finally, the lined evaporation basin was designated a curve number of 100, as applicable to water bodies. This data was utilized in the evaporation basin simulation and the HydroCAD model for determining peak run-off and total storm flow volumes.

### **Time of Concentration**

The "Time of Concentration", also known as the maximum travel time for the drainage areas is used in determining how quickly the hydrograph peaks for a drainage area. The Time of Concentration is shown on the HydroCAD reports (Attachment 1). AEC relied on the TR-55 and HEC 22 calculation methods and the associated variables (Manning's n) for the selected area types. A Manning's n of 0.05 (Fallow-no residue) was selected for Phase 3A sheet flow to estimate the projected top of the filled Phase 3A (prior to closure). A Manning's n of 0.13 (Range-natural) was selected for Outside the Landfill sheet flow. AEC selected 16.3 for the K value to represent the shallow concentrated flow velocity coefficient for Phase 3A as defined in TR-55 as unpaved. AEC selected 7 for K to represent the shallow concentrated flow velocity coefficient for Outside the Landfill corresponding to grass pasture. For all the non-rip-rapped ditches AEC selected a Manning's n of 0.022 corresponding to unlined-bare soil to represent the worst-case, un-vegetated ditch. For rip-rapped sections of the ditch a Manning's n of 0.035 was utilized. Slopes and lengths were determined using the design ditch, as-built topography data, and LiDAR topography data.

### **Climate Data**

Climate data was collected and analyzed from NOAA for the Garden City Experimental Station, the climate data were from 8/1/1948 through 5/20/2016; almost 68 years of data. Among other parameters, the data included daily precipitation and daily pan evaporation. The daily data was averaged and cumulated to form the average monthly data. For comparative purposes, the average daily maximum precipitation was calculated. AEC obtained the 25-year 24-hour storm event data from the KDOT Rainfall Intensity Tables for Finney County (Road Memorandum No. 16-03. September 2016).

### **Evaporation Basin Simulation**

For the Evaporation Basin Simulation, run-off amounts were calculated using the SCS Curve Number Method from monthly precipitation values and the Areas and Curve Numbers discussed above. The Simulation begins with a 25-year 24-hour storm event occurring prior to the start of the rainy season. As a conservative estimate, the total average monthly precipitation was assumed to occur during one storm to maximize run-off. Months where precipitation did not exceed the initial abstraction ( $I_a$ ), run-off was zero. As shown in the simulation, the evaporation basin only fills a maximum of about 2.4 feet deep. The basin is actually 12 feet deep allowing for extreme excess rainfall. This agrees with statements from facility personnel, in which, they indicate that the basin rarely contains significant fluid beyond localized puddles of water. The evaporation basin simulation is shown in Attachment 1.

### **Ditch Sizing**

AEC evaluated the site ditches utilizing the worst-case scenario of the shallowest slope of the ditch. The site ditches are all triangular with a minimum side slope of 3:1. The Time of Concentration Summary in the HydroCAD report for F1 through F3 show that all ditches have adequate capacity for the 25-year 24-hour storm.

\*\_\*\_\*\_\*\_\*

**APPENDIX A**

**CURVE NUMBER TABLES**

**Table 2-2a** Runoff curve numbers for urban areas <sup>1/</sup>

Cover description	Average percent impervious area <sup>2/</sup>	Curve numbers for hydrologic soil group			
		A	B	C	D
<i>Fully developed urban areas (vegetation established)</i>					
Open space (lawns, parks, golf courses, cemeteries, etc.) <sup>3/</sup> :					
Poor condition (grass cover < 50%) .....		68	79	86	89
Fair condition (grass cover 50% to 75%) .....		49	69	79	84
Good condition (grass cover > 75%) .....		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way) .....		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way) .....		98	98	98	98
Paved; open ditches (including right-of-way) .....		83	89	92	93
Gravel (including right-of-way) .....		76	85	89	91
Dirt (including right-of-way) .....		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) <sup>4/</sup> .....		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders) .....		96	96	96	96
Urban districts:					
Commercial and business .....	85	89	92	94	95
Industrial .....	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses) .....	65	77	85	90	92
1/4 acre .....	38	61	75	83	87
1/3 acre .....	30	57	72	81	86
1/2 acre .....	25	54	70	80	85
1 acre .....	20	51	68	79	84
2 acres .....	12	46	65	77	82
<i>Developing urban areas</i>					
Newly graded areas					
(pervious areas only, no vegetation) <sup>5/</sup> .....		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

<sup>1</sup> Average runoff condition, and  $I_a = 0.2S$ .<sup>2</sup> The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.<sup>3</sup> CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.<sup>4</sup> Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.<sup>5</sup> Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

**Table 2-2b** Runoff curve numbers for cultivated agricultural lands <sup>1/</sup>

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment <sup>2/</sup>	Hydrologic condition <sup>3/</sup>	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
C&T+ CR	Poor	65	73	79	81	
	Good	61	70	77	80	
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
C&T+ CR	Poor	60	71	78	81	
	Good	58	69	77	80	
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

<sup>1</sup> Average runoff condition, and  $I_a=0.2S$

<sup>2</sup> Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.

<sup>3</sup> Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good  $\geq 20\%$ ), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

**Table 2-2c** Runoff curve numbers for other agricultural lands <sup>1/</sup>

Cover description	Hydrologic condition	Curve numbers for hydrologic soil group			
		A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. <sup>2/</sup>	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. <sup>3/</sup>	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 <sup>4/</sup>	48	65	73
Woods—grass combination (orchard or tree farm). <sup>5/</sup>	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. <sup>6/</sup>	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 <sup>4/</sup>	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

<sup>1</sup> Average runoff condition, and  $I_a = 0.2S$ .

<sup>2</sup> *Poor*: <50% ground cover or heavily grazed with no mulch.

*Fair*: 50 to 75% ground cover and not heavily grazed.

*Good*: > 75% ground cover and lightly or only occasionally grazed.

<sup>3</sup> *Poor*: <50% ground cover.

*Fair*: 50 to 75% ground cover.

*Good*: >75% ground cover.

<sup>4</sup> Actual curve number is less than 30; use CN = 30 for runoff computations.

<sup>5</sup> CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

<sup>6</sup> *Poor*: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.

*Fair*: Woods are grazed but not burned, and some forest litter covers the soil.

*Good*: Woods are protected from grazing, and litter and brush adequately cover the soil.

**Table 2-2d** Runoff curve numbers for arid and semiarid rangelands <sup>1/</sup>

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition <sup>2/</sup>	A <sup>3/</sup>	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

<sup>1</sup> Average runoff condition, and  $I_a$ , = 0.2S. For range in humid regions, use table 2-2c.

<sup>2</sup> Poor: <30% ground cover (litter, grass, and brush overstory).

Fair: 30 to 70% ground cover.

Good: > 70% ground cover.

<sup>3</sup> Curve numbers for group A have been developed only for desert shrub.

**APPENDIX B**  
**MANNING'S  $n$  TABLES**

Sheet Flow Manning's n Table

Surface Description <sup>1</sup>	Manning's n
Smooth surfaces (concrete, asphalt, gravel or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover < 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses <sup>A</sup>	0.24
Bermuda grass	0.41
Range (natural)	0.13
Woods <sup>B</sup>	
Light underbrush	0.40
Dense underbrush	0.80

<sup>1</sup> Source: SCS, TR-55, Second Edition, June 1986.  
<sup>A</sup> Includes species such as bluestem grass, buffalo grass, grama grass, and native grass mixtures.  
<sup>B</sup> When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

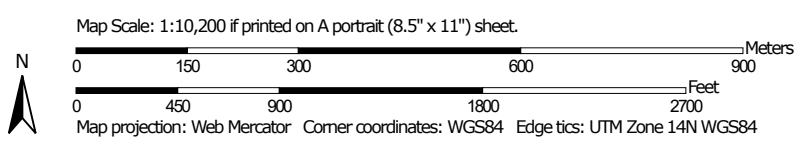
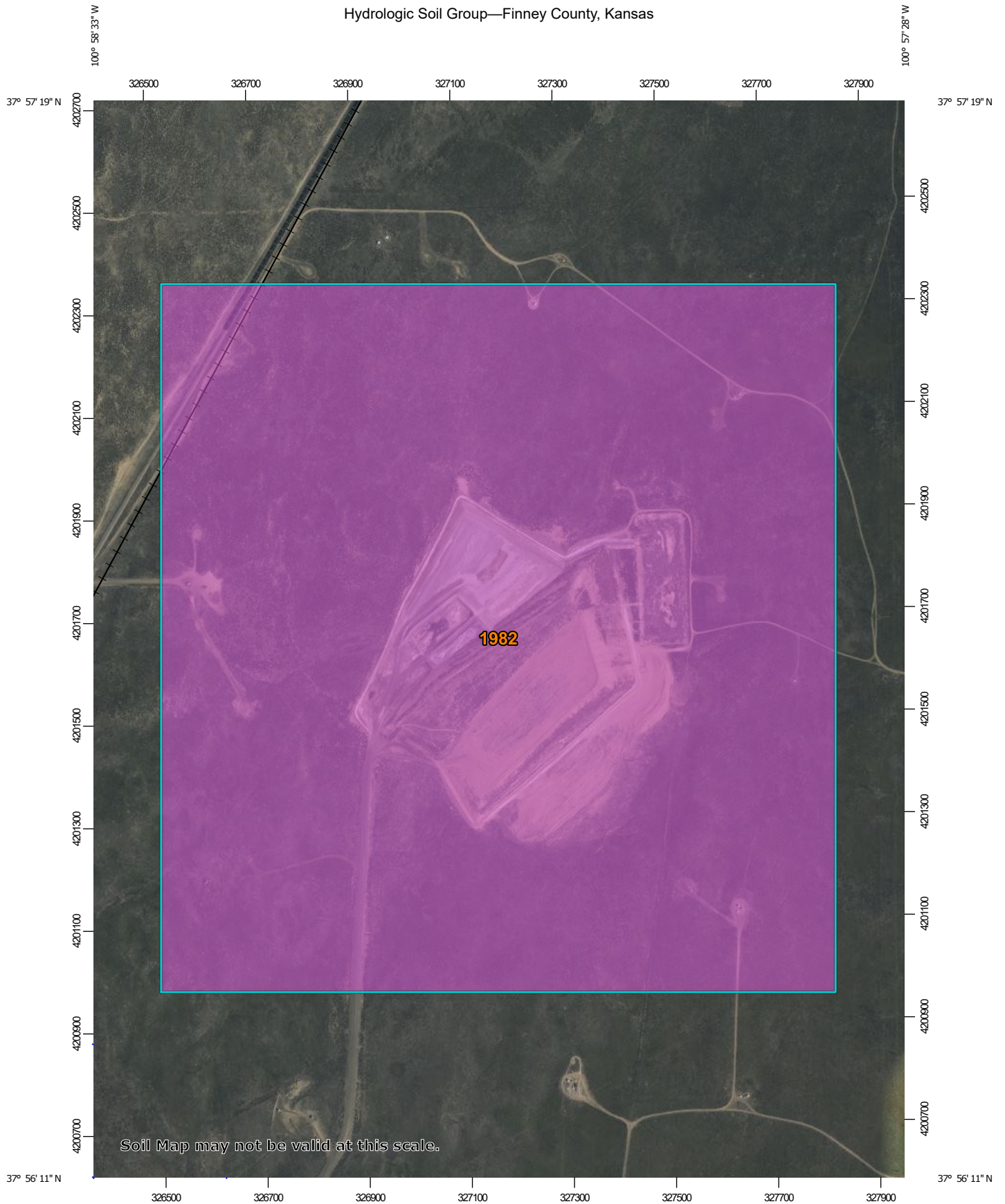
Ditch Lining Manning's n Table

Artificial Channels <sup>4</sup>		Depth Ranges		
Category	Lining Type	0-0.5 ft	0.5-2.0 ft	>2.0 ft
Grassed	Grass	0.050	0.040	0.035
Rigid	Concrete	0.016	0.013	0.013
	Grouted Riprap	0.040	0.030	0.028
	Gabions	0.030	0.030	0.030
	Stone Masonry	0.042	0.032	0.030
	Soil Cement	0.025	0.022	0.020
	Asphalt	0.018	0.016	0.016
Unlined	Bare Soil	0.023	0.020	0.020
	Rock Cut	0.045	0.035	0.025
Temporary*	Woven Paper Net	0.016	0.015	0.015
	Jute Net	0.028	0.022	0.019
	Fiberglass Roving	0.028	0.022	0.019
	Straw with Net	0.065	0.033	0.025
	Curled Wood Mat	0.066	0.035	0.028
	Synthetic Mat	0.036	0.025	0.021
Gravel Riprap	1-inch D <sub>50</sub>	0.044	0.033	0.030
	2-inch D <sub>50</sub>	0.066	0.041	0.034
Rock Riprap	6-inch D <sub>50</sub>	0.104	0.069	0.035
	12-inch D <sub>50</sub>	—	0.078	0.040

**APPENDIX C**


**NRCS WEB SOIL SURVEY**

Hydrologic Soil Group—Finney County, Kansas




## MAP LEGEND

### Area of Interest (AOI)









 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons





 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Lines


 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Points






 A  
 A/D  
 B  
 B/D

 C  
 C/D  
 D  
 Not rated or not available

### Water Features

 Streams and Canals

### Transportation

 Rails  
 Interstate Highways  
 US Routes  
 Major Roads  
 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

**Warning:** Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service  
 Web Soil Survey URL:  
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Finney County, Kansas  
 Survey Area Data: Version 19, Sep 13, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 6, 2020—Apr 3, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

## Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
1982	Valent fine sand, 5 to 20 percent slopes	A	452.3	100.0%
<b>Totals for Area of Interest</b>			<b>452.3</b>	<b>100.0%</b>

### Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

### Rating Options

*Aggregation Method: Dominant Condition*

*Component Percent Cutoff: None Specified*

*Tie-break Rule:* Higher

**APPENDIX D**  
**PLAN REVISIONS**

