Final Erosion Control Plan
Campus Drive Relocation Project

by

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Presented to:
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Construction Site Erosion Control

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1.0 Introduction

1.1 Summary

This document describes the erosion control plan for the Campus Drive Relocation Project which is planed at the University of Alabama Campus.

1.2 Objectives

The objective of this document is as follows.

1. Describe the site information including location, topography, soils, ground cover, adjacent properties, and receiving waters.
2. Describe the work phases.
3. Describe the hazardous potential at the site considering slopes.
4. Determine the hydrologic characteristics.
5. Calculate the soil loss by using RUSLE equation.
6. Determine the appropriate temporal and permanent plan.
7. Design channels and slope protection.
8. Design a temporary detention pond for sediment control.

2.0 Construction Site Description

2.1 Campus Drive Relocation Project General Information

Campus Derive Relocation Project is planned for the University of Alabama Campus on Campus Drive between Hackberry and Jefferson Avenue. The development and expansion of the northern portion of campus has created a need to improve the current roadway system. The construction is planned to relocate Hackberry Lane between Margaret and Riverside as well as the creation of new loop around Shelby Hall and service road to access facilities. The nearby receiving water, Black Warrior River is located north of the construction site. Figure 1 and Figure 2 describes the aerial image and the location of the project.

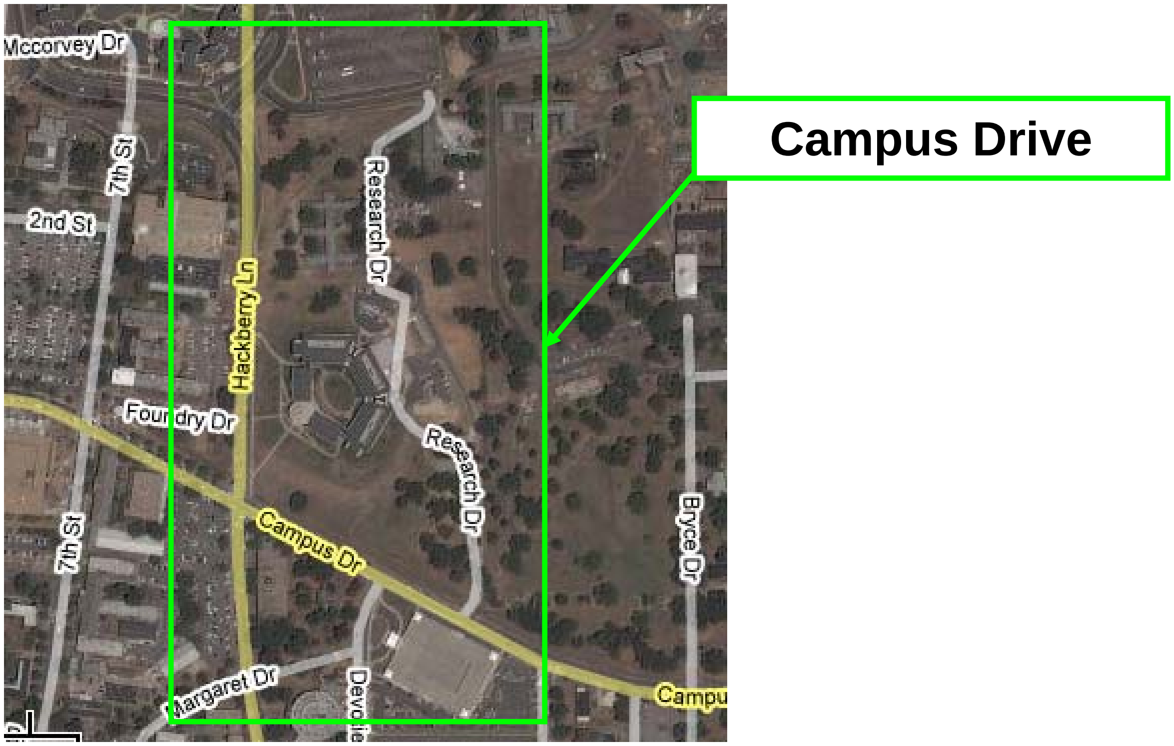

Figure 1: Campus Drive Relocation Project Aerial Image

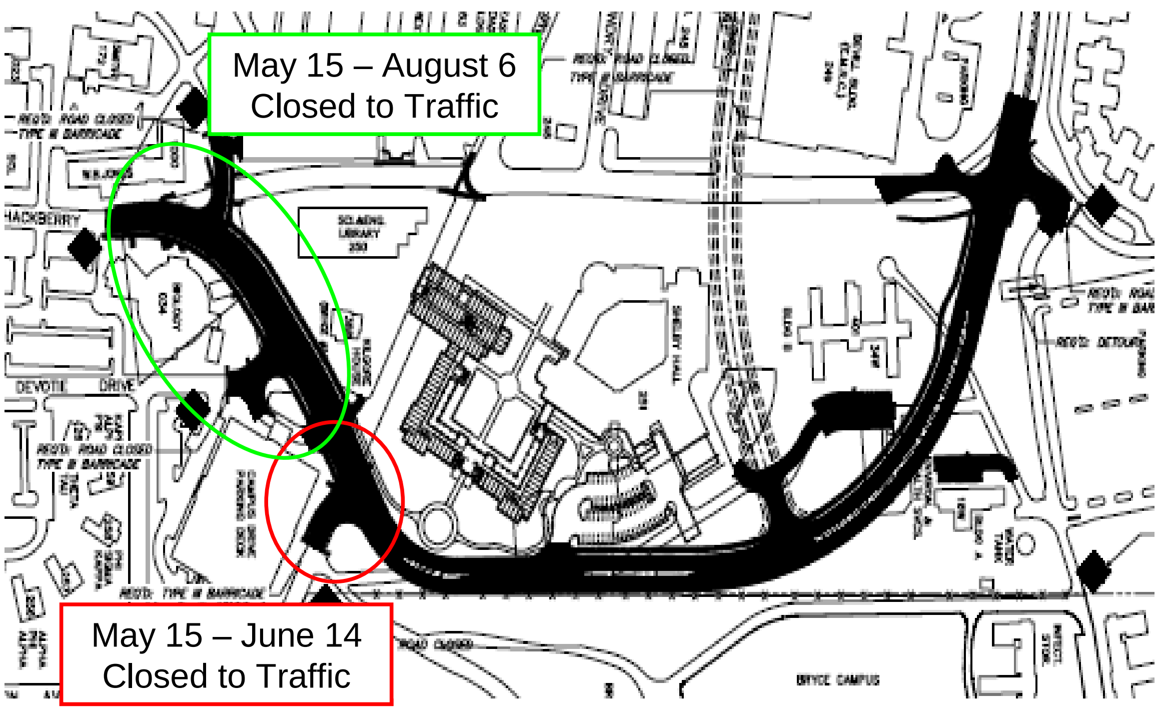

Figure 2: Campus Drive Relocation Project Location Map

2.2 Topography

The site has approximately 65 acres. New campus drive will relocate Hackberry Lane between Margaret and Riverside and it will provide the loop around Shelby Hall and service road to access facilities. The site will be levelled to approximately elevation of 220 ft. North area of the construction site is located at the relatively high slope land compared with south area. Thus, north area will require well maintained erosion control plan. East and west side do not have steep slope, but there are many existing inlets which have to be protected. Total construction period is approximately 9 months.

2.3 Drainage Patterns

The drainage basin for the site is approximately 65 acres. The construction site is located at the centre of the drainage area. The large amount of the flow is caught by the existing gutters and inlets and transported to the Black Warrior River, located approximately 1500 ft north of the construction site.

2.4 Soils

United States Department of Agriculture describes that the 97% of soil in this area is Bama-Urban land complex which is made from loamy marine deposits derived from sedimentary rock. These soils belong to the hydrologic group of B. Other 3% of soils consist of Shatta-Urban land complex which belong to the hydrologic group of C. Lest of 2% soils are hydrologic group B of Smithdale fine sandy loam. Figure 3 describes the soil type of the construction area. Also, Table 1 describes the detail information for the soil which is required for RUSLE calculation.

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
7	Bama-Urban land complex, 0 to 2 percent slopes	0.3	0.4%
8	Bama-Urban land complex, 2 to 6 percent slopes	59.1	96.6%
31	Shatta-Urban land complex, 0 to 2 percent slopes	0.5	0.8%
33	Smithdale fine sandy loam, 6 to 15 percent slopes	1.3	2.1%
Totals for Area of Interest (AOI)		**61.1**	**100.0%**

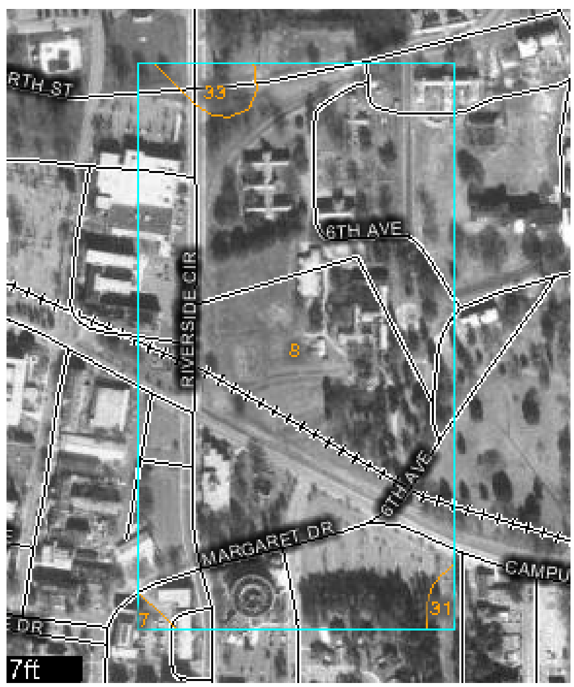

Figure 3: Soil Type of the Construction Site

Table 1: Soil Survey

Soil Number	Depth (in)	Hydrologic Soil Group	Permiability (in/hr)	Erodibility Factor K	Tolerable Soil Loss T (tons/ac/yr)
7,8 (Bama Urban land)	0-5	B	0.6-6.0	0.24	5
	5-54		0.6-2.0	0.32	
	54-72		0.6-2.0	0.32	
31 (Shatta Urban land)	0-7	C	0.6-2.0	0.37	3
	7-28		0.2-0.6	0.37	
	28-60		0.06-0.2	0.37	
38 (Smithdale)	0-5	B	2.0-6.0	0.28	5
	5-42		0.6-2.0	0.24	
	42-72		2.0-6.0	0.28	

2.5 Ground Cover

The ground cover over the site ranges from bare soils to matured trees. North side of the construction site is mostly covered by the glasses and small trees as well as the small areas of bare soils. East side is well vegetated and it is covered with relatively large trees and glasses. Shelby Hall is located on west side which has undisturbed ground covered with small trees and glasses. Major roads and buildings are located at south side which crates a large impervious area.

2.6 Adjacent Property

North side is newly developed residential buildings with a large parking lot. East side is covered with matured trees and glasses, so there will be less impact by the construction erosion. Western side is the campus building with a yard covered with small trees and glasses. South side is consisting of campus facilities and roads.

2.7 Receiving Waters

Black Warrior River is located approximately 1500 ft north of the construction site. Storm Water will be collected by the existing gutters and inlets and carried to the river by the pipes.

3.0 Construction Work Phases

3.1 Phase 1 Improvement

The first phase improvement starts from the north of the Hackberry Lane to the intersection of the new campus drive and the existing campus drive. The construction starts from clearing and grubbing, installation of the temporary access and parking to the site, and the demolition of the existing facilities. Erosion control and traffic control are done before the earthwork for the site and the sanitary sewer, storm sewer, water main, electrical line are installed. After that the curb, gutter, and sidewalks are constructed. Then the road is installed starting from the landscaping, base settlement, and paving. Finally striping and road signs are installed. After the completion of the road, parking lots for the Mcmillan and Environmental Health and Safety are constructed. After the tie-in of North Hackberry intersection, the road is opened for the traffic.

3.2 Existing Campus Drive and Hackberry Lane intersection

This phase is planned to start at the same time with the phase 2 improvement. Intersection of the existing Campus Drive and Hackberry lane are constructed. The work consists of the demolition of the existing facilities and the earth work. Then curb, gutter and sidewalks are installed. The intersection is completed by the paving, striping, and signage.

3.3 Phase 2 Improvement

The second phase improvement starts from the existing campus drive and the new campus drive constructed in the phase 1 improvement. The construction starts from clearing and grubbing, and the demolition of the existing facilities. Erosion control and traffic control are prepared before the earthwork for the site and the storm sewer, water main, and electrical line are installed. After that the curb, gutter, and sidewalks are constructed. Then the road construction is started from the landscaping, base and paving. Then, striping is done and road signs are installed. After the completion of the road, East Engineering Parking Lot is constructed. The road is opened for the traffic and the project is closed with the clean up for the site. Construction schedule for the site work is attached in Appendix 1.

4.0 Hazard Map (Appendix 2)

Hazardous maps are attached in Appendix 2 for the initial topography (left column) and the final topography (right column). Left column and right column figures are the same locations of the construction sites. Pink colour describes the low hazardous area (slope <2.0%), blue colour describes the moderate hazardous area (slope 2-5%), yellow colour describes high hazardous area (slope 5-10%), and orange colour describes high hazardous area (slope >10%). After the completion of the road, high hazardous areas are reduced, but it still requires other erosion control practice for the remaining high slope area.

5.0 Watershed analysis

5.1 Watershed delineation

Figure 4 shows sub-drainages for the upslope, down-slope, and on-site areas for the construction site. Red line indicates the watershed area for the site and the pink line subdivides them into upstream (U1-U4), onsite (O1-O5), and downstream (D1) areas. Blue line shows the flow pass for the area and the proposed location of the pond is marked in the figure with a blue circle. The watershed area has approximately 63 acres.

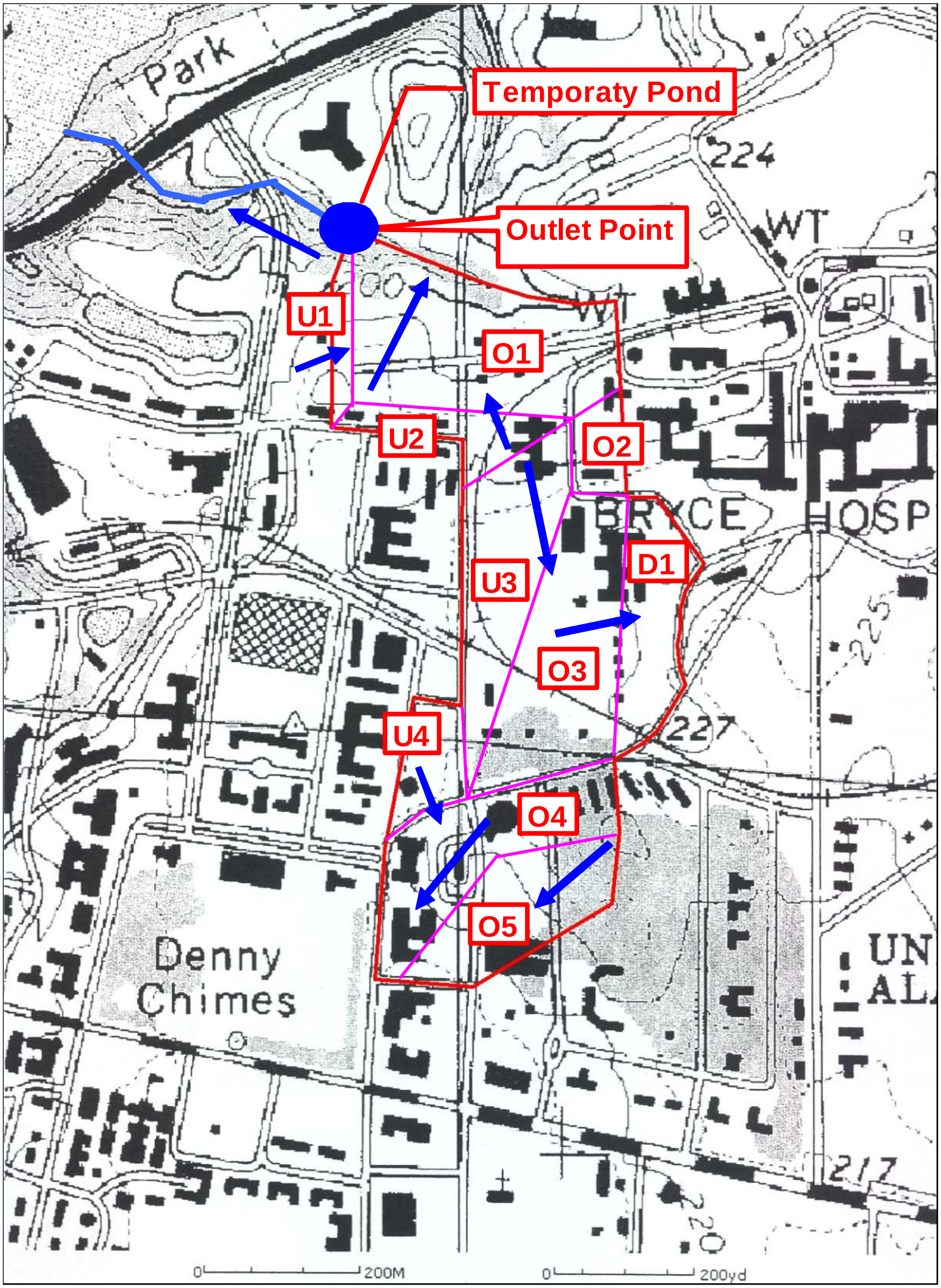

Figure 4: Watershed for the site (source: TerraServer)

5.2 Peak runoff rate for the 25 year storm (Appendix 3)

All calculations are done by Win TR55 for the peak runoff calculation. Soil type is determined by United States Department of Agriculture Web Soil Survey, described in Table 1 and Figure 3. The peak runoff is determined to 241.47 cubic feet per second at 12.20 hrs later for the 25 year storm. Detail information including the plot is attached in Appendix 3.

5.3 Erosion and Sediment Control for the site

Silt fences have been used at all side slopes and down slope edges of the construction site and existing inlets have been protected by silt fences and wattles. The intersection of the existing road and the new road is closed and protected by two lines of wattles in order to prevent a sediment runoff from the disturbed area. The construction site is located lower area compared with surroundings, so it has less erosion problem. Final plans for the site cover consist of asphalt road, parking lots, landscaping and sod at the entrance of parking lots as well as the area along with the newly constructed road.

6.0 RUSLE Calculation (Appendix 4)

6.1 Phase 1 Improvement

The first phase improvement has been started from December 15th 2006 to May 3rd 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site for Phase 2 improvement. The total soil loss on the site for this period was estimated in 3313 tons. The annual rainfall energy R was estimated as 375 and the erosion index of 29% is estimated to affect the erosion considering the location and the period of phase 1 improvement. The credibility factor K is determined from the information of Table 1 considering that at least 5 inch of the top soil will be removed before the construction. The cover factor C has estimated as 0.001 for undisturbed and well protected areas as well as 1.0 for active construction areas. Detail calculation is attached in Appendix 4.

6.2 Phase 2 Improvement and Campus and Hackberry X-section

Site is currently the second phase improvement and it has been started from May 14th 2007 to July 27th 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site completed during the phase 1 improvement. The total soil loss on the site for this period was estimated in 1701 tons. The annual rainfall energy R was estimated as 375 and the erosion index of 26% is estimated to affect the erosion. The credibility factor K is determined from the information of Table 1 considering that at least 5 inch of the top soil will be removed before the construction. The cover factor C has estimated as 0.001 for undisturbed and well protected areas as well as 1.0 for active construction areas. Detail calculation is attached in Appendix 4.

6.3 After Active Construction and All Land Covered

The soil runoff calculation is for the construction of July 30th 2007 to August 6th 2007. The entire site is covered after the completion of the construction. The total soil loss on the site for this period was estimated in 1.12 tons. The annual rainfall energy R was estimated as 375 and the erosion index of 7% is estimated to affect the erosion. The cover factor C has estimated as 0.001 for undisturbed and well protected areas. Detail calculation is attached in Appendix 4.

7.0 Temporary and Permanent Erosion Control Plan

7.1 Temporary Erosion Control Plan

The temporary erosion control plans for the site are stabilized construction entrances, silt fences, and sediment traps. Type "A" silt filter fences are used at all side slopes and down slope edges of the construction site. A stone stabilized pad will be installed at entrance and exit for vehicles at the construction site in order to reduce the transport of mud from the construction area onto public roads by motor vehicles and runoff. This pad should consist of an eight inch layer of Alabama Highway Department No. 1 coarse aggregate. It should be 50 feet long and 20 feet in width for the largest construction vehicle at the site. Sediment filters should be installed at the drop inlets and curb inlets in order to prevent sediment from entering the storm drainage systems during construction and prior to permanent stabilization of the disturbed area. Also, Millet and Rye are suggested by Alabama Soil and Water Conservation Committee as a temporary cover for Central Alabama. Millet can be installed from April 1st to August 15th and Rye will be installed from September 1st to October 15th.

7.2 Permanent Erosion Control Plan

Permanent erosion control plan will be sod. The area for sod should be relatively flat with a slope of 3%. All the area along with the newly constructed road would be suitable for sobbing. Site will be ready for sobbing in August, Bermudagrass or Fescue will be appropriate. The road is located on campus, for landscaping, trees, shrubs and flowers are planted.

8.0 Channel design calculation (Appendix 5)

The site consists of one main channel that diverts water from the upper portion of the watershed. The channel is located at the north side of the watershed area of the construction site. All the required geometry calculations were performed by using excel spread sheet. Detail calculation is attached in Appendix 5.

9.0 Slope protection (Appendix 5)

The site is divided into upstream, onsite, and downstream areas. The slope of the site is categorized into four types including: slope <2.0%, slope 2-5%, slope 5-10%, and slope >10%. The peak flow rates for individual watershed areas were calculated using the WinTR-55. Manning's n is 0.02 for the sandy loam as described above. The site has mainly two work phases and it will require the slope protection for the active construction sites during the construction and between these work phases.

The SC150 mat has a C of 0.11 (intermediate in the above range) and an n of 0.055 for this slope and condition therefore this mat is selected for the slope protection. All detail calculation is attached in Appendix 5.

10.0 Pond design calculation (Appendix 6)

The pond is designed to remove approximately 90% of suspended solids. The pond needs to safely pass the flows from the 25 yr storm. The soil type is described previously. The following are the areas associated with each land use in the drainage area.

- Paved area: 16.66 acres
- Undeveloped area: 17.32 acres
- Construction area: 29.24 acres
- Total site area: 63.22 acres

10.1 Pond profile

Table 2 describes the pond profile and Figure 5 shows the corresponding drawing. Detail calculation is attached in Appendix 6.

Table 2: Pond final profile

Zone	Depth (ft)	Pond Depth from the Bottom (ft)	Surface Area at Depth (acres)	Pond Storage Below Elevation (acre-ft)	Pond Slope Between Elevations (%)
Bottom	0	0	0.71	0	-
Sediment Storage	4	4	0.88	3.18	36
Scour Protection	3	7	1.04	2.88	30
Water Quality Live Storage	2	9	1.85	2.89	5
Emergency Spillway	1	10	2.34	2.10	5
Freeboard	1	11	2.89	2.62	5

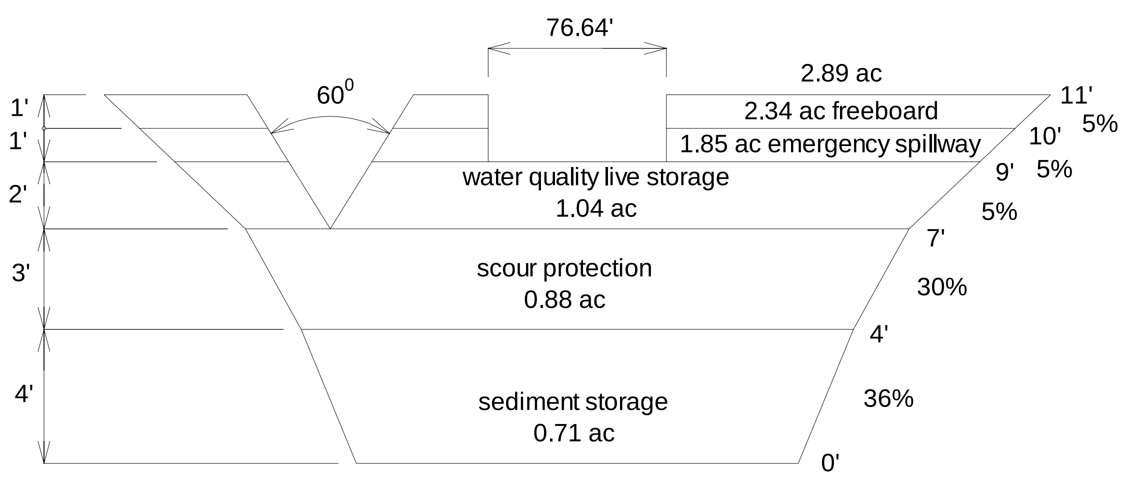

Figure 5: Pond final profile

11.0 Filter fence design (Appendix 6)

The filter fence is expected to remove maximum 50 % of suspended solids. The following section describes the design of filter fences for the site. The fence will be installed all side and down slopes areas.

11.1 Location and type of the fence

The site has a relatively high slope at the edge of the construction site where the fence is planed to install. Based on ground slopes and surrounding facilities, Type "A" silt filter fences are used at all side slopes and down slope edges of the construction site. Figure 6 describes the location of the fence which is shown in the green line in the figure.

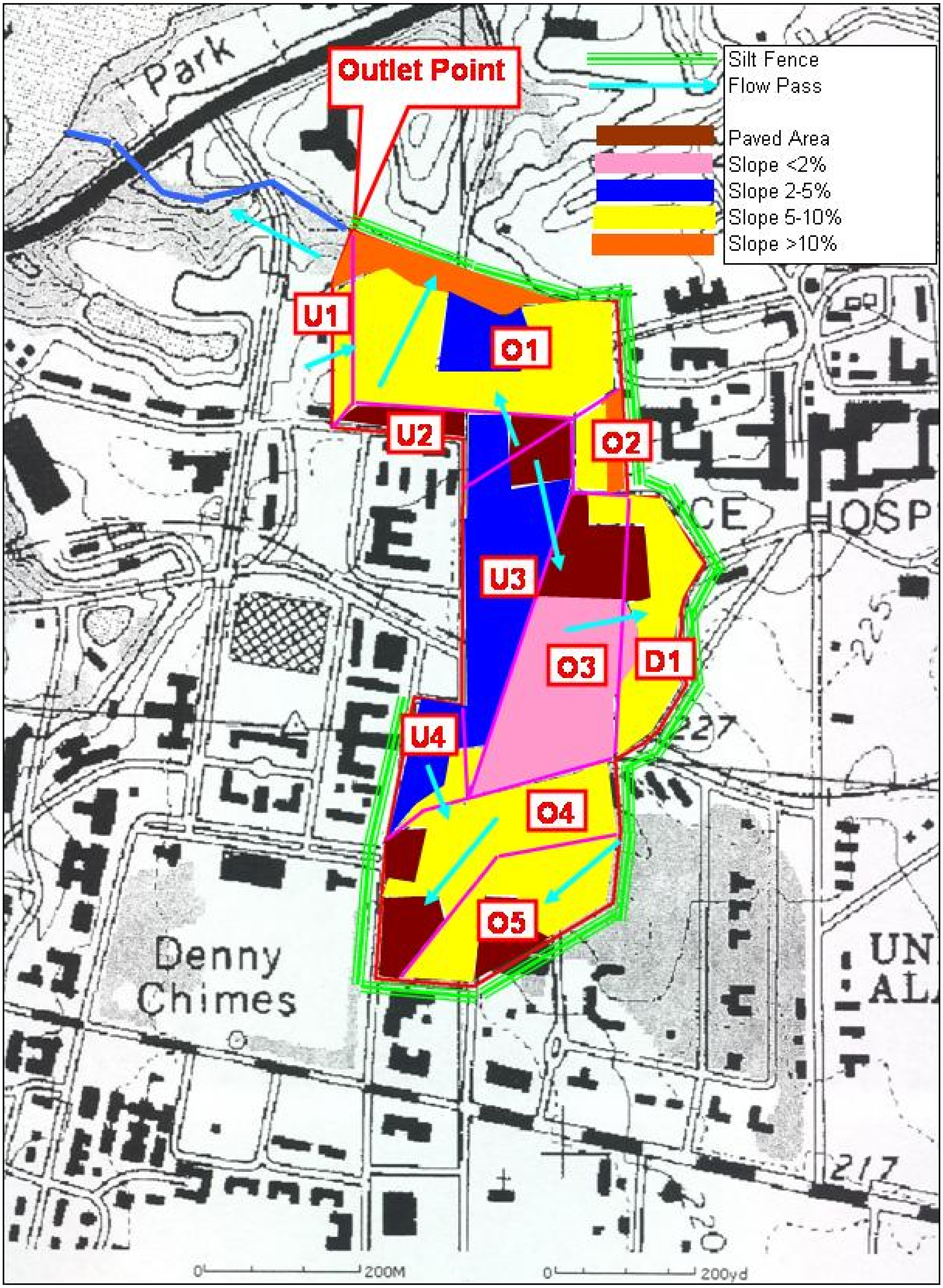

Figure 6: Filter fence location

11.2 Expected silt fence performance for Phase 1 Improvement

The first phase improvement has been started from December 15th 2006 to May 3rd 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site for Phase 2 improvement. The total soil loss on the site for this period was estimated at the previous analysis and it is 3313 tons. After the installation of Type "A" silt filter fence, the estimated soil loss is 1657 tons. Detail calculation is attached in Appendix 6.

11.3 Expected silt fence performance for Phase 2 Improvement and Campus and Hackberry X-section

Site is currently the second phase improvement and it has been started from May 14th 2007 to July 27th 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site completed during the phase 1 improvement. The total soil loss on the site for this period was estimated in 1701 tons at the previous analysis. After the installation of Type "A" silt filter fence, the estimated soil loss is 851 tons. Detail calculation is attached in Appendix 6.

11.4 Expected silt fence performance for after active construction and all land covered

The soil runoff calculation is for the construction of July 30th 2007 to August 6th 2007. The entire site is covered after the completion of the construction. The total soil loss on the site for this period was estimated in 1.12 tons which is analyzed previously. After the installation of Type "A" silt filter fence, the estimated soil loss is 0.71 tons. Detail calculation is attached in Appendix 6.

12.0 Recommendation

The site is located in the middle of the campus; therefore it is necessary to perform a suitable sediment control practice for the stock piles, entrances for the site, and existing inlets in order to keep the campus clean. Sediment filters should be installed at the drop inlets and curb inlets in order to prevent sediment from entering the storm drainage systems during construction and prior to permanent stabilization of the disturbed area. Inspections should be performed at least once every two weeks and following a significant storm event. This allows any changes in site conditions to be observed, and ensure that erosion and sediment controls are effective as designed and approved. Repairs and changes to any erosion control devices should be performed immediately after the inspection in order to prevent sediment runoff.

13.0 Conclusion

This discussion has shown that the use of simple erosion control method can provide an effective water quality benefits such as a stone stabilized pads at the construction entrance, silt fences, and sediment filters for the inlets as well as the vegetation practices. The temporary detention pond is designed at the site and this pond may have a future, used as a permanent pond after the construction. Fitter fences are suitable for much smaller and moderate slope areas, but their maximum expected performance is less. In order to increase the level of protection, it is necessary to combine several erosion control plans at the site.

References

Pitt, R., Clark, E., Shirley, & Lake, D. (2007). Construction Site Erosion and Sediment Controls.

Alabama Soil and Water Conservation Committee. Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas. June 2003. Website: http://www.swcc.state.al.us/

Appendix 1: Construction schedule for the site work

Construction site schedule is described in the Figure 7 and Figure 8.

ID	Indicator	Task Name	Duration	Start	Finish
1	calendar	***PHASE I IMPROVEMENTS***	98 days	Fri 12/15/06	Tue 5/1/07
2	✓	CLEARING & GRUBBING	21 days	Fri 12/15/06	Fri 1/12/07
3	✓	TEMPORARY ACCESS & PARKING	5 days	Mon 12/18/06	Fri 12/22/06
4	✓	DEMOLITION	25 days	Mon 12/18/06	Fri 1/19/07
5	calendar	EROSION CONTROL	97 days	Mon 12/18/06	Tue 5/1/07
6	calendar	TRAFFIC CONTROL	97 days	Mon 12/18/06	Tue 5/1/07
7	calendar	EARTHWORK	15 days	Mon 3/12/07	Fri 3/30/07
8	✓	SANITARY SEWER	16 days	Mon 1/15/07	Mon 2/5/07
9	calendar	STORM SEWER SYSTEM	60 days	Mon 1/22/07	Fri 4/13/07
10	calendar	WATER MAIN INSTALLATION	52 days	Wed 2/21/07	Thu 5/3/07
11	calendar	ELECTRICAL / SITE LIGHTING	30 days	Mon 3/12/07	Fri 4/20/07
12	calendar	CURB & GUTTER / SIDEWALKS	15 days	Mon 4/2/07	Fri 4/20/07
13	calendar	LANDSCAPING	1 day	Mon 4/23/07	Mon 4/23/07
14	calendar	BASE & PAVING	13 days	Mon 4/9/07	Wed 4/25/07
15	calendar	STRIPING & SIGNAGE	4 days	Thu 4/26/07	Tue 5/1/07
16	calendar	MCMILLIAN & ENV. HEALTH PARKING LOTS	50 days	Mon 2/12/07	Fri 4/20/07
17	calendar	NORTH HACKBERRY X-SECTION TIE-IN	13 days	Mon 4/16/07	Wed 5/2/07
18		***OPEN TRAFFIC PHASE I***	1 day	Thu 5/3/07	Thu 5/3/07
19					
20	calendar	***CAMPUS & HACKBERRY X-SECTION***	16 days	Mon 5/14/07	Mon 6/4/07
21	calendar	DEMOLITION / EARTHWORK	5 days	Mon 5/14/07	Fri 5/18/07
22	calendar	CURB & GUTTER / SIDEWALKS	6 days	Fri 5/18/07	Fri 5/25/07
23	calendar	BASE & PAVING	8 days	Mon 5/21/07	Wed 5/30/07

Figure 7: Construction Schedule

ID	ℹ	Task Name	Duration	Start	Finish
24		STRIPING & SIGNAGE	1 day	Fri 6/1/07	Sat 6/2/07
25		***OPEN TRAFFIC***	1 day	Mon 6/4/07	Mon 6/4/07
26					
27		***PHASE II IMPROVEMENTS***	61 days	Mon 5/14/07	Mon 8/6/07
28		CLEARING & GRUBBING	10 days	Mon 5/14/07	Fri 5/25/07
29		DEMOLITION	10 days	Mon 5/14/07	Fri 5/25/07
30		EROSION CONTROL	60 days	Mon 5/14/07	Fri 8/3/07
31		TRAFFIC CONTROL	60 days	Mon 5/14/07	Fri 8/3/07
32		EARTHWORK	15 days	Mon 5/28/07	Fri 6/15/07
33		STORM SEWER SYSTEM	28 days	Wed 5/16/07	Fri 6/22/07
34		WATER MAIN INSTALLATION	40 days	Mon 4/30/07	Fri 6/22/07
35		ELECTRICAL / TRAFFIC SIGNALS	28 days	Wed 5/16/07	Fri 6/22/07
36		CURB & GUTTER / SIDEWALKS	20 days	Mon 6/11/07	Fri 7/6/07
37		LANDSCAPING	1 day	Mon 7/9/07	Mon 7/9/07
38		BASE & PAVING	20 days	Mon 7/2/07	Fri 7/27/07
39		STRIPING & SIGNAGE	3 days	Mon 7/30/07	Wed 8/1/07
40		EAST ENGINEERING PARKING IMPROVEMENTS	40 days	Mon 6/4/07	Fri 7/27/07
41		***OPEN TRAFFIC PHASE II***	1 day	Mon 8/6/07	Mon 8/6/07
43					
42		PROJECT CLEAN UP / CLOSE-OUT	5 days	Mon 7/30/07	Fri 8/3/07
44		***PROJECT COMPLETE***	1 day	Mon 8/6/07	Mon 8/6/07

Figure 8: Construction Schedule cont.

Appendix 2: Hazard map

Following Figure 9 and Figure 10 describe the hazardous map for the site.

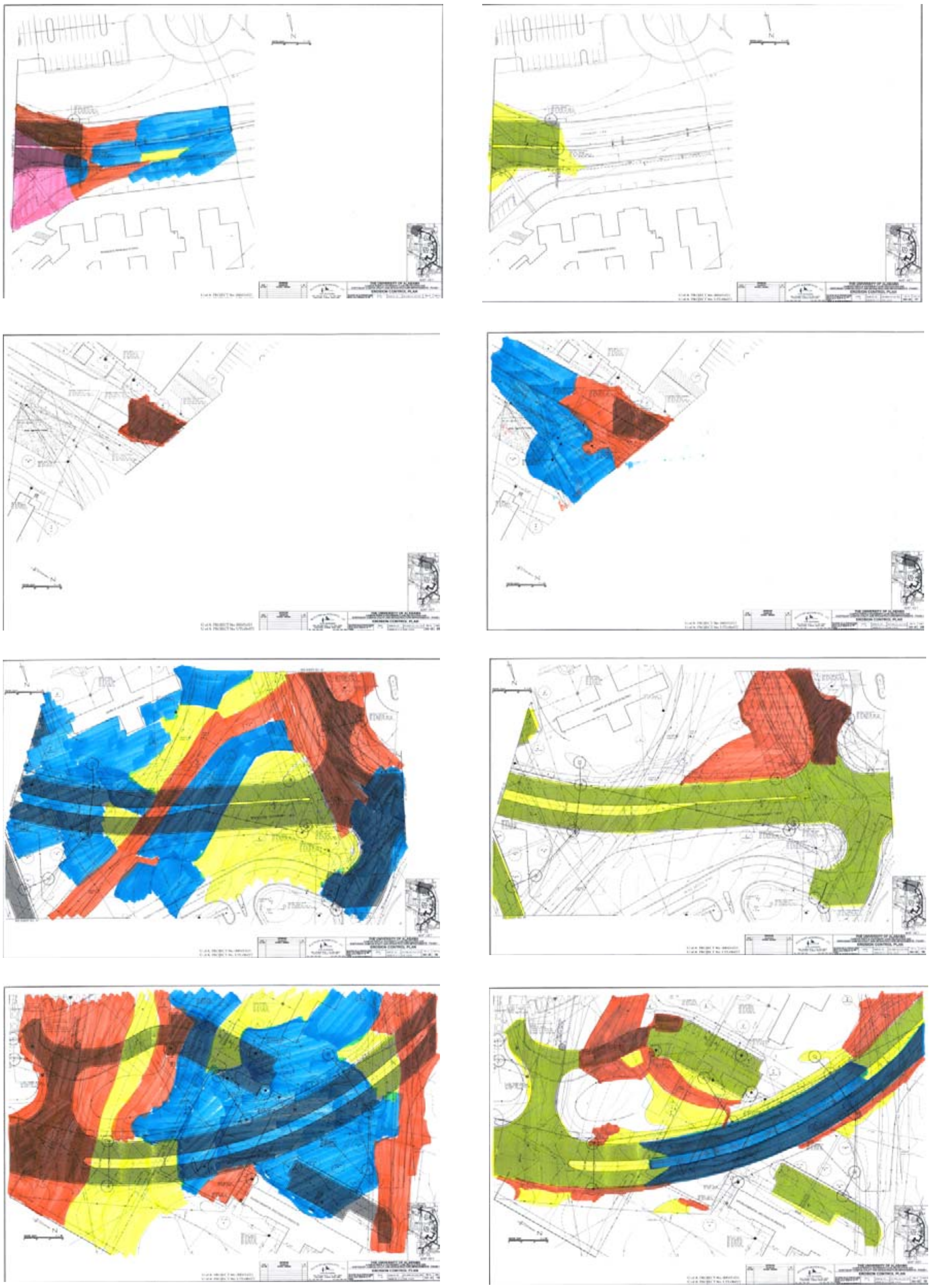

Figure 9: Hazard Map (left column: initial and right column: final topography)

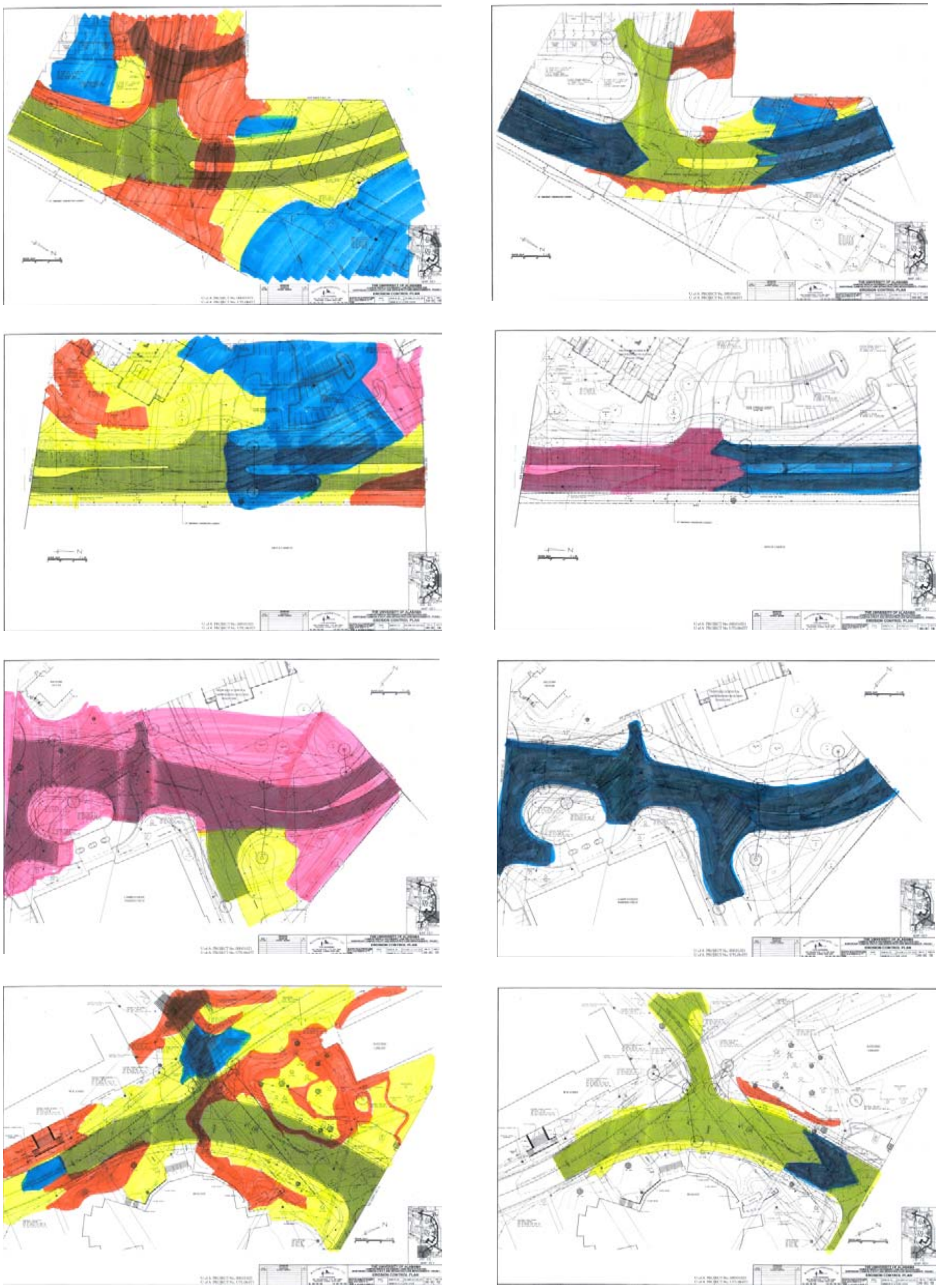

Figure 10: Hazard Map cont. (left column: initial and right column: final topography)

Appendix 3: Peak runoff calculation by Win TR55

Figure 11 describes the plot of hydrographs for the construction site. Following explanation is the detail information for the hydrological calculation done by Win TR55.

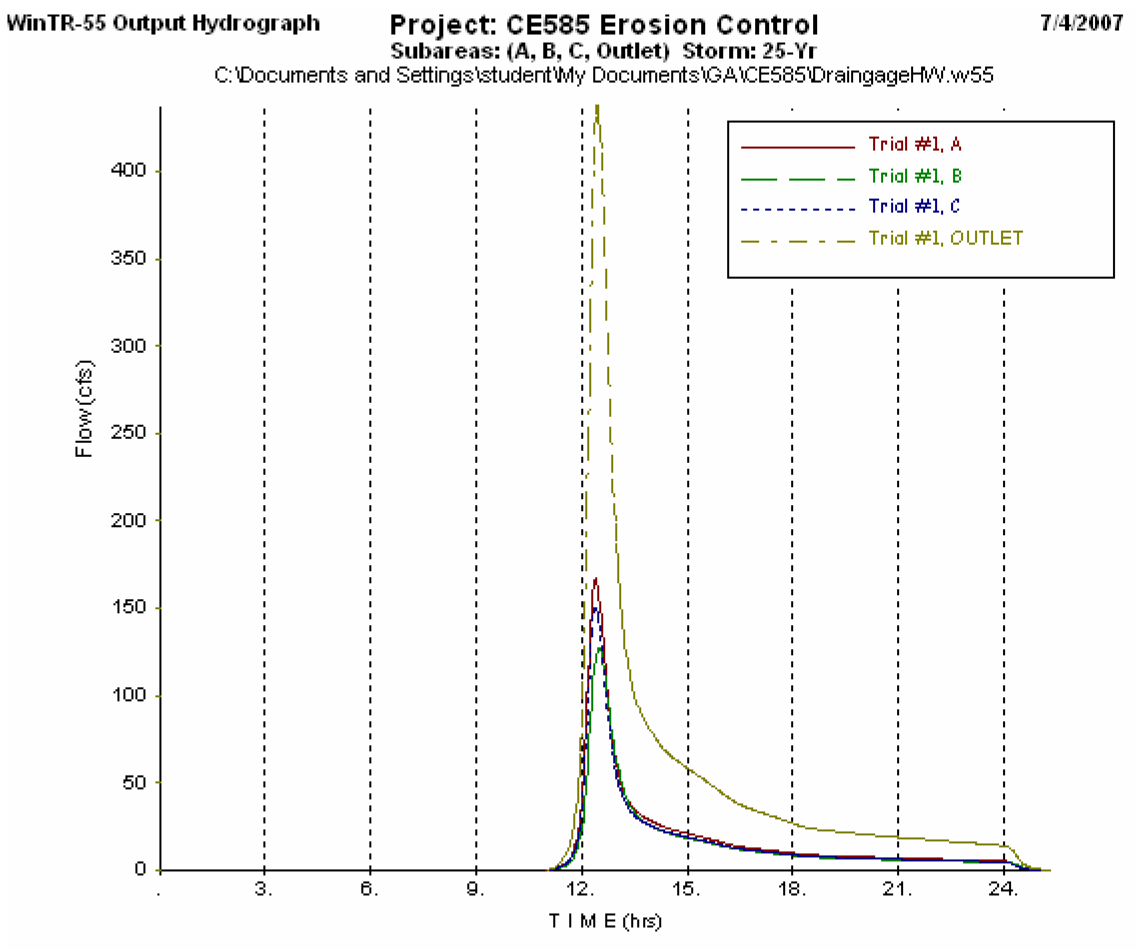

Figure 11: Output Hydrograph (source: WinTR-55)

WinTR-55 Current Data Description

--- Identification Data ---

User:	Noboru	Date:	7/10/2007
Project:	Campus Drive Relocation	Units:	English
SubTitle:		Areal Units:	Acres
State:	Alabama		
County:	Tuscaloosa		
Filename:	C:\Documents and Settings\Hunter\My Documents\GA\CE585\Campus Drive.w55		

--- Sub-Area Data ---

Name	Description	Reach	Area(ac)	RCN	Tc
U1	Upslope	U1 Reach	2.01	98	0.1
U2	Upslope	U2 Reach	3.04	98	.116
U3	Upslope	U3 Reach	9.13	68	.321
U4	Upslope	U4 Reach	3.14	98	0.1
O1	On site	O1 Reach	15.28	71	.117
O2	On site	O2 Reach	2.37	65	.138
O3	On site	O3 Reach	11.59	78	.324
O4	On site	O4 Reach	10.11	89	.281
O5	On site	O5 Reach	6.55	95	.156

Total area: 63.22 (ac)

--- Storm Data --

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
4.2	5.4	6.3	7.1	7.8	8.6	3.6

Storm Data Source: Tuscaloosa County, AL (NRCS)
Rainfall Distribution Type: Type III
Dimensionless Unit Hydrograph: <standard>

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Tuscaloosa County, Alabama

Storm Data

Rainfall Depth by Rainfall Return Period

2-Yr (in)	5-Yr (in)	10-Yr (in)	25-Yr (in)	50-Yr (in)	100-Yr (in)	1-Yr (in)
4.2	5.4	6.3	7.1	7.8	8.6	3.6

Storm Data Source: Tuscaloosa County, AL (NRCS)
Rainfall Distribution Type: Type III
Dimensionless Unit Hydrograph: <standard>

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Watershed Peak Table

Sub-Area or Reach Identifier	Peak Flow by Rainfall Return Period 25-Yr (cfs)	100-Yr (cfs)
SUBAREAS		
U1	11.95	14.49
U2	17.93	21.74
U3	25.46	34.75
U4	18.69	22.66
O1	59.13	78.79
O2	7.48	10.33
O3	42.14	54.54
O4	46.89	58.06
O5	36.88	44.90
REACHES		
U1 Reach	11.95	14.49
Down	11.95	14.49
U2 Reach	17.93	21.74
Down	17.93	21.73
U3 Reach	25.46	34.75
Down	25.45	34.73
U4 Reach	18.69	22.66
Down	18.68	22.64
O1 Reach	241.53	309.65
Down	241.47	309.63
O2 Reach	167.13	212.26
Down	167.13	212.26
O3 Reach	161.17	204.02
Down	161.04	203.83
O4 Reach	99.79	122.28
Down	99.73	122.22
O5 Reach	36.88	44.90
Down	36.87	44.88
OUTLET	241.47	309.63

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Tuscaloosa County, Alabama

Hydrograph Peak/Peak Time Table

Peak Flow and Peak Time (hr) by Rainfall Return Period

Sub-Area or Reach Identifier	25-Yr (cfs) (hr)	100-Yr (cfs) (hr)
SUBAREAS		
U1	11.95	14.49
	12.10	12.10
U2	17.93	21.74
	12.11	12.11
U3	25.46	34.75
	12.24	12.22
U4	18.69	22.66
	12.10	12.10
O1	59.13	78.79
	12.12	12.12
O2	7.48	10.33
	12.13	12.13
O3	42.14	54.54
	12.23	12.22
O4	46.89	58.06
	12.18	12.19
O5	36.88	44.90
	12.12	12.12
REACHES		
U1 Reach	11.95	14.49
	12.10	12.10
Down	11.95	14.49
	12.11	12.11
U2 Reach	17.93	21.74
	12.11	12.11
Down	17.93	21.73
	12.12	12.12
U3 Reach	25.46	34.75
	12.24	12.22
Down	25.45	34.73
	12.26	12.26
U4 Reach	18.69	22.66
	12.10	12.10
Down	18.68	22.64
	12.13	12.12
O1 Reach	241.53	309.65
	12.15	12.15
Down	241.47	309.63
	12.16	12.16

O2 Reach	167.13	212.26
	12.20	12.20
Down	167.13	212.26
	12.20	12.20
O3 Reach	161.17	204.02
	12.18	12.18
Down	161.04	203.83
	12.20	12.20
O4 Reach	99.79	122.28
	12.15	12.15
Down	99.73	122.22
	12.16	12.16
O5 Reach	36.88	44.90
	12.12	12.12
Down	36.87	44.88
	12.12	12.13
OUTLET	241.47	309.63

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Noboru **Campus Drive Relocation**

Tuscaloosa County, Alabama

Sub-Area Summary Table

Sub-Area Identifier	Drainage Area (ac)	Time of Concentration (hr)	Curve Number	Receiving Reach	Sub-Area Description
U1	2.01	0.100	98	U1 Reach	Upslope
U2	3.04	0.116	98	U2 Reach	Upslope
U3	9.13	0.321	68	U3 Reach	Upslope
U4	3.14	0.100	98	U4 Reach	Upslope
O1	15.28	0.117	71	O1 Reach	On site
O2	2.37	0.138	65	O2 Reach	On site
O3	11.59	0.324	78	O3 Reach	On site
O4	10.11	0.281	89	O4 Reach	On site
O5	6.55	0.156	95	O5 Reach	On site

Total Area: 63.22 (ac)

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Noboru **Campus Drive Relocation**

Tuscaloosa County, Alabama

Reach Summary Table

Reach Identifier	Receiving Reach Identifier	Reach Length (ft)	Routing Method
U1 Reach	O1 Reach	750	CHANNEL
U2 Reach	O1 Reach	725	CHANNEL
U3 Reach	O3 Reach	1725	CHANNEL
U4 Reach	O4 Reach	1100	CHANNEL
O1 Reach	Outlet	1600	CHANNEL

O2 Reach	O1 Reach	450	CHANNEL
O3 Reach	O2 Reach	1800	CHANNEL
O4 Reach	O3 Reach	1275	CHANNEL
O5 Reach	O4 Reach	250	CHANNEL

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Tuscaloosa County, Alabama

Sub-Area Time of Concentration Details

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
U1							
SHEET	100	0.2000	0.011				0.007
SHALLOW	125	0.1600	0.025				0.004
CHANNEL	750	0.1333	0.013	0.50	2.50	13.889	0.015
					Time of Concentration		0.1
U2							
SHEET	100	0.2000	0.150				0.057
SHALLOW	125	0.1600	0.025				0.004
SHALLOW	300	0.0667	0.025				0.016
CHANNEL	700	0.0286	0.013	0.50	2.50	6.705	0.029
CHANNEL	350	0.0571	0.013	0.50	2.50	9.722	0.010
					Time of Concentration		.116
U3							
SHEET	100	0.2000	0.240				0.083
SHALLOW	475	0.0421	0.050				0.040
SHALLOW	425	0.0471	0.025				0.027
CHANNEL	1725	0.0232	0.013	0.50	2.50	5.990	0.080
CHANNEL	1875	0.0213	0.013	0.50	2.50	5.723	0.091
					Time of Concentration		.321
U4							
SHEET	100	0.2000	0.011				0.007
SHALLOW	142	0.0141	0.025				0.016
SHALLOW	120	0.1667	0.025				0.004
CHANNEL	425	0.0471	0.013	0.50	2.50	8.433	0.014
CHANNEL	350	0.0571	0.013	0.50	2.50	9.722	0.010
					Time of Concentration		0.1
O1							
SHEET	100	0.2000	0.011				0.007
SHALLOW	725	0.1103	0.025				0.030
SHALLOW	625	0.0960	0.025				0.028
CHANNEL	1625	0.0492	0.013	0.50	2.50	8.681	0.052
					Time of Concentration		.117
O2							
SHEET	100	0.2000	0.240				0.083

SHALLOW	375	0.1067	0.050				0.020
SHALLOW	350	0.1143	0.050				0.018
CHANNEL	300	0.1333	0.013	0.50	2.50	13.889	0.006
CHANNEL	450	0.0889	0.013	0.50	2.50	11.364	0.011
				Time of Concentration			.138
							========
O3							
SHEET	100	0.2000	0.240				0.083
SHALLOW	675	0.0296	0.050				0.068
SHALLOW	550	0.0364	0.050				0.050
CHANNEL	1825	0.0110	0.013	0.50	2.50	4.122	0.123
				Time of Concentration			.324
							========
O4							
SHEET	100	0.2000	0.011				0.007
SHALLOW	1325	0.0453	0.025				0.085
SHALLOW	1225	0.0490	0.025				0.076
CHANNEL	1050	0.0571	0.013	0.50	2.50	9.409	0.031
CHANNEL	2000	0.0300	0.013	0.50	2.50	6.775	0.082
				Time of Concentration			.281
							========
O5							
SHEET	100	0.2000	0.011				0.007
SHALLOW	1175	0.0681	0.025				0.062
SHALLOW	1050	0.0952	0.025				0.047
CHANNEL	1375	0.0582	0.013	0.50	2.50	9.549	0.040
				Time of Concentration			.156
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Noboru **Campus Drive Relocation**

Tuscaloosa County, Alabama

Sub-Area Land Use and Curve Number Details

Sub-Area Identifier	Land Use		Hydrologic Soil Group	Sub-Area Area (ac)	Curve Number
U1	Paved parking lots, roofs, driveways		B	2.009	98
	Total Area / Weighted Curve Number			2.01	98
				====	==
U2	Paved parking lots, roofs, driveways		B	3.042	98
	Total Area / Weighted Curve Number			3.04	98
				====	==
U3	Open space; grass cover > 75%	(good)	B	7.306	61
	Paved parking lots, roofs, driveways		B	1.827	98
	Total Area / Weighted Curve Number			9.13	68
				====	==
U4	Paved parking lots, roofs, driveways		B	3.142	98

	Total Area / Weighted Curve Number		3.14	98
			====	==
O1	Open space; grass cover 50% to 75% (fair)	A	.306	49
	Open space; grass cover 50% to 75% (fair)	B	13.447	69
	Paved parking lots, roofs, driveways	B	1.528	98
	Total Area / Weighted Curve Number		15.28	71
			=====	==
O2	Open space; grass cover > 75% (good)	B	2.13	61
	Paved parking lots, roofs, driveways	B	.237	98
	Total Area / Weighted Curve Number		2.37	65
			====	==
O3	Open space; grass cover 50% to 75% (fair)	B	8.115	69
	Paved parking lots, roofs, driveways	B	3.478	98
	Total Area / Weighted Curve Number		11.59	78
			=====	==
O4	Open space; grass cover 50% to 75% (fair)	B	3.032	69
	Paved parking lots, roofs, driveways	B	7.076	98
	Total Area / Weighted Curve Number		10.11	89
			=====	==
O5	Open space; grass cover 50% to 75% (fair)	B	.655	69
	Paved parking lots, roofs, driveways	B	5.24	98
	Paved parking lots, roofs, driveways	C	.655	98
	Total Area / Weighted Curve Number		6.55	95
			====	==

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Appendix 4: RUSLE calculation

14.0 RUSLE Calculation

14.1 Phase 1 Improvement

The first phase improvement has been started from December 15th 2006 to May 3rd 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site for Phase 2 improvement. The total soil loss on the site for this period was estimated in 3313 tons. The annual rainfall energy R was estimated as 375 and the erosion index of 29% is estimated to affect the erosion considering the location and the period of phase 1 improvement. The credibility factor K is determined from the information of Table 1 considering that at least 5 inch of the top soil will be removed before the construction. The cover factor C has estimated as 0.001 for undisturbed and well protected areas as well as 1.0 for active construction areas. The Table 3 shows the soil runoff for the phase 1 improvement.

Table 3: RUSLE Calculation for December 15, 2006 to May 3, 2007

Phase 1 Improvement Soil Runoff (December 15, 2006-May 3, 2007)										
	Description	**Area (ac.)**	**R for pharse period**	**K Erodibility Factors**	**Length of the Slope (ft)**	**Slope (ft/ft)**	**LS Sloop Length Factore**	**C Cover Factor**	**Unit Area Soil Loss (tons/acres/period)**	**Total Area Soil Loss (tons/period)**
A	**Undisturbed**	2.01	108.75	0.32	125	0.160	3.21	0.001	0.112	0.22
B	**Undisturbed**	3.04	108.75	0.32	300	0.067	1.81	0.001	0.063	0.19
C	**Undisturbed**	9.13	108.75	0.32	475	0.042	2.69	0.001	0.094	0.85
D	**Undisturbed**	3.14	108.75	0.32	142	0.014	0.23	0.001	0.008	0.03
E1	**Active**	6.11	108.75	0.24	725	0.1103	6.65	1.000	173.565	1060.48
E2	**Active**	9.17	108.75	0.32	625	0.096	4.79	1.000	166.692	1528.57
F	**Active**	2.37	108.75	0.32	375	0.1067	3.99	1.000	138.852	329.08
G	**Active**	11.59	108.75	0.32	675	0.0291	0.97	1.000	33.756	391.23
H	**Phase 2**	10.11	108.75	0.32	1325	0.0453	2.55	0.001	0.089	0.90
I1	**Phase 2**	1.31	108.75	0.37	1175	0.0952	7.02	0.001	0.282	0.37
I2	**Phase 2**	5.24	108.75	0.32	1050	0.0582	3.3	0.001	0.115	0.60
total		63.220								3312.52

14.2 Phase 2 Improvement and Campus and Hackberry X-section

Site is currently the second phase improvement and it has been started from May 14th 2007 to July 27th 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site completed during the phase 1 improvement. The total soil loss on the site for this period was estimated in 1701 tons. The annual rainfall energy R was estimated as 375 and the erosion index of 26% is estimated to affect the erosion. The credibility factor K is determined from the information of Table 1 considering that at least 5 inch of the top soil will be removed before the construction. The cover factor C has estimated as 0.001 for undisturbed and well protected areas as well as 1.0 for active construction areas. The Table 4 shows the soil runoff calculation result.

Table 4: RUSLE Calculation for May 14, 2007 to July 27, 2007

Phase 2 Improvement and Campus & Hackberry X-Section Soil Runoff (May 14, 2007-July 27, 2007)										
	Description	**Area (ac.)**	**R for pharse period**	**K Erodibility Factors**	**Length of the Slope (ft)**	**Slope (ft/ft)**	**LS Sloop Length Factore**	**C Cover Factor**	**Unit Area Soil Loss (tons/acres/period)**	**Total Area Soil Loss (tons/period)**
A	**Undisturbed**	2.01	97.50	0.32	125	0.160	3.21	0.001	0.100	0.20
B	**Undisturbed**	3.04	97.50	0.32	300	0.067	1.81	0.001	0.056	0.17
C	**Undisturbed**	9.13	97.50	0.32	475	0.042	2.69	0.001	0.084	0.77
D	**Active**	3.14	97.50	0.32	142	0.014	0.23	1.000	7.176	22.53
E1	**Completed**	6.11	97.50	0.24	725	0.075	2.40	0.001	0.056	0.34
E2	**Completed**	9.17	97.50	0.32	625	0.075	2.21	0.001	0.069	0.63
F	**Completed**	2.37	97.50	0.32	375	0.035	0.94	0.001	0.029	0.07
G	**Completed**	11.59	97.50	0.32	675	0.035	1.26	0.001	0.039	0.46
H	**Active**	10.11	97.50	0.32	1325	0.0453	2.55	1.000	79.560	804.35
I1	**Active**	1.31	97.50	0.37	1175	0.0952	7.02	1.000	253.247	331.75
I2	**Active**	5.24	97.50	0.32	1050	0.0582	3.3	1.000	102.960	539.51
total		63.220								1700.79

14.3 After Active Construction and All Land Covered

The soil runoff calculation is for the construction of July 30th 2007 to August 6th 2007. The entire site is covered after the completion of the construction. The total soil loss on the site for this period was estimated in 1.12 tons. The annual rainfall energy R was estimated as 375 and the erosion index of 7% is estimated to affect the erosion. The cover factor C has estimated as 0.001 for undisturbed and well protected areas. Table 5 shows the result.

Table 5: RUSLE Calculation for July 30, 2007 to August 6, 2007

After Active Construction and All Land Covered Soil Runoff (July 30, 2007-August 6, 2007)										
	Description	**Area (ac.)**	**R for pharse period**	**K Erodibility Factors**	**Length of the Slope (ft)**	**Slope (ft/ft)**	**LS Sloop Length Factore**	**C Cover Factor**	**Unit Area Soil Loss (tons/acres/period)**	**Total Area Soil Loss (tons/period)**
A	**Undisturbed**	2.01	26.25	0.32	125	0.160	3.21	0.001	0.027	0.05
B	**Undisturbed**	3.04	26.25	0.32	300	0.067	1.81	0.001	0.015	0.05
C	**Undisturbed**	9.13	26.25	0.32	475	0.042	2.69	0.001	0.023	0.21
D	**Completed**	3.14	26.25	0.32	142	0.020	0.37	0.001	0.003	0.01
E1	**Completed**	6.11	26.25	0.24	725	0.075	2.40	0.001	0.015	0.09
E2	**Completed**	9.17	26.25	0.32	625	0.075	2.21	0.001	0.019	0.17
F	**Completed**	2.37	26.25	0.32	375	0.035	0.94	0.001	0.008	0.02
G	**Completed**	11.59	26.25	0.32	675	0.035	1.26	0.001	0.011	0.12
H	**Completed**	10.11	26.25	0.32	1325	0.035	1.86	0.001	0.016	0.16
I1	**Completed**	1.31	26.25	0.37	1175	0.035	1.86	0.001	0.018	0.02
I2	**Completed**	5.24	26.25	0.32	1050	0.075	4.91	0.001	0.041	0.22
total		63.220								1.12

Appendix 5: Channel design and slope protection

15.0 Channel design calculation

The site consists of one main channel that diverts water from the upper portion of the watershed. The channel is located at the north side of the watershed area of the construction site. The cross section of the channel will be a trapezoidal in shape as shown in Figure 12.

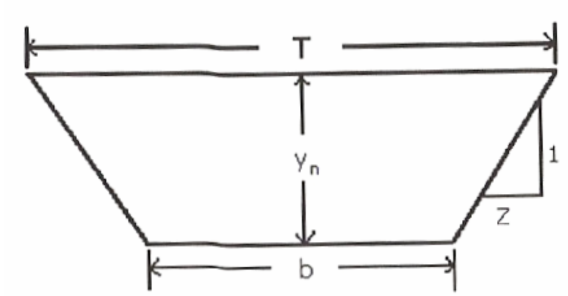


Figure 12: Cross section of the channel

The soil at the site is identified as sandy loam by Tuscaloosa County Soil Survey and the design criteria for the channel is as follows.

Maximum permissible velocity (V_{max}): 2.5 ft/sec
Allowable shear stress (τ_0): 0.075 lb/ft^2

Sandy loam soil have the manning's coefficient is 0.02. Manning's equation for open channel flow will be used to compute the hydraulic radius.

$$AR^{2/3} = \frac{nQ}{1.49S^{0.5}}$$

$$A = \frac{Q}{V} = (b + Zy)y$$

$$P = b + Zy$$

$$A = Q/V = (b + Zy)y$$

$$P = b + Zy\sqrt{1 + Z^2}$$

where,
R = hydraulic radius, ft
V= permissible velocity, ft/sec
S = channel slope, ft/ft
n = roughness of channel lining material, dimensionless
P= wetted parameter
Z= slope
A= area

All the required geometry calculations were performed by using excel spread sheet. Table 6 describes the channel design and lining selection.

Table 6: Channel design and lining selection

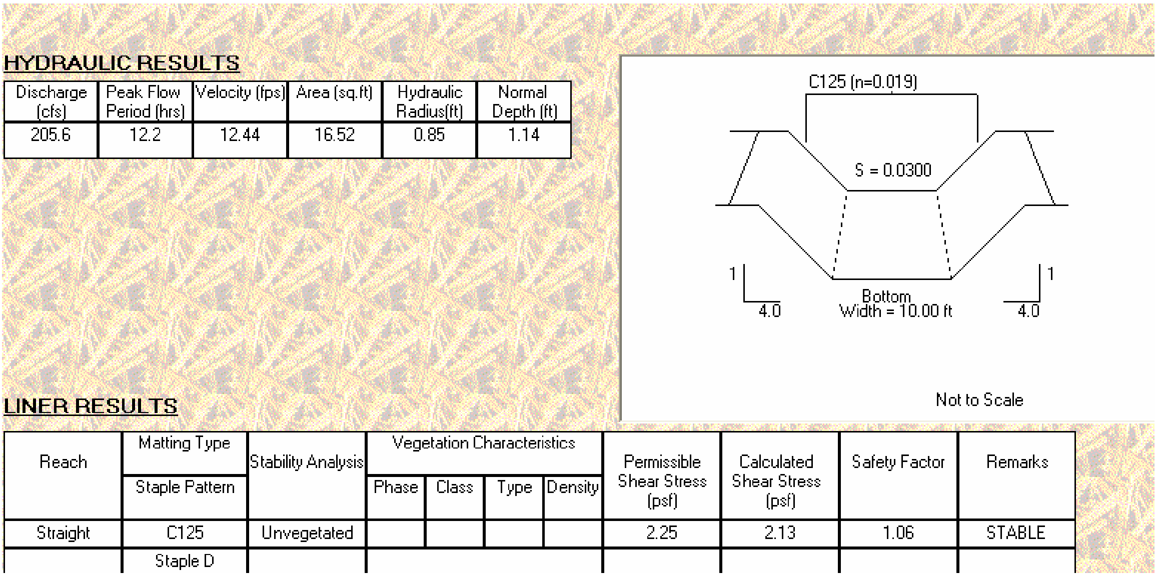
Channel ID	Q (ft^3/s)	S_0	$nQ/1.49S_0^{1/2}$	b (ft)	z	y (ft)	A (ft^2)	P (ft)	R (ft)	$AR^{2/3}$	V_{max} (ft/s)	τ_0 (lb/ft^2)	Need lining?	Type of lining	Allowable τ_0 (lb/ft^2)
U1	10.60	0.133	0.390	6	1	0.19	1.206	6.551	0.184	0.390	8.791	1.619	Yes	C125BN	2.35
U2	15.90	0.028	1.285	6	1	0.40	2.550	7.127	0.358	1.285	6.235	0.686	Yes	C125BN	2.35
U3	20.69	0.023	1.823	6	1	0.49	3.191	7.390	0.432	1.823	6.484	0.712	Yes	C125BN	2.35
U4	16.57	0.018	1.649	6	1	0.46	2.992	7.309	0.409	1.649	5.539	0.526	Yes	C125BN	2.35
O1	205.59	0.050	12.341	6	1	1.53	11.488	10.317	1.113	12.341	17.896	4.762	Yes	P300	8.00
O2	143.28	0.089	6.450	6	1	1.04	7.354	8.953	0.821	6.450	19.483	5.791	Yes	P300	8.00
O3	138.53	0.011	17.649	6	1	1.88	14.768	11.304	1.306	17.649	9.380	1.299	Yes	C125BN	2.35
O4	87.68	0.047	5.423	6	1	0.94	6.541	8.665	0.755	5.423	13.404	2.769	Yes	P300	8.00
O5	32.58	0.080	1.546	6	1	0.45	2.870	7.260	0.395	1.546	11.351	2.223	Yes	C125BN	2.35

Channel ID	Q (ft^3/s)	S_0	$nQ/1.49S_0^{1/2}$	b (ft)	z	y (ft)	A (ft^2)	P (ft)	R (ft)	$AR^{2/3}$	V_{max} (ft/s)	τ_0 (lb/ft^2)	Need lining?	Type of lining	Allowable τ_0 (lb/ft^2)
U1	10.60	0.133	0.390	10	1	0.14	1.451	10.404	0.139	0.390	7.308	1.190	Yes	SC150BN	2.10
U2	15.90	0.028	1.285	10	1	0.29	3.014	10.828	0.278	1.285	5.275	0.504	Yes	SC150BN	2.10
U3	20.69	0.023	1.823	10	1	0.36	3.744	11.022	0.340	1.823	5.526	0.523	Yes	SC150BN	2.10
U4	16.57	0.018	1.649	10	1	0.34	3.518	10.962	0.321	1.649	4.710	0.386	Yes	SC150BN	2.10
O1	205.59	0.050	12.341	10	1	1.14	12.686	13.221	0.960	12.341	16.206	3.553	Yes	P300	5.50
O2	143.28	0.089	6.450	10	1	0.77	8.319	12.184	0.683	6.450	17.224	4.284	Yes	P300	5.50
O3	138.53	0.011	17.649	10	1	1.41	16.081	13.987	1.150	17.649	8.614	0.976	Yes	SC150BN	2.10
O4	87.68	0.047	5.423	10	1	0.70	7.443	11.968	0.622	5.423	11.780	2.045	Yes	SC150BN	2.10
O5	32.58	0.080	1.546	10	1	0.33	3.380	10.926	0.309	1.546	9.639	1.634	Yes	SC150BN	2.10

Channel ID	Q (ft^3/s)	S_0	$nQ/1.49S_0^{1/2}$	b (ft)	z	y (ft)	A (ft^2)	P (ft)	R (ft)	$AR^{2/3}$	V_{max} (ft/s)	τ_0 (lb/ft^2)	Need lining?	Type of lining	Allowable τ_0 (lb/ft^2)
U1	10.60	0.133	0.390	10	4	0.14	1.492	11.165	0.134	0.390	7.105	1.175	Yes	S75	1.55
U2	15.90	0.028	1.285	10	4	0.29	3.178	12.352	0.257	1.285	5.004	0.491	Yes	S75	1.55
U3	20.69	0.023	1.823	10	4	0.35	3.987	12.884	0.309	1.824	5.190	0.506	Yes	S75	1.55
U4	16.57	0.018	1.649	10	4	0.33	3.735	12.721	0.294	1.650	4.437	0.375	Yes	S75	1.55
O1	205.59	0.050	12.341	10	4	1.03	14.503	18.475	0.785	12.341	14.176	3.207	Yes	P300	5.50
O2	143.28	0.089	6.450	10	4	0.72	9.261	15.931	0.581	6.451	15.472	3.990	Yes	P300	5.50
O3	138.53	0.011	17.649	10	4	1.25	18.653	20.268	0.920	17.649	7.427	0.862	Yes	S75	1.55
O4	87.68	0.047	5.423	10	4	0.65	8.229	15.381	0.535	5.423	10.655	1.918	Yes	SC150BN	2.10
O5	32.58	0.080	1.546	10	4	0.32	3.581	12.620	0.284	1.547	9.097	1.586	Yes	SC150BN	2.10

Note: Highlighted graph indicate the selected channels for the site.

The table indicates that all channels require the lining in order to satisfy the shear stress requirement. Also, Figure 13 shows the channel design and lining selection by North American Green software.


HYDRAULIC RESULTS

Discharge (cfs)	Peak Flow Period (hrs)	Velocity (fps)	Area (sq.ft)	Hydraulic Radius(ft)	Normal Depth (ft)
205.6	12.2	12.44	16.52	0.85	1.14

LINER RESULTS

Reach	Matting Type / Staple Pattern	Stability Analysis	Vegetation Characteristics: Phase	Class	Type	Density	Permissible Shear Stress (psf)	Calculated Shear Stress (psf)	Safety Factor	Remarks
Straight	C125	Unvegetated					2.25	2.13	1.06	STABLE
	Staple D									

Figure 13: Channel design and lining selection by North American Green software

16.0 Slope protection

The site is divided into upstream, onsite, and downstream areas. The slope of the site is categorized into four types including: slope <2.0%, slope 2-5%, slope 5-10%, and slope >10%. The peak flow rates for individual watershed areas were calculated using the WinTR-55. Manning's n is 0.02 for the sandy loam as described above. The site has mainly two work phases and it will require the slope protection for the active construction sites during the construction and between these work phases. Onsite 3 is chosen to perform the slope protection analysis, having the following characteristics.

Slope (So) = 11%
Width of slope (W) = 150 ft
Flowrate (Q) = 18.88 cfs
q = Q/W = 0.126 cfs/ft
Manning's coefficient (n) = 0.02

Manning's equation is used to calculate the nominal depth for a sheetflow as follows.

$$y = \left(\frac{qn}{1.49s^{0.5}}\right)^{3/5} = \left(\frac{0.126\times 0.02}{1.49\times 0.16^{0.5}}\right)^{3/5} = 0.0421\,ft$$

Where:
y = the flow depth (in feet),
q = the unit width flow rate (Q/W)
n = the sheet flow roughness coefficient for the slope surface
s = the slope (as a fraction)

The corresponding maximum shear stress is calculated as follows.

$$\tau_0 = \gamma y s = 62.4 \times 0.0421 \times 0.11 = 0.289 lb/ft^2$$

where:
γ = specific weight of water (62.4 lbs/ft3)
y = flow depth (ft)
S = slope (ft/ft)

The allowable shear stress (τ0) is 0.075 lb/ft2. Thus, it is necessary to install the vegetated mat in order to satisfy the stress requirement. The effective shear stress impacting the soil underneath an erosion control mat is calculated as follows.

$$\tau_e = \tau_0 (1 - C_f) \left(\frac{n_s}{n} \right)^2$$

$$0.075 = 0.289(1 - 0) \left(\frac{0.02}{n_{mat}} \right)$$

$$n_{mat} = 0.077$$

Where,
τe = effective shear stress exerted on soil beneath mat on slope
τo = maximum shear stress from the flowing water = 0.289 lbs/ft2
Cf = vegetal cover factor (this factor is 0 for an unvegetated channel) = 0 for critical unvegetated slope
ns = roughness coefficient of underlying soil = 0.02
nmat = roughness coefficient of mat

The final mat selection can be selected by applying the RUSLE.

$$A = (R)(K)(LS)(C)(P) = 375 \times 0.32 \times 6.65 = 798 tons/acre/year$$

Where,
R = 375 (Tuscaloosa, Alabama)
K = 0.32
LS = 6.65 for length of 725 ft and slope of 11%
C = 1 for bare slope

The total soil loss is 798 tons/acre/year or 4.75 inches per year. The maximum allowable erosion loss is 0.25 to 0.5 inches/year. The required C factor is from 0.25/4.75 to 0.5/4.75, which rages 0.053 to 0.11.
The C125 mat has a C of 0.09 (intermediate in the above range) and an n of 0.022 for this slope and condition.
The mat n is 0.022 and it cannot satisfy the required n value of 0.077. Thus, it requires terraces to divide the slope into several segments, and use diversion drains in order to collect the water from each terrace bench. Assume to divide slope into two parts (362.5 ft each) which enable the flowrate of Q to be half of the original as well as the flow depth of q to be half.

$$y = \left(\frac{qn}{1.49 s^{0.5}} \right)^{3/5} = \left(\frac{0.063 \times 0.02}{1.49 \times 0.16^{0.5}} \right)^{3/5} = 0.0248\, ft$$

The resulting share stress is calculates as follows.

$$\tau_0 = \gamma y s = 62.4 \times 0.0248 \times 0.11 = 0.170 lb / ft^2$$

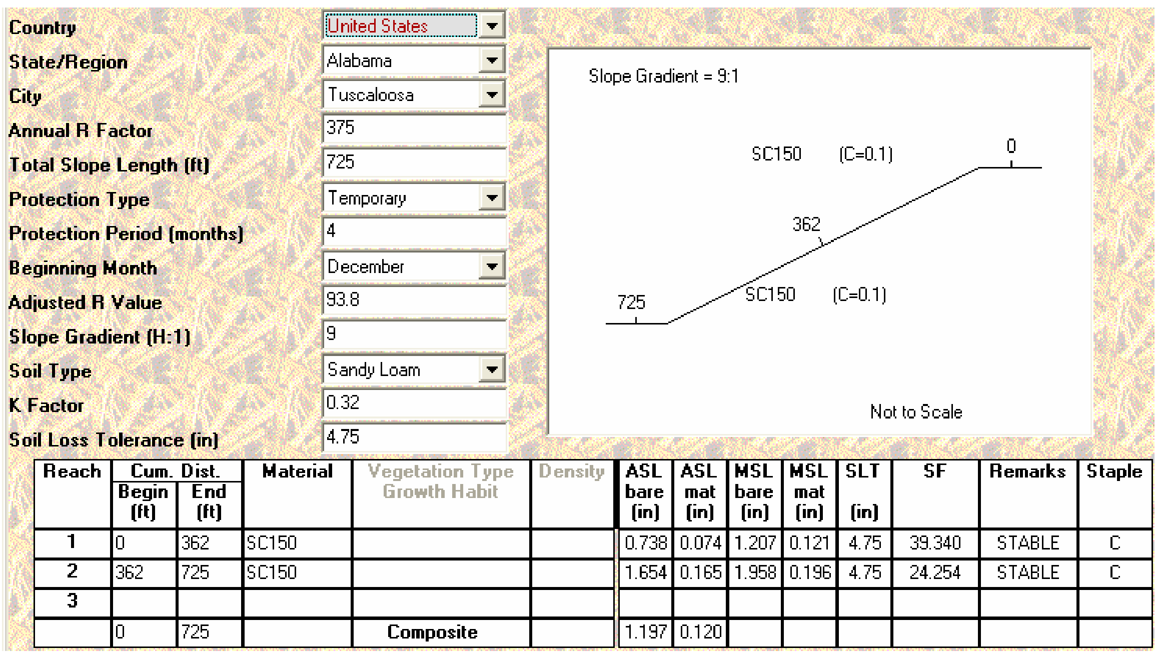
The required value for n is as follows.

$$\tau_e = \tau_0 (1 - C_f) \left(\frac{n_s}{n} \right)^2$$

$$0.075 = 0.289 (1 - 0) \left(\frac{0.02}{n_{mat}} \right)$$

$$n_{mat} = 0.045$$

The SC150 mat has a C of 0.11 (intermediate in the above range) and an n of 0.055 for this slope and condition therefore this mat is selected for the slope protection.
Also, Figure 14 shows the slope selection calculated by North American Green software.



Reach	Cum. Dist. Begin (ft)	End (ft)	Material	Vegetation Type Growth Habit	Density	ASL bare (in)	ASL mat (in)	MSL bare (in)	MSL mat (in)	SLT (in)	SF	Remarks	Staple
1	0	362	SC150			0.738	0.074	1.207	0.121	4.75	39.340	STABLE	C
2	362	725	SC150			1.654	0.165	1.958	0.196	4.75	24.254	STABLE	C
3													
	0	725		Composite		1.197	0.120						

Figure 14: Slope protection by North American Green software

Appendix 6: Pond design and filter fence design

17.0 Pond design calculation

The pond is designed to remove approximately 90% of suspended solids. The pond needs to safely pass the flows from the 25 yr storm. The soil type is described previously. The following are the areas associated with each land use in the drainage area.

- Paved area: 16.66 acres
- Undeveloped area: 17.32 acres
- Construction area: 29.24 acres
- Total site area: 63.22 acres

17.1 Basic pond area and "live" storage volume

Table 7 shows the calculation of the pond surface area and water quality volume for a runoff from the 1.25 inches of rainfall. The water quality live storage has a surface area of 1.04 acres and a volume of 34.68 acre-inches or 2.89 acre-ft.

Table 7: Pond surface area and water quality volume

Site Subarea	Area (acres)	% of Area Needed-	Pond Surface Area (acres)	Water Quality Volume (inches of runoff)	Pond Volume (acre-inches)
Paved	16.66	3	0.500	1.1	18.326
Undeveloped	17.32	0.6	0.104	0.1	1.732
Construction	29.24	1.5	0.439	0.5	14.620
Total	**63.22**		**1.042**		**34.678**

17.2 Top surface area and side slope

Table 8 describes the calculation of the top surface area of the water quality live storage and determination of the site slope. Depth is calculated considering the alternative side slopes. The depth is determined 2.0 ft and the most appropriate slope would be 5 % having the top area of 1.85 acres.

Table 8: Top surface area and side slope

Surface Area (acres)	Volume (acre-ft)	Depth (ft)	Top Area (acres)	Top Area (ft^2)	Top Radius (ft)	Surface Area (ft^2)	Surface Radius (ft)	Slope (%)	Accept?
1.042	2.890	1.0	4.738	206387.280	256.311	45389.520	120.200	0.7	too shallow
1.042	2.890	1.5	2.811	122461.680	197.435	45389.520	120.200	1.9	too shallow
1.042	2.890	2.0	1.848	80498.880	160.074	45389.520	120.200	5.0	Yes
1.042	2.890	2.5	1.270	55321.200	132.700	45389.520	120.200	20.0	Too steep
1.042	2.890	3.0	0.885	38536.080	110.754	45389.520	120.200	-31.8	No
1.042	2.890	3.5	0.609	26546.709	91.924	45389.520	120.200	-12.4	No

17.3 Selection of primary outlet device

At the top of the live storage volume, this pond will have 2 ft of stage and 1.85 acres of maximum pond area.

According to Table 6.9 to 6.11 in Construction Site Erosion and Sediment Controls, the 60^o V-notch Weir requires at least 1.4 acres of pond surface at 2 feet of stage in order to provide about 90% control of sediment. The 45° V-notch Weir will require 1.0 acres, while the 90° V-notch Weir would require 2.5 acres. None of the rectangular weirs can be suitable, as the smallest 2 ft weir requires at least 2.6 acres at 2 feet of stage. The 60° weir is closest to the area available and is therefore selected for this pond. Another possible outlet structure would be an 18" drop tube structure which requires at least 1.1 acres (Pitt, Clark, & Lake, 2007).

17.4 Sacrificial drainage volume

The pond water surface is 1.04 acres. With a 3 ft dead storage depth to minimize scour, the surface area at the top of the sediment storage zone (and the bottom of the scour protection zone), will be about 0.88 acres with a 30% underwater slope. Table 9 shows the calculation of the top sediment storage area.

Table 9: Top sediment storage area (bottom of the scour protection zone)

Surface Area (acres)	Volume (acre-ft)	Depth (ft)	Top Sediment Storage Area (acres)	Top Sediment Storage Area (ft²)	Top Sediment Storage Radius (ft)	Surface Area (ft²)	Surface Radius (ft)	Slope (%)
1.042	2.877	3.0	0.876	38151.319	110.200	45389.520	120.200	30.0

Calculate the sediment loss for the complete construction period for the site area draining to the pond. The sediment loss for different phases of the construction period is calculated at the previous analysis using the RUSLE equation. The calculated amount of dirt is 5014.43 tons for the 235 days of total project time which has a total area of 63.22 acres. The sediment volume is about 5114.72 yd³, or 3.17 acre-ft. The sacrificial storage zone can be about 4 ft deep which will have the bottom pond area of about 0.71 acres with a side slope of 36%. Table 10 shows the calculation of the bottom area and a side slope.

Table 10: Bottom area and side slope

Top Sediment Storage Area (acres)	Volume (acre-ft)	Depth (ft)	Bottom Area (acres)	Bottom Area (ft²)	Bottom Radius (ft)	Top Sediment Storage Area (ft²)	Top Sediment Storage Radius (ft)	Slope (%)	Accept?
0.876	3.170	3.0	1.237	53905.481	130.991	38151.319	110.200	-14.4	No
0.876	3.170	3.5	0.936	40754.510	113.897	38151.319	110.200	-94.7	No
0.876	3.170	4.0	0.709	30891.281	99.161	38151.319	110.200	36.2	Yes
0.876	3.170	4.5	0.533	23219.881	85.972	38151.319	110.200	18.6	No
0.876	3.170	5.0	0.392	17082.761	73.740	38151.319	110.200	13.7	No
0.876	3.170	5.5	0.277	12061.481	61.962	38151.319	110.200	11.4	No

17.5 Selection of emergency spillway

The purpose for the pond is only a temporary storage of a runoff during the construction period. The design runoff for the emergency spillway is 50 year storm event. The design flow rate is calculated at the previous analysis using Win TR55 and the rate is 273.24 ft³/s at 12.13 hrs later. The emergency spillway will be a rectangular weir. At the one foot of stage for this weir plus the spillway, the 60° V-notch weir would have 3 ft of stage in total. The V-notch weir will discharge 28 ft³/s at this stage. Therefore, the rectangular weir will need to handle 245.24 ft³/s. The rectangular weir is calculated as follows.

$$L_w = \frac{q_o}{3.2 \times H_w^{1.5}}$$

where,
q_o = desired ourflow rate, ft^3/s
L_w = length of a rectangular weir, ft
H_w = stage, ft

The selected rectangular weir has a length of 76.64 ft and the stage of 1.0 ft. Table 11 describes the calculation of an emergency spillway.

Table 11: Emergency spillway

H_w (ft)	Total Discharge (ft^3/s)	60° Vnotch Discharge (ft^3/s)	q_0 (ft^3/s)	L_w (ft)	Accept?
1.0	273.240	28	245.240	76.638	Yes
2.0	273.240	46	227.240	25.107	No
3.0	273.240	81	192.240	11.561	No

Keeping the slope of 5% from the water quality storage, the top area of the emergency storage is 2.34 acres. The top area of the detention pond is 2.89 acres, considering 1.0 feet of freeboard above the maximum expected water level and a slope of 5%.

17.6 Final pond profile

Table 12 describes the pond profile and Figure 15 shows the corresponding drawing.

Table 12: Pond final profile

Zone	Depth (ft)	Pond Depth from the Bottom (ft)	Surface Area at Depth (acres)	Pond Storage Below Elevation (acre-ft)	Pond Slope Between Elevations (%)
Bottom	0	0	0.71	0	-
Sediment Storage	4	4	0.88	3.18	36
Scour Protection	3	7	1.04	2.88	30
Water Quality Live Storage	2	9	1.85	2.89	5
Emergency Spillway	1	10	2.34	2.10	5
Freeboard	1	11	2.89	2.62	5

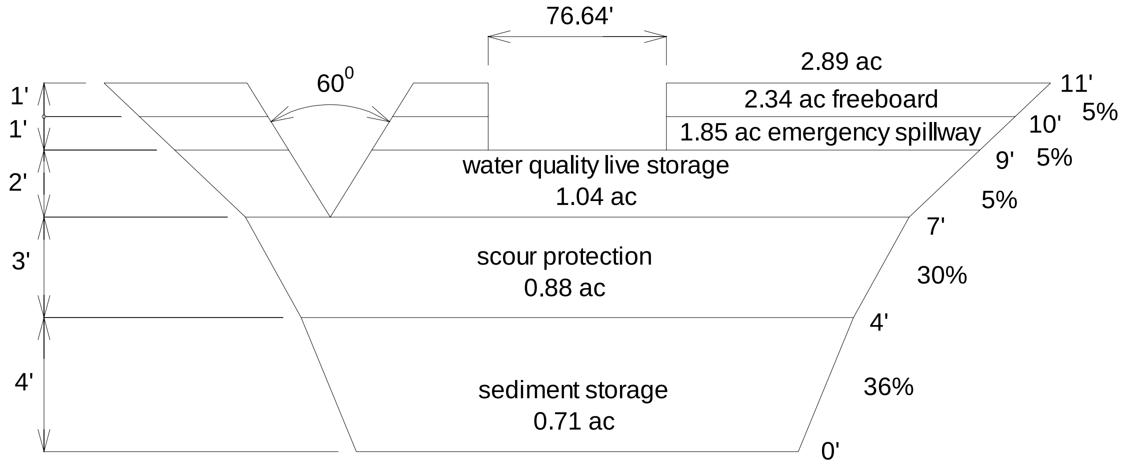


Figure 15: Pond final profile

18.0 Filter fence design

The filter fence is expected to remove maximum 50 % of suspended solids. The following section describes the design of filter fences for the site. The fence will be installed all side and down slopes areas.

18.1 Location and type of the fence

The site has a relatively high slope at the edge of the construction site where the fence is planed to install. Type "A" silt filter fences are used at all side slopes and down slope edges of the construction site. Figure 6 describes the location of the fence which is shown in the green line in the figure.

18.2 Expected silt fence performance for Phase 1 Improvement

The first phase improvement has been started from December 15^{th} 2006 to May 3^{rd} 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site for Phase 2 improvement. The total soil loss on the site for this period was estimated at the previous analysis and it is 3313 tons. After the installation of Type "A" silt filter fence, the estimated soil loss is 1657 tons. The Table 13 shows the soil runoff for the phase 1 improvement with and without the fence

Table 13: Phase 1 soil runoff with and without the fence

Phase 1 Improvement Soil Runoff (December 15, 2006-May 3, 2007)						
	Description	Area (ac.)	Unit Area Soil Loss (tons/acres/period)	Soil Loss Without Fence (tons/period)	Type of the Fence	Soil Loss With Fence (tons/period)
A	Undisturbed	2.01	0.112	0.22	-	0.22
B	Undisturbed	3.04	0.063	0.19	-	0.19
C	Undisturbed	9.13	0.094	0.85	-	0.85
D	Undisturbed	3.14	0.008	0.03	A	0.01
E1	Active	6.11	173.565	1060.48	A	530.24
E2	Active	9.17	166.692	1528.57	A	764.28
F	Active	2.37	138.852	329.08	A	164.54
G	Active	11.59	33.756	391.23	A	195.62
H	Phase 2	10.11	0.089	0.90	A	0.45
I1	Phase 2	1.31	0.282	0.37	A	0.19
I2	Phase 2	5.24	0.115	0.60	A	0.30
total		63.220		3312.52		1656.90

18.3 Expected silt fence performance for Phase 2 Improvement and Campus and Hackberry X-section

Site is currently the second phase improvement and it has been started from May 14th 2007 to July 27th 2007 which includes the 4 active construction areas and 7 undisturbed areas including the site completed during the phase 1 improvement. The total soil loss on the site for this period was estimated in 1701 tons at the previous analysis. After the installation of Type "A" silt filter fence, the estimated soil loss is 851 tons. The Table 14 shows the soil runoff calculation result with and without the fence.

Table 14: Phase 2 Improvement and Campus & Hackberry X-Section soil runoff with and without the fence

Phase 2 Improvement and Campus & Hackberry X-Section Soil Runoff (May 14, 2007-July 27, 2007)						
	Description	Area (ac.)	Unit Area Soil Loss (tons/acres/period)	Total Area Soil Loss (tons/period)	Type of the Fence	Soil Loss With Fence (tons/period)
A	Undisturbed	2.01	0.100	0.20	-	0.20
B	Undisturbed	3.04	0.056	0.17	-	0.17
C	Undisturbed	9.13	0.084	0.77	-	0.77
D	Active	3.14	7.176	22.53	A	11.27
E1	Completed	6.11	0.056	0.34	A	0.17
E2	Completed	9.17	0.069	0.63	A	0.32
F	Completed	2.37	0.029	0.07	A	0.03
G	Completed	11.59	0.039	0.46	A	0.23
H	Active	10.11	79.560	804.35	A	402.18
I1	Active	1.31	253.247	331.75	A	165.88
I2	Active	5.24	102.960	539.51	A	269.76
total		63.220		1700.79		850.96

18.4 Expected silt fence performance for after active construction and all land covered

The soil runoff calculation is for the construction of July 30th 2007 to August 6th 2007. The entire site is covered after the completion of the construction. The total soil loss on the site for this period was estimated in 1.12 tons which is analyzed previously. After the installation of Type "A" silt filter fence, the estimated soil loss is 0.71 tons. Table 15 shows the soil runoff calculation result with and without the fence.

Table 15: After active construction and all land covered soil runoff with and without the fence

After Active Construction and All Land Covered Soil Runoff (July 30, 2007-August 6, 2007)						
	Description	**Area (ac.)**	**Unit Area Soil Loss (tons/acres/period)**	**Total Area Soil Loss (tons/period)**	**Type of the Fence**	**Soil Loss With Fence (tons/period)**
A	**Undisturbed**	2.01	0.027	0.05	-	0.05
B	**Undisturbed**	3.04	0.015	0.05	-	0.05
C	**Undisturbed**	9.13	0.023	0.21	-	0.21
D	**Completed**	3.14	0.003	0.01	A	0.00
E1	**Completed**	6.11	0.015	0.09	A	0.05
E2	**Completed**	9.17	0.019	0.17	A	0.09
F	**Completed**	2.37	0.008	0.02	A	0.01
G	**Completed**	11.59	0.011	0.12	A	0.06
H	**Completed**	10.11	0.016	0.16	A	0.08
I1	**Completed**	1.31	0.018	0.02	A	0.01
I2	**Completed**	5.24	0.041	0.22	A	0.11
total		63.220		1.12		0.71