Addendum to Appendix B

Detailed Stormwater Management Conservation Design

Revised Concept Plan Design

The final concept plan represents a combination of subareas and treatment features based on analysis of predicted site control summaries using WinSLAMM, version 9.0 and the results of the soil test analysis.

The following chart provides a summary of the preferred site controls based upon the preliminary analysis described previously. Recognizing that most of the wet ponds are at minimum recommended size and considering the increase permeability of the soils as indicated in the soils test, a second analysis was conducted. The purpose of this analysis was to refine the treatment train, combine subareas and their site controls and make final selection of the most effective treatment train for the storm water management from the site.

In the final concept plan, subareas one and two have been combined, subareas four and five have also been combined. Subarea 3 remains the same as in the original analysis. WinSLAMM was used to evaluate and predict performance of alternative combinations of site controls, the results of which follow.

Preliminary Site Controls

Subarea 1

Set of Controls

- bioswales = 1,100 ft
- wet pond = 0.25 to 1.0 acre (5 to 8 ft depth)
- percolation pond = 100 ft by 100 ft

Subarea 2

Set of Controls

- bioswales = 1,500 ft
- wet pond = 0.32 to 0.86 acre (5 to 8 ft depth)
- percolation pond = 120 ft by 120 ft

Subarea 3

Set of Controls

- bioswales = 2,230 ft
- wet pond =0.5 to 1.2 acre (5 to 8.5 ft depth)
- percolation pond =150 ft by 150 ft

Subarea 4

Set of Controls

- bioswales = 970 ft
- wet pond = 0.25 to 0.85 acre (5 to 8 ft depth)
- percolation pond = 100 ft by 100 ft

Subarea 5

Set of Controls

- bioswales = 1,850 ft
- wet pond = 0.25 to 0.93 acre (5 to 8 ft depth)
- percolation pond = 100 ft by 100 ft

Combined Subareas I and II:
This combined subarea comprises about 36 acres. The following list shows the estimated surface covers:

- Roofs (directly connected): 5.6 acres
- Paved parking (directly connected): 1.4 acres
- Streets (0.7 curb-miles): 2.2 acres
- Service roads (0.24 curb-miles): 0.5 acres
- Small landscaped areas (B or sandy-loam soils, but assumed silty soils due to compaction):
  26 acres

Four new buildings are in this area. The stormwater control options examined in this subarea included the following:

Controls
The wet pond in this area has the following approximate dimensions:

pond elevation (ft)	pond area (acres)
2	0.25*
4	0. 5*
5	0.72 (normal pool elevation, and invert elevation of 45^{o} v-notch weir).
7.5	1.38 (invert elevation of flood flow broad-crested weir). Normal maximum elevation during one and two year rains.
8.5	1.64 (approximate maximum pond elevation, or as determined based on flood flow analysis). Additional storage and emergency spillway may be needed to accommodate flows in excess of the design flood flow.

*These areas are approximate and need to be adjusted to ensure satisfactory safety ledge and deep portion of pond.

This pond has about 4.1 acre-ft of storage above 5 ft. The side slopes are about 6.4%.

The large percolation pond has an area of about 180 by 360 ft and has an infiltration rate of 0.5 in/hr.

The swale drainageways are about 2,600 ft in length and are described below. The sealed swales are assumed to have a low infiltration rate of 0.05 in/hr.

Bioretention swales:
The swale should be about 10 feet wide (at the bottom), with about 3 to 1 (H to V) side slopes, and 2 to 3 feet deep. The top width would therefore be about 20 ft. Limestone rock check dams should be placed in the swales to slow the water down and to help neutralize that water (and add alkalinity). This will assist with metal retention in the soils. The check dams should be located every 50 ft, if the swale bottom slope is about 2%, every 100 ft for a 1% slope, etc. The bottoms of the swales should be amended with organic material, if needed, resulting in an optimal soil organic content of 40 to 60% to a one-foot depth. Before sodding the swale, the density of the soil will likely also need to

be decreased to compensate for typical soil compaction associated with site development. The use of drought tolerant native grasses having deep root systems is especially encouraged for the swales to maintain good soil structure and infiltration. The on-site swales should not be located directly adjacent to the paved areas, but at least 10 feet (and preferably 30 ft) from the paved areas and buildings, separated with good turf grass to provide pre-treatment before any infiltration in the swale drainages. The vegetation in the drainage should be native grasses having deep roots and be mowed to a height of about 6 inches, or longer. Any cut grass should be left in place to act as a mulch, which will help preserve infiltration rates.

Performance Calculations

The following tables summarize the expected performance of the different options examined. The expected volume reduction with this control option is almost 70%, while the particulate solids expected control is about 95%. This option was also examined with the full 40 years of available rain information, and resulted in similar expected levels of control.

Areas I and II combined: Summary of Stormwater Quality Control (6 years: 1987-1992 rains)

	Runoff Volume				SS conc.	Particulate Solids Yield	
Practice	ft^3	Rv	% reduc.	Avg. peak reduction ratio and flushing ratio (for pond)	mg/L	lbs	% reduc.
Base conditions	1.41×10^7	0.33	-	-	212	186,000	-
Bio swales and pond	4.42×10^6	0.10	69 %	0.95 (0.11)	36	9,610	95 %
Sealed swales, pond, and large percolation pond	3.34×10^6	0.08	76%	0.58 (0.29)	40	8,300	96%

Areas I and II combined: Summary of Stormwater Quality Control (40 years: 1959-1999 rains)

	Runoff Volume				SS conc.	Particulate Solids Yield	
Practice	ft^3	Rv	% reduc.	Avg. peak reduction ratio and flushing ratio (for pond)	mg/L	lbs	% reduc.
Base conditions	8.66×10^7	0.32	-	-	207	1.12×10^6	-
Bio swales and pond	2.35×10^7	0.09	73 %	0.85 (0.09)	33	48,900	96 %
Sealed swales, pond, and large percolation pond	1.78×10^7	0.07	79%	0.66 (0.28)	39	43,300	96%

Areas I and II combined: Bioswales and Pond Performance for Different Rain Conditions

Rain Depth (inches)	Total Runoff Volume Before Controls (ft^3)	Total Runoff Volume at Outfall (ft^3)	Runoff Volume % Reduc.	Outfall Rv	Outfall CN	Flush. ratio in pond	Pond Influent SS (mg/L)	Pond Effluent SS (mg/L)	Total Part. Solids Yield Before Controls (lbs)	Outfall Part. Solids Yield (lbs)	Part. % Reduc.
0.01	12	0	100%	0.00	n/a	0	n/a	n/a	<1	<1	n/a
0.05	390	0	100%	0.00	n/a	0	n/a	n/a	<1	<1	n/a
0.10	1,280	0	100%	0.00	n/a	0	n/a	n/a	<1	<1	n/a
0.25	7,000	0	100%	0.00	n/a	0	n/a	n/a	52	<1	100%
0.50	17,600	0	100%	0.00	n/a	0	n/a	n/a	166	<1	100%
0.75	28,900	0	100%	0.00	n/a	0	n/a	n/a	287	<1	100%
1.00	40,200	0	100%	0.00	n/a	0	n/a	n/a	459	<1	100%
1.50	65,500	11,800	82%	0.06	71	0.16	203	<10	829	<1	100%
2.00	94,200	39,800	58%	0.15	73	0.55	219	10	1,290	23	98%
2.50	128,000	73,300	43%	0.23	73	1.01	241	20	1,920	93	95%
3.00	165,000	110,000	33%	0.28	73	1.51	256	30	2,630	211	92%
4.00	249,000	189,000	24%	0.36	72	2.84	289	57	4,490	675	85%

Subarea III

This subarea comprises about 24.5 acres. The following list shows the estimated surface covers:

- Roofs (directly connected): 4.3 acres
- Paved parking (directly connected): 1.1 acres
- Streets (0.3 curb-miles): 1.0 acres
- Service roads (0.6 curb-miles): 1.2 acres
- Small landscaped areas (B or sandy-loam soils, but assumed silty soils due to compaction):
  17.0 acres

Portions of four new buildings are in this area. The stormwater control options examined in this subarea included the following:

Controls

The wet pond in this area has the following approximate dimensions:

pond elevation (ft)	pond area (acres)
2	0.25*
4	0.35*
5	0.5 (normal pool elevation, and invert elevation of 30^o v-notch weir).
7.5	1.0 (invert elevation of flood flow broad-crested weir). Normal maximum elevation during one and two year rains.
8.5	1.2 (approximate maximum pond elevation, or as determined based on flood flow analysis). Additional storage and emergency spillway may be needed to

	accommodate flows in excess of the design flood flow.

*These areas are approximate and need to be adjusted to ensure satisfactory safety ledge and deep portion of pond.

This pond has about 1.83 acre-ft of storage above 5 ft. The side slopes are about 7.8%. The percolation pond is about 150 by 150 ft, while the large percolation pond is twice as large, at 150 by 300 ft. The percolation ponds have infiltration rates of 0.5 in/hr.

The swale drainageways are about 2230 ft in length and are similar to those described for subarea I. The sealed swales are assumed to have a low infiltration rate of 0.05 in/hr.

Performance Calculations

The following tables summarize the expected performance of the different options examined. The controls that can provide close to 60%, or more, volume reductions and 90% particulate solids reductions are:

Wet pond and bioswale
Wet pond and percolation pond
Wet pond and large percolation pond
Wet pond, percolation pond, and bioswale
Sealed swales, wet pond, and percolation pond
Sealed swales, wet pond, and large percolation pond

The combination of the wet pond plus the bioswales and percolation pond, or the wet pond and the percolation pond alone may be most suitable for this site, depending on the type of industrial activity. If uncertain, then the sealed swales, wet pond, and large percolation pond option would be best. These options were examined with the full 40 years of available rain information, and resulted in similar levels of control.

Area III: Summary of Stormwater Quality Control (6 years: 1987-1992 rains)

	Runoff Volume				SS conc.	Particulate Solids Yield	
Practice	ft^3	Rv	% reduc.	Avg. peak reduction ratio and flushing ratio (for pond)	mg/L	lbs	% reduc.
Base conditions	1.030×10^7	0.35	-	-	197	126,709	-
Bioretention swales	4.587×10^6	0.16	55%	-	231	66,033	48%
Pond	1.026×10^7	0.35	0.4%	0.24 (0.28)	22	13,867	89%
Bio swales and pond	3.95×10^6	0.14	62%	0.94 (0.12)	29	7,229	94%
Pond and percolation pond	3.98×10^6	0.14	61%	0.12 (0.28)	33	8,276	93%
Sealed swales, pond, and percolation	3.80×10^6	0.13	63%	0.59 (0.27)	33	7,858	94%

pond							
Pond and large percolation pond	2.57×10^6	0.09	75%	0.36 (0.28)	36	5,838	95%
Sealed swales, pond, and large percolation pond	2.47×10^6	0.08	76%	0.56 (0.27)	36	5,580	96%
Bio swales, pond, and perc. pond	2.00×10^6	0.07	81%	0.92 (0.12)	36	4,548	96%

Area III: Summary of Stormwater Quality Control (40 years: 1959-1999 rains)

	Runoff Volume				SS conc.	Particulate Solids Yield	
Practice	ft^3	Rv	% reduc.	Avg. peak reduction ratio and flushing ratio (for pond)	mg/L	lbs	% reduc.
Base conditions	6.28×10^7	0.34	-	-	192	753,931	-
Pond and large perc. pond	1.39×10^7	0.08	78%	0.38 (0.27)	35	30,535	96%
Bioswales and pond	2.25×10^7	012	64%	0.94 (0.11)	27	37,500	95%
Bio swales, pond, and perc. pond	1.00×10^7	0.05	84%	0.91 (0.11)	37	23,196	97%
Sealed swales, pond, and large percolation pond	1.32×10^7	0.07	79%	0.65 (0.26)	35	29,040	96%

Area III: Bioswales, Pond, and Percolation Pond Performance for Different Rain Conditions

Rain Depth (inches)	Total Runoff Volume Before Controls (ft^3)	Total Runoff Volume at Outfall (ft^3)	Runoff Volume % Reduc.	Outfall Rv	Outfall CN	Flush. ratio in pond	Pond Influent SS (mg/L)	Pond Effluent SS (mg/L)	Total Part. Solids Yield Before Controls (lbs)	Outfall Part. Solids Yield (lbs)	Part. % Reduc.
0.01	9.2	0	100%	0	n/a	0	n/a	n/a	<1	<1	n/a
0.05	303	0	100%	0	n/a	0	n/a	n/a	<1	<1	n/a
0.10	989	0	100%	0	n/a	0	n/a	n/a	<1	<1	n/a
0.25	5,229	0	100%	0	n/a	0	n/a	n/a	35	<1	100%
0.50	13,000	0	100%	0	n/a	0	n/a	n/a	113	<1	100%
0.75	21,300	0	100%	0	n/a	0	n/a	n/a	200	<1	100%
1.00	29,580	0	100%	0	n/a	0.08	n/a	n/a	320	<1	100%
1.50	48,160	1700	96%	0.01	63	0.39	189	<10	570	<1	100%
2.00	68,925	13,300	81%	0.07	66	0.75	202	13	870	2.1	99%
2.50	93,200	33,900	64%	0.15	68	1.17	222	24	1,290	51	96%
3.00	119,200	57,900	51%	0.22	69	1.62	235	34	1,750	123	93%
4.00	178,200	115,000	35%	0.32	69	2.64	267	52	2,970	2,510	15%

Combined Subarea IV and V:
This combined subarea comprises about 25 acres. The following list shows the estimated surface covers:

- Roofs (directly connected): 5.4 acres
- Paved parking (directly connected): 1.4 acres
- Streets (0.4 curb-miles): 1.2 acres
- Service roads (0.2 curb-miles): 0.3 acres
- Small landscaped areas (B or sandy-loam soils, but assumed silty soils due to compaction): 17 acres

Five new buildings are in this area. The stormwater control options examined in this subarea included the following:

Controls

The wet pond in this area has the following approximate dimensions:

pond elevation (ft)	pond area (acres)
2	0.15*
4	0. 3*
5	0.5 (normal pool elevation, and invert elevation of 30^o v-notch weir).
7.5	0.98 (invert elevation of flood flow broad-crested weir). Normal maximum elevation during one and two year rains.
8.5	1.17 (approximate maximum pond elevation, or as determined based on flood flow analysis). Additional storage and emergency spillway may be needed to accommodate flows in excess of the design flood flow.

*These areas are approximate and need to be adjusted to ensure satisfactory safety ledge and deep portion of pond.

This pond has about 2.9 acre-ft of storage above 5 ft. The side slopes are about 7.7%. The large percolation pond is about 150 by 300 ft and has an infiltration rate of 0.5 in/hr.

The swale drainageways are about 2,800 ft in length and are similar to those described for subarea I. The sealed swales have a low infiltration rate of 0.05 in/hr.

Performance Calculations

The following tables summarize the expected performance of the different options examined. The expected volume reduction with this control option is about 73%, while the particulate solids expected control is about 95%.

Areas IV and V combined: Summary of Stormwater Quality Control (6 years: 1987-1992 rains)

	Runoff Volume				SS conc.	Particulate Solids Yield	
Practice	ft^3	Rv	% reduc.	Avg. peak reduction ratio and flushing ratio (for pond)	mg/L	lbs	% reduc.
Base conditions	1.11×10^7	0.37	-	-	179	124,000	-
Bio swales and pond	2.50×10^6	0.08	77%	0.96 (0.10)	32	4,990	94%
Sealed swales, pond, and large	2.79×10^6	0.09	75%	0.67 (0.36)	35	6,000	95%

percolation pond							

Areas IV and V combined: Summary of Stormwater Quality Control (40 years: 1959-1999 rains)

	Runoff Volume				SS conc.	Particulate Solids Yield	
Practice	ft^3	Rv	% reduc.	Avg. peak reduction ratio and flushing ratio (for pond)	mg/L	lbs	% reduc.
Base conditions	6.86×10^7	0.36	-	-	173	740,000	-
Bio swales and pond	1.24×10^7	0.07	82%	0.97 (0.08)	33	25,300	97%
Sealed swales, pond, and large percolation pond	1.51×10^7	0.08	78%	0.97 (0.35)	33	31,300	96%

Areas IV and V combined: Bioswales and Pond Performance for Different Rain Conditions

Rain Depth (inches)	Total Runoff Volume Before Controls (ft^3)	Total Runoff Volume at Outfall (ft^3)	Runoff Volume % Reduc.	Outfall Rv	Outfall CN	Flush. ratio in pond	Pond Influent SS (mg/L)	Pond Effluent SS (mg/L)	Total Part. Solids Yield Before Controls (lbs)	Outfall Part. Solids Yield (lbs)	Part. % Reduc.
0.01	12	0	100%	0.00	n/a	0	n/a	n/a	<1	<1	n/a
0.05	312	0	100%	0.00	n/a	0	n/a	n/a	<1	<1	n/a
0.10	1,040	0	100%	0.00	n/a	0	n/a	n/a	<1	<1	n/a
0.25	5,740	0	100%	0.00	n/a	0	n/a	n/a	34	<1	100%
0.50	14,300	0	100%	0.00	n/a	0	n/a	n/a	110	<1	100%
0.75	23,400	0	100%	0.00	n/a	0	n/a	n/a	192	<1	100%
1.00	32,400	0	100%	0.00	n/a	0	n/a	n/a	305	<1	100%
1.50	52,100	0	100%	0.00	n/a	0	n/a	n/a	550	<1	100%
2.00	74,200	15,900	79%	0.09	67	0.35	185	<10	858	3	100%
2.50	99,700	40,900	59%	0.18	70	0.91	200	13	1,280	34	97%
3.00	127,000	67,900	47%	0.25	71	1.50	220	23	1,750	100	94%
4.00	187,000	130,000	30%	0.36	72	3.17	250	48	2,970	398	86%

Conclusions and Recommendations

The following charts provide a summary of the performance of the final alternatives which include both bioswales and combined ponds (Alternative 1) or sealed swales combined wet ponds together with large percolation ponds (Alternative 2). Comparing the predicted performance levels of the final alternatives, results in the selection of the first alternative which will be significantly less expensive while performing relatively the same. The cost savings by not requiring approximately 7,600 LF of bioswales to be sealed and deleting three large percolation ponds with a total area of approximately 3.5 acres could total between $75,000 to $100,000.00.

Alternative 1

Combined Subareas and Total Site Conditions for Bioswales and Combined Wet Ponds

	Runoff Volume (ft^3/year)		Particulate Solids Concentration (mg/L)		Particulate Solids Discharge (lb/year)	
Combined Subareas	**Base Conditions**	**With Controls**	**Base Conditions**	**With Controls**	**Base Conditions**	**With Controls**
I and II	2.2×10^6	0.59×10^6 (73%)	210	33	28,000	1,200 (96%)
III	1.6×10^6	0.56×10^6 (65%)	190	27	18,800	940 (95%)
IV and V	1.7×10^6	0.31×10^6 (82%)	170	33	18,500	630 (97%)
Total site	5.5×10^6	1.46×10^6 (73%)	190	34	65,300	2,770 (96%)

The following summary is for the scenario where the industrial runoff water requires pretreatment before infiltration. The grass swales are sealed to reduce the infiltration before the pond pretreatment. The large percolation ponds therefore infiltrate the stormwater after the groundwater contamination potential is significantly reduced by treatment in the wet ponds.

Alternative 2

Combined Subareas and Total Site Conditions for Sealed Swales, Combined Wet Ponds and Large Percolation Ponds

	Runoff Volume (ft^3/year)		Particulate Solids Concentration (mg/L)		Particulate Solids Discharge (lb/year)	
Combined Subareas	**Base Conditions**	**With Controls**	**Base Conditions**	**With Controls**	**Base Conditions**	**With Controls**
I and II	2.2×10^6	0.45×10^6 (79%)	210	39	28,000	1,080 (96%)
III	1.6×10^6	0.33×10^6 (79%)	190	35	18,800	730 (96%)
IV and V	1.7×10^6	0.38×10^6 (78%)	170	33	18,500	780 (96%)
Total site	5.5×10^6	1.16×10^6 (79%)	190	36	65,300	2,590 (96%)