City of Seven Hills
Hemlock Creek Watershed
Basis of Design

January, 2013

09452

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Hemlock Creek Drainage Area
Basis of Design
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January 25, 2013

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A. Project Area

Hemlock Creek is generally considered a minor tributary of the Cuyahoga River. The drainage area within Seven Hills is shown in Figure 1.

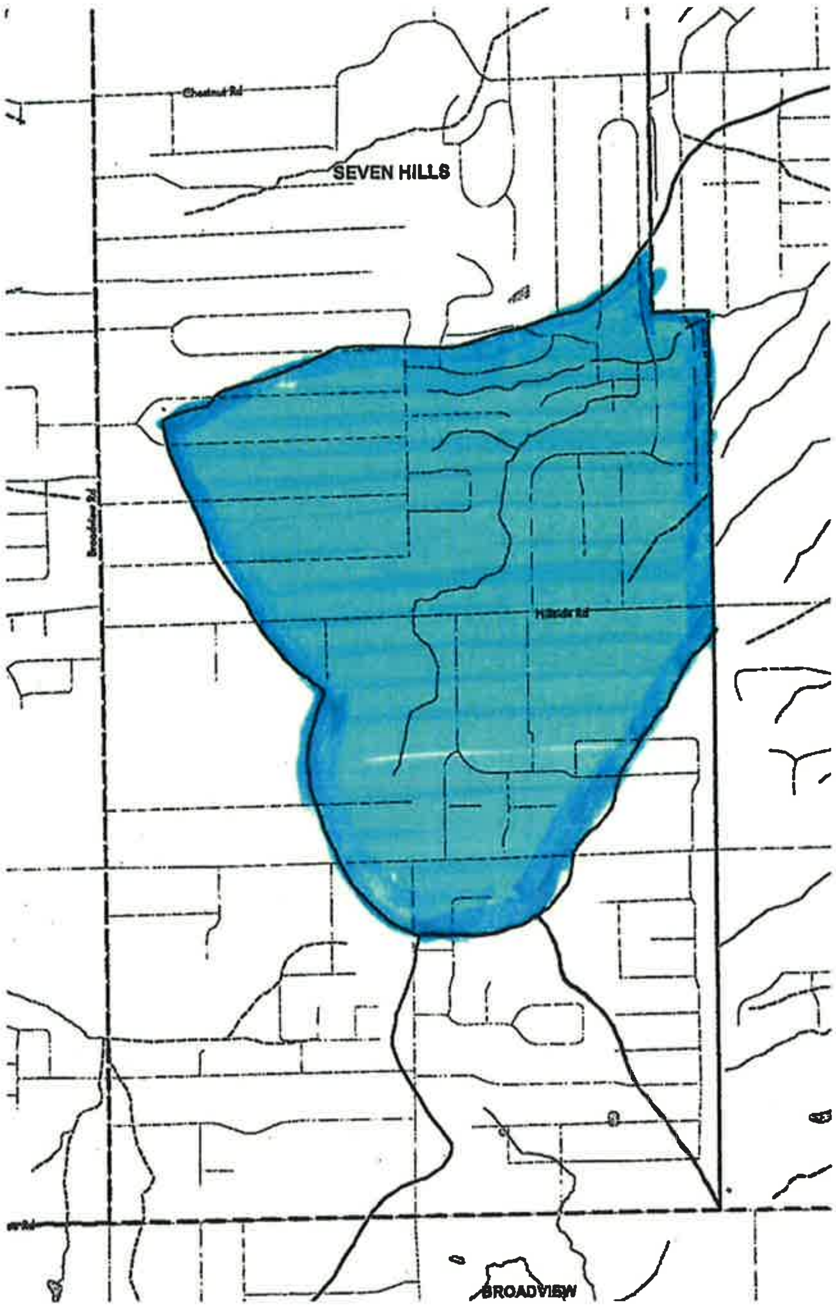

Figure 1 – Drainage Area

The sanitary sewer project area consists of the area of the City that is within the Hemlock Creek watershed and is also not currently served by sanitary sewers (Figure 2).

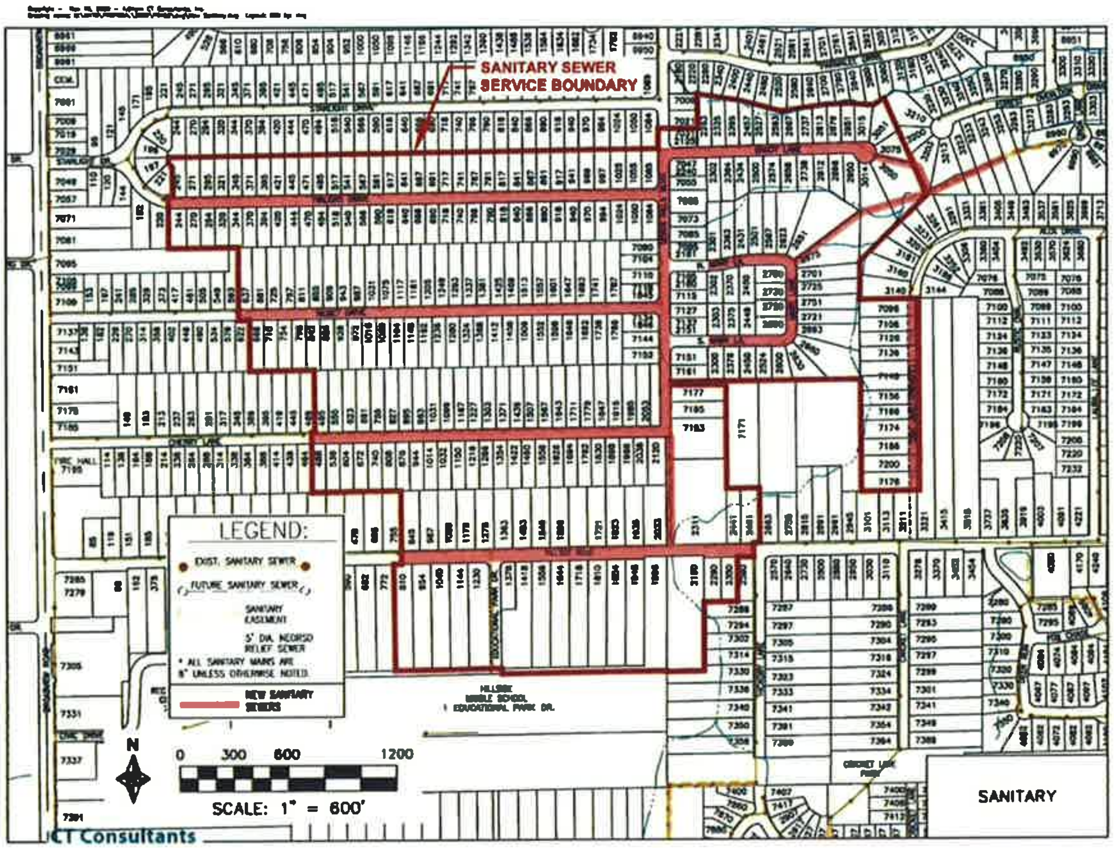

Figure 2 – Sanitary Sewer Project Area

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The storm sewer project area includes all of the area in the sanitary sewer project area plus storm sewers that are tributary to the storm sewers in the Hemlock Creek drainage area. This project area is shown in Figure 3.

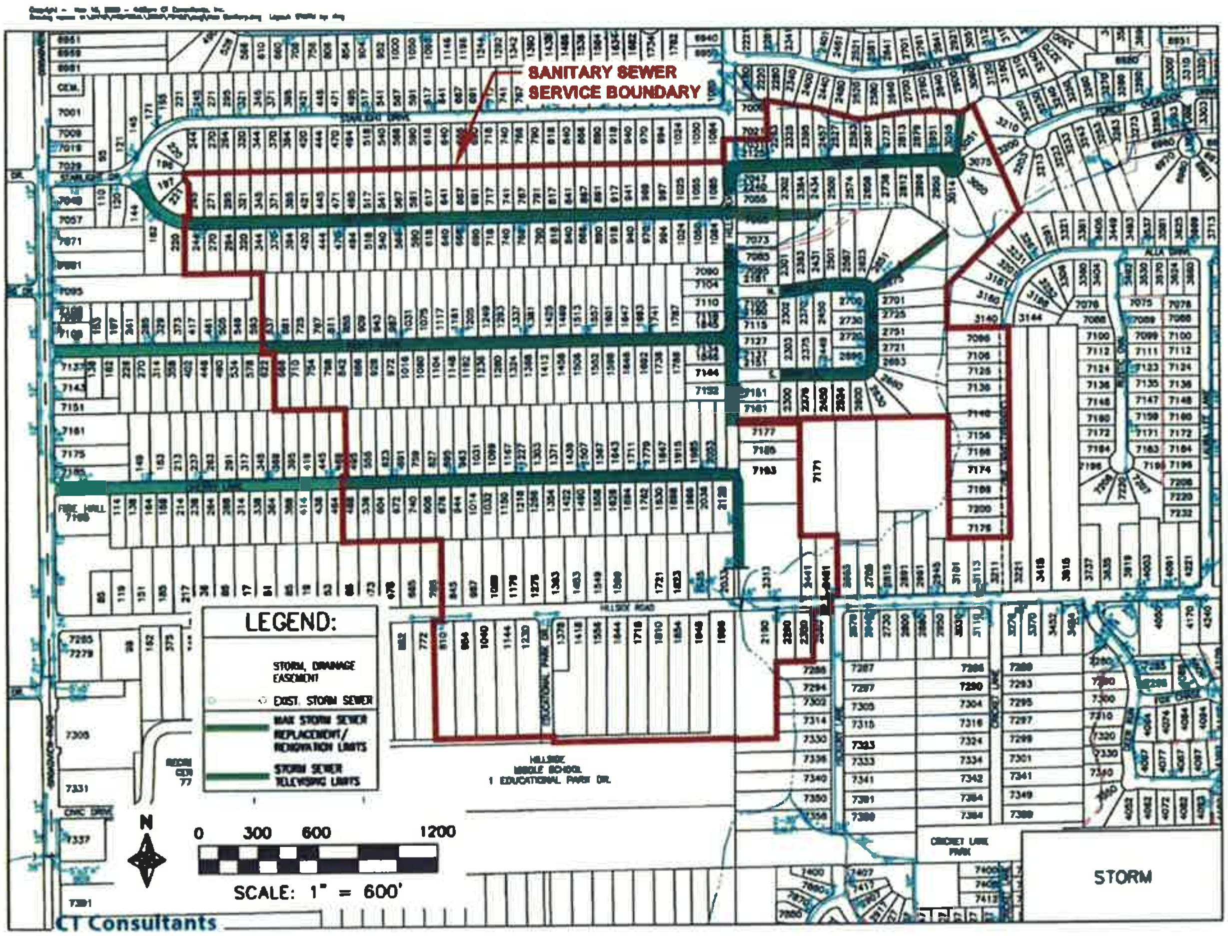

Figure 3 – Storm Sewer Project Area

The water main project area includes portions of the area in the sanitary sewer project area and is limited to Shady Lane, Seven Hills Boulevard, Mary Lane(s), and Oak Lane. This water line project area is shown in Figure 4.

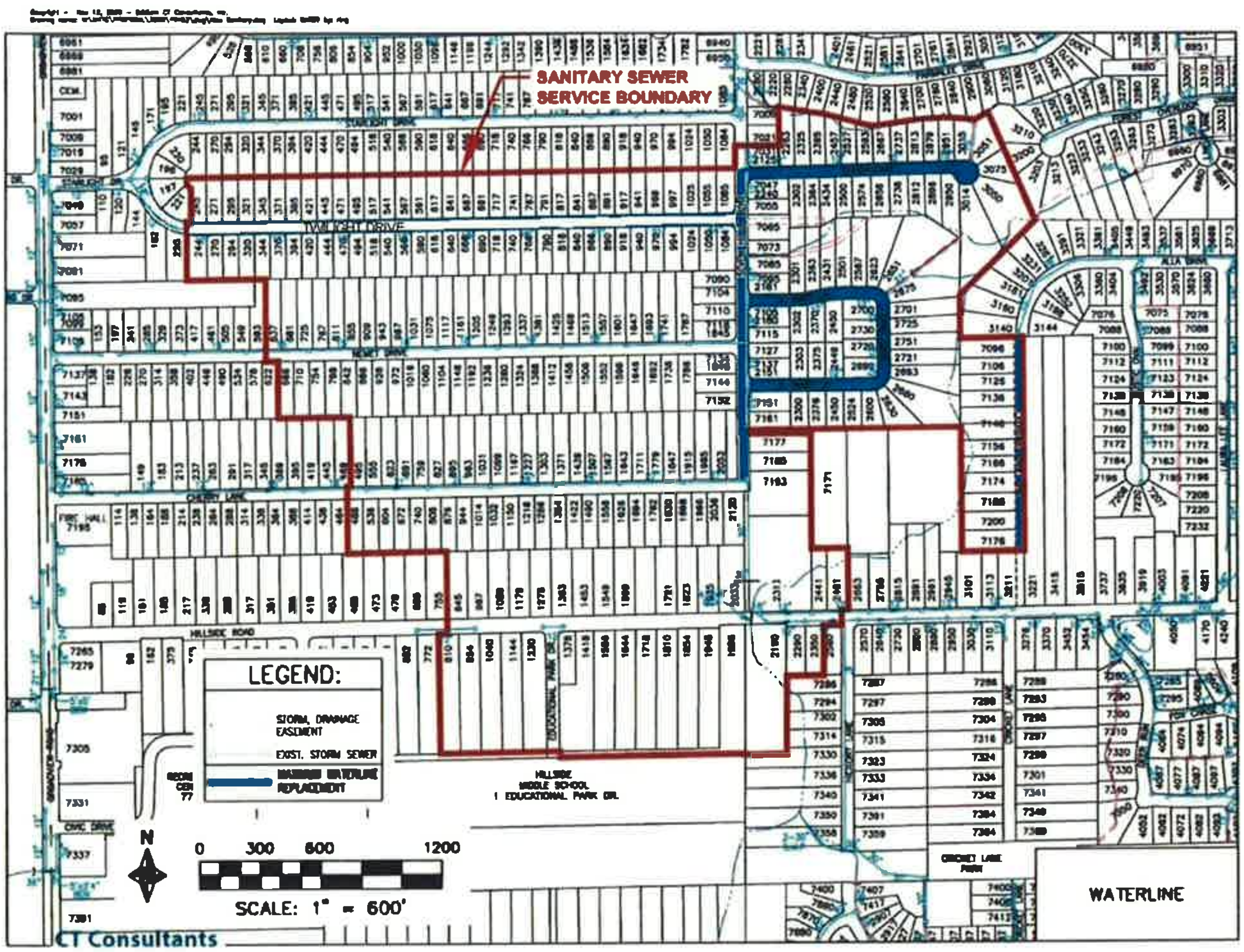

Figure 4 - Water Main Project Area

The pavement project area includes the same streets of the project area that are impacted by the project. This pavement project area is shown in Figure 5.

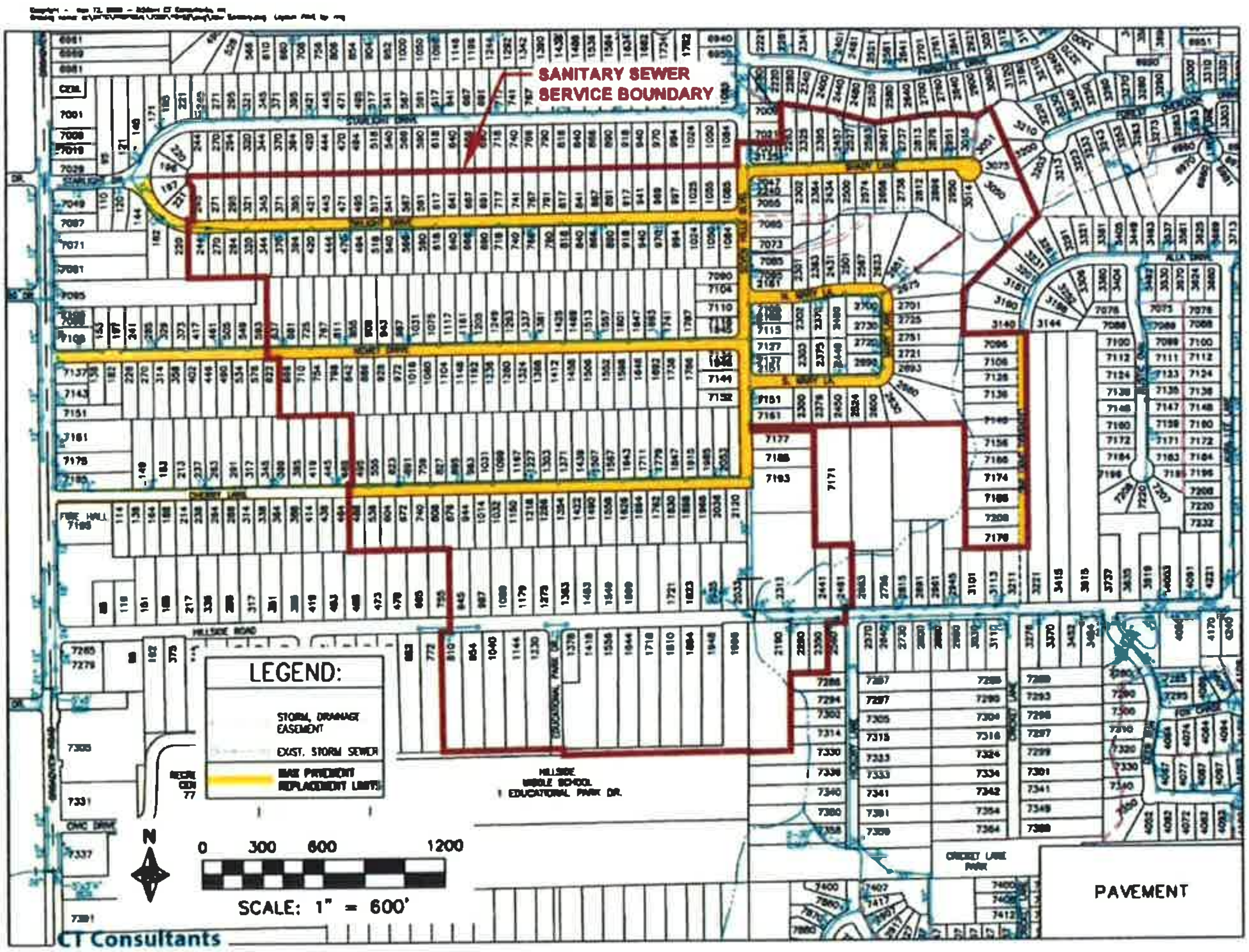

Figure 5 – Pavement Repair Project Area

B. Sanitary Sewer

1. Alignment in the City Master Plan

The City has a sanitary sewer master plan for the Hemlock Creek area that was developed in 2002 by Fultech Consulting Engineers of Valley View, Ohio. The alignment proposed in the plan consisted of approximately 1,500 linear feet of sanitary sewer which connected the project area to an existing sanitary sewer adjacent to and north of the Forest Overlook Detention Basin (Figure 6). Variations of this alignment along the same corridor were developed also but required additional lengths of sewer. The sanitary sewer corridor follows a heavily wooded, narrow, steep ravine roughly following Hemlock Creek between the Linda Lane/Forest Overlook Drive area and Mary Lane/Shady Lane area. The master plan corridor allows for gravity sewers with no pump stations. Construction of a sanitary sewer along this corridor would have been difficult since access is severely limited to the site by the surrounding existing homes in residential subdivisions. The 20-foot wide permanent existing easements are relatively narrow traversing down steep grades which provide no room to accommodate construction equipment needed to excavate and haul material to and from the site. The impact to gain access for construction equipment would be significant. The storm water management and erosion control required to protect water quality during construction will be extensive. To provide for long term sewer maintenance, the corridor would also require significant grading, an access road capable of carrying maintenance vehicles, and retaining walls; all of which would have resulted in significant alteration of the terrain and appreciable environmental challenges.

Other alignments with potentially less impact are considered preferable and are presented in this Basis of Design.

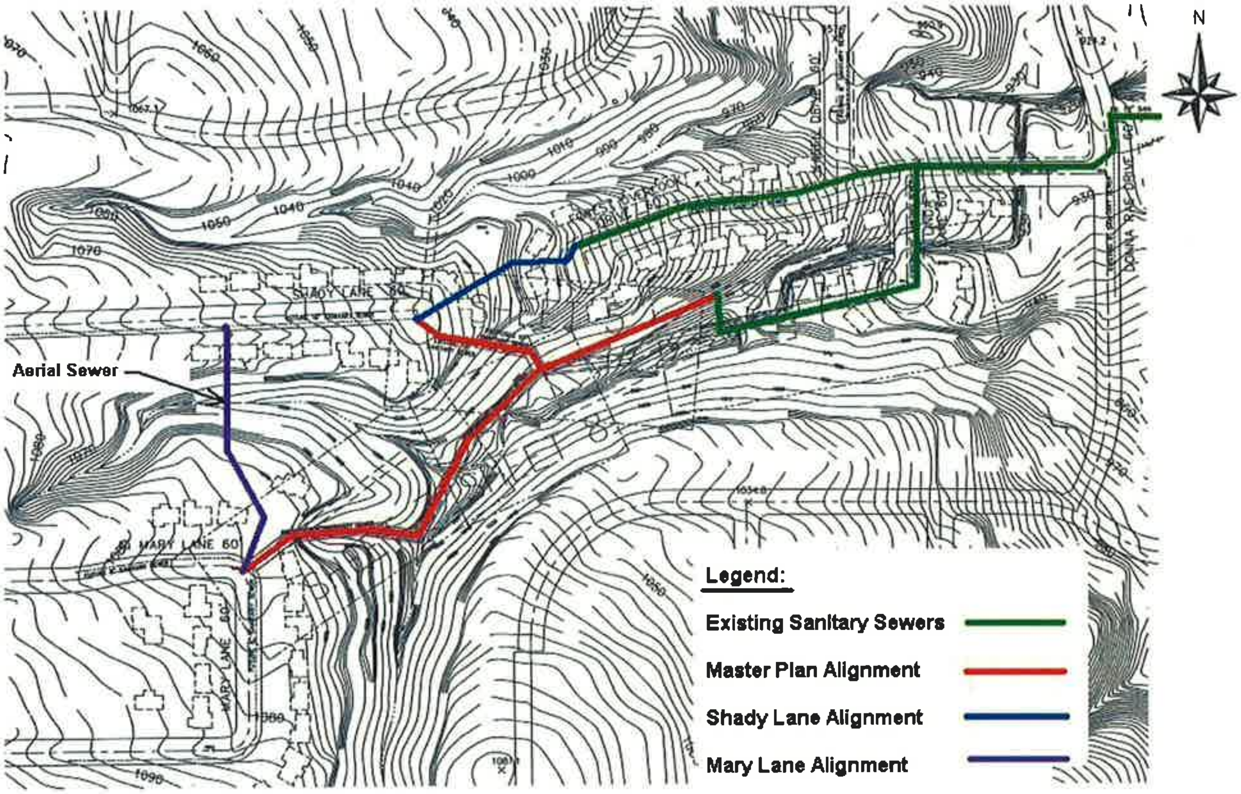

Figure 6 – Alternative Alignments

2. Alternative Alignment
   a. Description of Route

      The goal of the alternative alignment is to connect the Project Area by gravity with the city's existing sanitary sewer on Forest Overlook Drive, as in the Master Plan.

      An alignment that connects the cul-de-sac on the east end of Shady Lane with cul-de-sac on the west end of Forest Overlook Drive is a relatively short connection through a previously disturbed area. The alignment requires that easements be obtained between adjacent homes on the cul-de-sacs of each street. The connection can be accomplished by gravity and there is sufficient room between the homes to construct a sewer. The length of this connection is roughly 450 linear feet from centers of the cul-de-sacs.

The connection from Mary Lane to Forest Overlook needs a ravine crossing at some location. The proposed route connects Mary Lane to Forest Overlook by gravity via Shady Lane using an aerial crossing over the ravine between Mary Lane and Shady Lane. This connection length is roughly 580 feet. The crossing would be accomplished using an aerial sewer that would be roughly 100 feet long with a maximum height over the ravine of 20 feet (Figure 7). Both ends of the aerial sewer will have barrier fences (Figure 8) installed to guard against people attempting to climb or straddle on the aerial portion of the sewer.

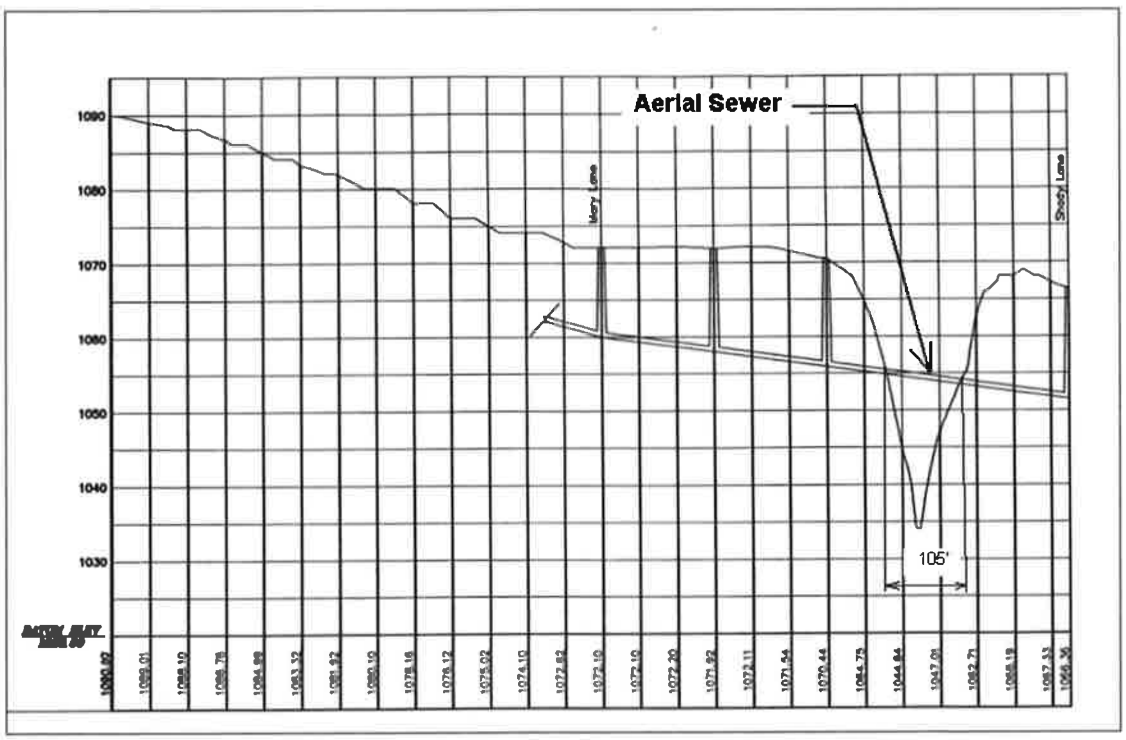

Figure 7 – Aerial Sewer Profile

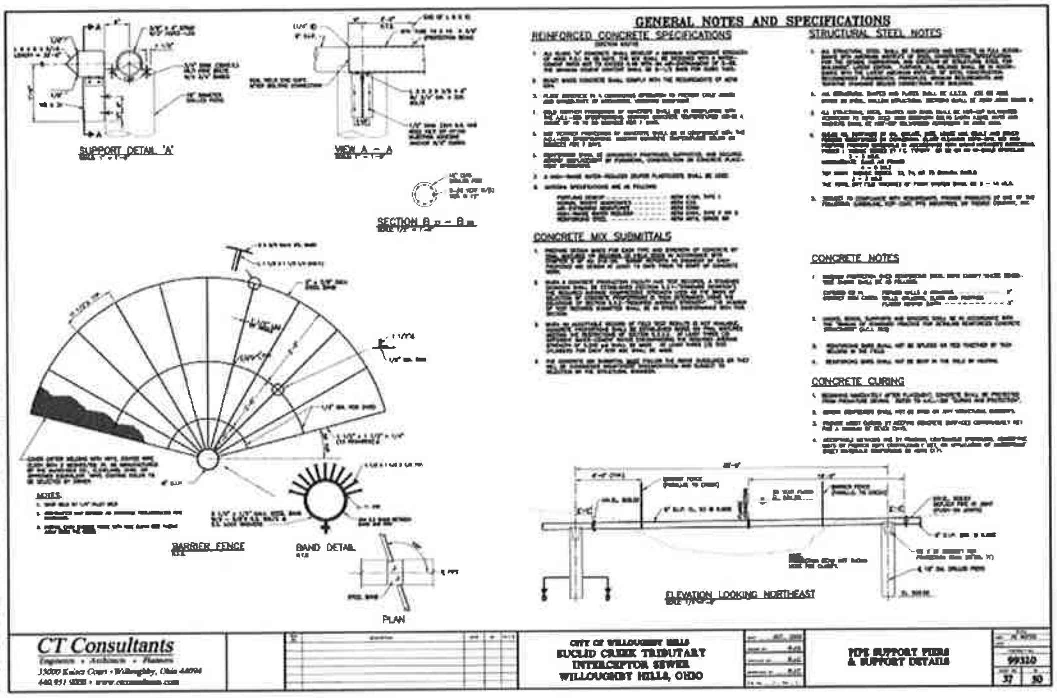

Figure 8 – Aerial Pipe Details

The total length of these two easements is 1,090 linear feet which is 30% less length than the master plan alignment.

The affected properties on Mary Lane, Shady Lane and Forest Overlook Drive are shown in Photos No. 1 through No. 4.

Photo 1 – 2651 North Mary Lane ↑

Photo 2 – 2658 & 2574 Shady Lane ↑

Photo 3 – 3051 & 3075 Shady Lane ↑

Photo 4 – 3200 & 3210 Forest Overlook Drive ↑

b. Creek Crossing Alternatives

i. Aerial Sewer

Crossing the ravine using an aerial sewer involves constructing abutments on the north and south side of the creek and designing a pipe to span between the abutments. This design would have no encroachment on the stream floodway and therefore would have no negative impact on the stream hydraulics.

ii. Embankment Sewer

The sewer could be encapsulated within an embankment that would cross the ravine. This design would require construction of a culvert to convey the stream flow through the embankment. Regardless of the design storm selected, the culvert will have an impact on the floodway and will require additional flood routing calculations to determine the exact impacts.

c. Preliminary Cost Comparison of Master Plan Route, Aerial Sewer Route, Embankment Route.

The preliminary costs for the three alignments discussed above are for construction related to connecting to the existing sanitary sewer only; no soft costs for engineering, easement acquisition, legal cost, and advertising are included. All costs are assumed to reflect prevailing wage costs using 2011 indices. Cost calculations are included in Appendix O.

Aerial Sewer: The preliminary opinion of probable construction cost is $286,000.

Embankment Sewer: The preliminary opinion of probable construction cost is $318,000.

Master Plan Route: The preliminary opinion of probable construction cost is $751,000.

d. Environmental Evaluation of Routes

i. Aerial Sewer: The aerial sewer alignment has the least impact of the three alternatives. The alignment is primarily through previously disturbed sublots on Mary Lane and Shady Lane. The aerial sewer is assumed to be able to span the ravine using two abutments and two piers with minimal infringement on the floodway. Some tree removal will be required in the immediate vicinity of the pipe, perhaps 10 feet on either side of the alignment. Visual impact is expected to be minimal after regrowth of the vegetation.

Freezing is not a concern with short runs of aerial sewers. The wastewater in a sewer is always well above the freezing temperature (typically the lowest temperature is 40°F) and the wastewater is not in contact with the aerial sewer long enough to develop into ice. Heat tracer wires, exterior pipe insulation, etc. do not provide any enhanced protection from freezing and are an unnecessary item that requires maintenance.

ii. Embankment Sewer: The embankment sewer alignment is expected to have more impact than the aerial sewer alignment due to the disturbance from building the culvert and placing the embankment around and over it. The embankment slope needed for stability will have a wider impact area than the aerial sewer, perhaps as much as 40 feet wide assuming a 1:1 slope. Tree removal will need to be complete in the affected area with removal of all stumps. The embankment will need to be maintained free of invasive plants or trees and the visual impact will be significantly more than the aerial sewer.

iii. Master Plan Route: The master plan alignment is expected to have the most impact of the three alignments since the alignment parallels a narrow steep ravine. Access for construction alone will have a significant disturbance including tree removal, regrading, drainage control, sediment control, terracing (excavation and embankment), and the need for a permanent access roadway. Retaining walls will be required as part of the terracing. The visual impact will be significant and vegetation control will be necessary to maintain access.

3. Route Recommendation

Based on the cost and impacts, it is recommended that the City consider the aerial sewer as the preferred route and the basis of design.

4. Sanitary Sewer Materials

The majority of sanitary sewers in the project area are expected to be constructed at normal depths and using PVC pipe (ASTM D3034) SDR 26. For the aerial sewer crossing, ductile iron pipe will be used with a class thickness based on the anticipated maximum span.

5. Sanitary Sewer Sizing

The anticipated flow from each tributary area is provided in Table 1.

Table 1 – Sanitary Sewer Flow

Tributary Area	Homes	ADF/Home (1)	ADF (gpd)	ADF Total (gpd)	Peak Flow (gpd)(2)
Hillside Road	31	400 gpd	12,400		
Cherry Lane	49	400 gpd	19,600		
Nemet Drive	53	400 gpd	21,200		
Twilight Drive	68	400 gpd	27,200		
Seven Hills Blvd.	23	400 gpd	9,200		
Mary Lanes	30	400 gpd	12,000		
Shady Lane	26	400 gpd	10,400		
Connection to Forest Overlook Drive	280			112,000	458,200
Oak Lane	11	400 gpd	4,400	4,400	19,400

Notes:

(1) Average Daily Flow (ADF) per home based on an assumed average of 4 people per home at 100 gpd per person. Per Ten State Standards 11.243(b), 100 gpd when used with the peaking factor (see Note 2) is intended to include normal infiltration.

(2) The peaking factor from Ten States Standards is from Chapter 10, Figure 1 and is computed using the formula (18+P^.5)/(4+P^.5) where P is the population in thousands.

An 8-inch diameter sewer at a minimum slope of 0.40% at a Manning's n of 0.013 has a capacity of 485,000 gpd, which is sufficient for the anticipated peak flow. Given the existing grades on Shady Lane, it is expected the sewer will be installed at a steeper slope, and sufficient capacity will be provided.

6. Downstream Sanitary Sewer Capacity: Flow monitoring was done at two locations in the sewer system downstream of the proposed connection points. One meter was located at the end of Forest Overlook Drive at the intersection of Donna Rae Drive. This site had very little flow and has adequate capacity for the proposed sanitary sewer extension. The second meter site was on Cheryl Ann Drive in Independence just north of the Seven Hills corporation line. The calculated capacity of the sewer is sufficient during dry weather to accept the additional sanitary flow from the proposed sewer extension. However, the

10-year, 1-hour design storm I/I rate is calculated to be 6.2 mgd which exceeds the apparent capacity of the sewer, observed to be 3.5 mgd based on Manning's curve.

The City should investigate the sources of rain derived inflow and infiltration in the area tributary to Cheryl Ann Drive and make corrections. This should be done regardless of construction of the construction of the new sanitary sewers.

A copy of the Flow Monitoring Report is included in Appendix E.

C. Drainage/Pavement

1. Description of Drainage Area: The drainage area contributing to the existing storm sewer systems within the project limits consists of slightly over 129 acres of low density residential development that is conveyed to five (5) separate storm sewer outlet points. These contributing drainage areas are shown in Figure 9.

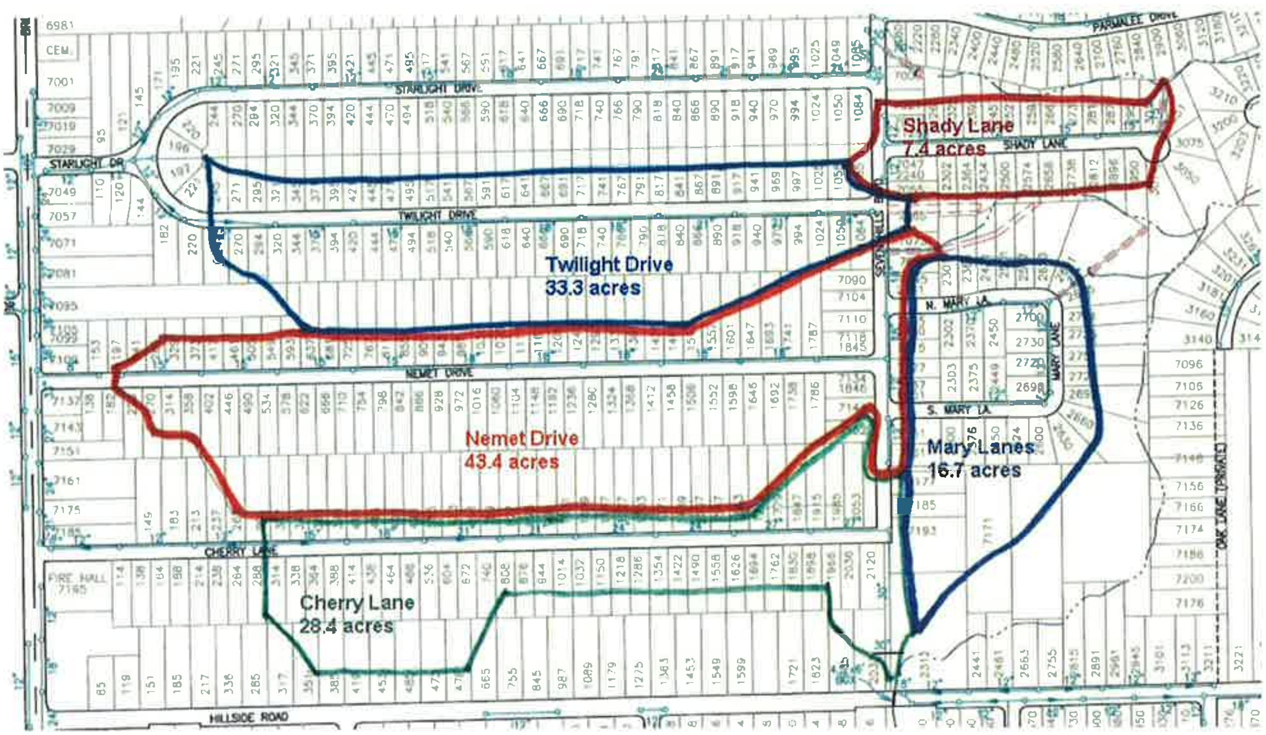

Figure 9 – Drainage Areas

The sub catchments for the drainage area are shown in Figure 10 and are generally delineated by the downstream catch basin or inlet.

Figure 10 - Subcatchments

2. Design Storm: A design storm is the rainfall intensity and duration used to form the basis of design for a storm water improvement. A design storm is typically associated with a recurrence interval i.e. a 10-year storm would statistically have a 100% chance of happening in any given 10 year period….or has a 10% chance of happening in any year. In essence, a design storm recurrence frequency is the probability that a given storm will not be exceeded. Typically, the design storm for a drainage improvement is driven by local ordinances which for residential areas may be a 5 year or 10 year recurrence interval.

3. Adequacy of System for Design Storm Conveyance: Based on a preliminary analysis, it appears the existing storm water drainage system was designed to convey a 5 or a 10 year design storm. These existing storm sewer system calculations are shown in Table 2. BMP's incorporated into the project will not affect the conveyance capacity of the drainage system in less frequent storms, but will reduce the flow of water in the drainage system in minor (<1 year) events.

The storm sewer system was televised to determine the physical condition of the conduits and inlet structures. There are areas of the system that need to be repaired or replaced as shown in Figure 11.

Figure 11 – Storm Drainage Pipe Needing Repair or Replacement

The log of the television inspection is included in the Appendix D.

Table 3 shows the estimated cost to restore the storm sewer system to function as originally designed and constructed.

Table 2

Calculation of Storm Flow and Sewer Capacity

10 year Recurrence Interval

DONE BY: RSW DATE: 4/10/2012

CHECKED BY: DATE:

MANNINGS "N": 0.013 YEAR DESIGNED: 10

STORM SEWER COMPUTATION

PROJECT NAME: Seven Hill - Hemlock Creek (Existing Conditions) SHEET 1 OF 1

PROJECT NUMBER: 09452 P/D

1	2	3	4	5	6		7		8	9	10		11	12	13	14	15	16	17	18	19	20	21	22	23	24
STRUCTURE NO.	MH OR CB	STATION	SIDE	AREA NO.	DRAINAGE AREA (Acres)		TIME OF CONCENTRATION (minutes)		RAIN-FALL (in/hr)	COEFF OF RUNOFF	COLUMN 4 X COLUMN 7		DISCHARGE (CFS) Q=CIA	PIPE SIZE (in)	LENGTH OF RUN (ft)	SLOPE OF RUN (%)	VELOCITY (ft/sec)	PIPE CAPACITY (cfs)	INVERT ELEV INTO MH	INVERT ELEV OUT OF MH	HYD GRADE RAINFALL	HYD GRADE DISCHARGE	FRICT SLOPE (%)	HEADLOSS (ft)	ELEV OF HYD GRADE	CASTING ELEV.
					INC. A	SUM A	INC. T	SUM T	I	C	INC. CA	SUM CA	SUM Q	D	L	S	V	Q			I hg	Q hg	Sf	H		
	CHERRY LANE																									
7739	MH				4.32	4.32	30.0	30.0	2.79	0.42	1.81	1.81	5.06	15	312	0.42	3.4	4.30		1128.45						
7153	MH				4.63	8.95	1.5	31.5	2.71	0.42	1.94	3.76	10.19	24	298	0.54	5.3	16.83	1125.13	1124.93						
7063	MH				4.48	13.43	0.9	32.5	2.66	0.42	1.88	5.64	15.00	24	600	0.52	5.2	16.39	1123.32	1123.32						
6731	MH				1.76	15.19	1.0	34.4	2.56	0.42	0.74	6.38	16.33	24	300	0.50	5.1	16.00	1120.17	1120.17						
6682	MH				2.63	17.82	1.0	35.4	2.52	0.42	1.10	7.48	18.86	24	300	1.37	8.4	26.51	1118.67	1118.67						
6426	MH				2.47	20.29	0.5	35.9	2.49	0.42	1.04	8.52	21.22	24	300	1.53	8.0	28.01	1114.55	1114.55						
6360	MH				2.30	22.59	0.6	36.5	2.47	0.42	0.97	9.49	23.43	24	276	2.79	12.0	37.76	1109.95	1109.95						
4875	MH				2.74	25.33	0.4	36.9	2.45	0.42	1.15	10.64	26.06	30	87	0.61	6.5	32.09	1102.26	1102.26						
4857	MH				2.61	27.94	0.2	37.1	2.44	0.42	1.10	11.73	28.63	30	461	1.04	8.5	41.90	1101.85	1101.85						
7993	MH				0.22	28.16	0.9	38.0	2.40	0.42	0.09	11.83	28.39	30	15	0.67	6.8	33.49	1097.04	1096.74						
7981	MH				0.27	28.43	0.0	38.0	2.40	0.42	0.11	11.94	28.66	30	30	1.00	8.4	41.02	1096.64	1096.54						
HW																			1096.24							
	NEMET DRIVE and SEVEN HILLS BOULEVARD																									
2383	MH				2.12	2.12	30.0	30.0	2.79	0.42	0.89	0.89	2.48	15	305	0.66	4.3	5.20		1117.25						
2197	MH				2.84	4.96	1.2	31.2	2.71	0.42	1.19	2.08	5.65	18	300	0.30	3.3	5.79	1115.25	1115.15						
2263	MH				0.00	4.96	1.6	32.7	2.63	0.42	0.00	2.08	5.48	18	295	0.42	3.8	6.78	1114.22	1114.02						
1939	MH				4.20	9.16	1.3	34.0	2.57	0.42	1.76	3.85	9.89	18	298	0.85	5.5	9.70	1112.79	1112.59						
1784	MH				4.30	13.46	0.9	34.9	2.53	0.42	1.81	5.65	14.30	21	302	0.60	5.2	12.60	1110.05	1109.85						
1718	MH				3.19	16.65	1.0	35.9	2.49	0.42	1.34	6.99	17.41	21	302	0.94	6.4	15.34	1107.94	1107.84						
1660	MH				6.17	22.82	0.8	36.7	2.45	0.42	2.59	9.58	23.48	21	303	1.93	9.2	22.04	1105.01	1105.01						
1607	MH				3.91	26.73	0.6	37.2	2.43	0.42	1.64	11.23	27.28	24	293	1.64	9.2	28.99	1099.15	1099.05						
1336	MH				4.78	31.51	0.5	37.8	2.41	0.42	2.01	13.23	31.89	24	293	1.97	10.1	31.75	1094.24	1094.24						
1265	MH				4.52	36.03	0.5	38.2	2.39	0.42	1.90	15.13	36.17	24	279	2.46	11.3	35.45	1088.47	1088.37						
4490	MH				3.24	39.27	0.4	38.7	2.37	0.42	1.36	16.49	39.09	30	165	1.20	9.2	44.03	1081.52	1081.22						
4456	MH				0.75	40.02	0.3	39.0	2.36	0.42	0.32	16.81	39.67	30	238	1.12	8.9	43.44	1079.24	1079.24						
4276	MH				3.41	43.43	0.4	39.4	2.34	0.42	1.43	18.24	42.68	30	190	1.00	8.4	41.02	1076.57	1076.57						
HW																			1074.67							
	SEVEN HILLS BOULEVARD - SIDE RUN																									
4711	MH				0.55	0.55	30.0	30.0	2.79	0.42	0.23	0.23	0.64	12	153	2.27	6.8	5.37		1092.78						
4678	MH				1.93	2.48	0.4	30.4	2.76	0.42	0.81	0.81	2.24	12	245	2.16	6.7	5.24	1089.31	1089.21						
4490	MH																		1083.92							
	TWILIGHT DRIVE																									
3799	MH				0.00	0.00	30.0	30.0	2.79	0.45	0.00	0.00	0.00	12	319	0.30	2.5	1.98		1118.27						
3718	MH				2.43	2.43	2.1	32.1	2.79	0.45	1.09	1.09	3.06	15	298	0.92	5.0	6.19	1117.30	1117.30						
3406	MH				4.80	7.23	1.0	33.1	2.73	0.45	2.16	3.25	8.88	18	300	0.95	5.8	10.24	1114.56	1114.56						
3286	MH				5.26	12.49	0.9	34.0	2.68	0.45	2.37	5.62	15.06	18	299	1.28	6.7	11.90	1111.68	1111.68						
3353	MH				3.70	16.19	0.7	34.7	2.64	0.45	1.67	7.29	19.23	18	301	2.37	9.1	16.16	1107.84	1107.74						
3069	MH				3.92	20.11	0.6	35.3	2.62	0.45	1.76	9.05	23.71	18	298	2.47	9.3	16.51	1100.62	1100.62						
3139	MH				3.95	24.06	0.5	35.8	2.59	0.45	1.78	10.83	28.04	24	301	2.65	11.7	36.83	1093.26	1093.16						
2769	MH				3.76	27.82	0.4	36.2	2.57	0.45	1.69	12.52	32.17	24	325	1.36	8.4	26.35	1085.18	1085.18						
2689	MH				4.11	31.93	0.6	36.9	2.54	0.45	1.85	14.37	36.50	24	184	1.70	9.4	29.46	1080.77	1080.67						
2727	MH				1.33	33.26	0.3	37.2	2.53	0.45	0.60	14.97	37.87	24	195	1.00	7.2	22.62	1077.55	1077.55						
HW																			1075.60							
	SOUTH MARY AND MARY LANE																									
6137	MH				1.33	1.33	30.0	30.0	2.79	0.48	0.64	0.64	1.78	12	324	2.12	6.6	5.18		1077.79						
6050	MH				6.19	7.52	0.8	30.8	2.77	0.48	2.97	3.61	10.00	12	51	2.59	7.3	5.73	1070.93	1070.43						
6037	MH				0.12	7.64	0.1	30.9	2.76	0.48	0.06	3.67	10.12	12	166	2.43	7.1	5.55	1069.11	1069.11						
5786	MH				1.94	9.58	0.4	31.3	2.70	0.48	0.93	4.60	12.42	12	192	1.72	5.9	4.67	1065.08	1065.08						
5819	MH				5.69	15.27	0.5	31.0	2.66	0.48	2.73	7.33	19.50	12	40	6.50	11.6	9.08	1061.78	1061.78						
5707	MH				1.41	16.68	0.1	31.9	2.63	0.48	0.68	8.01	21.06	12	100	1.00	4.5	3.56	1059.18	1058.98						
HW																			1057.98							
	NORTH MARY LANE																									
5581	MH				1.03	1.03	30.0	30.0	2.79	0.48	0.49	0.49	1.38	12	223	7.15	12.1	9.53		1079.68						
5847	MH				2.61	3.64	0.3	30.3	2.76	0.48	1.25	1.25	3.46	12	129	1.36	5.3	4.15	1063.73	1063.63						
5819	MH																		1061.88							
	SEVEN HILLS BOULEVARD and SHADY LANE																									
4170	MH				0.43	0.43	30.0	30.0	2.79	0.68	0.29	0.29	0.82	12	80	1.86	6.2	4.66		1074.87						
4133	MH				0.08	0.51	0.2	30.2	2.77	0.68	0.05	0.35	0.96	12	67	2.91	7.7	6.06	1073.38	1073.38						
4115	MH				0.99	1.50	0.1	30.4	2.76	0.68	0.67	1.02	2.82	12	301	1.64	5.8	4.56	1071.43	1069.93						
5017	MH				0.58	2.08	0.9	31.2	2.70	0.68	0.39	1.41	3.82	12	282	2.99	7.6	6.16	1064.89	1064.79						
5066	MH				2.23	4.31	0.6	31.8	2.68	0.68	1.52	2.93	7.80	12	258	3.81	8.9	6.96	1056.57	1056.17						
5225	MH				1.34	5.65	0.5	32.3	2.65	0.68	0.91	3.84	10.10	15	254	3.86	10.3	12.70	1046.34	1046.34						
5416	MH				1.74	7.39	0.4	32.7	2.61	0.68	1.18	5.03	13.12	15	100	1.00	5.3	6.46	1036.53	1036.43						
HW																			1035.43							

Table 3
Hemlock Creek
Storm Sewer Condition Assessment

Street Name	From CB	To CB	Comments	Pipe size	Replacement length (ft)	Replacement Cost
				(in)		
Nemet Drive	2363	2197	Debris in pipe run	15		
	2197	2263	Debris in pipe run	18		
	2263	1939	No repairs recommended	18		
	1939	1784	No repairs recommended	18		
	1784	1718	No repairs recommended	18		
	1718	1660	Replace pipe @ 282 ft	21	12	$ 960.00
	1660	1607	No repairs recommended	21		
	1607	1336	Replace pipe @ 57, 73 & 170 ft	21	36	$ 2,880.00
	1336	1265	Replace pipe @ 66, 267	21	24	$ 1,920.00
	1265	4490	Replace entire pipe length	21	279	$ 22,320.00
Twilight Drive	4091	3799	Replace pipe @ 70 ft	12	12	$ 600.00
	3799	3718	Replace pipe @ 77 ft, from 300 ft to CB 3718	12	36	$ 1,800.00
	3718	3406	No repairs recommended	15		
	3406	3286	No repairs recommended	18		
	3286	3353	Replace pipe from 225-240 ft	18	15	$ 1,050.00
	3353	3069	Replace pipe from 30-60 ft	18	30	$ 2,100.00
	3069	3139	Replace from CB 3067 - 55 ft, @ 93 ft	18	65	$ 4,550.00
	3139	2769	Replace from 123-170 ft	24	47	$ 4,700.00
	2689	2769	Replace from CB 2689 to 45 ft, 75-140 ft, 165-175 ft	24	120	$ 12,000.00
	2689	2727	Replace entire pipe length	24	185	$ 18,500.00
	2727	2727A	No repairs recommended	24		
	2727A	Outlet	No repairs recommended	30		
Cherry Lane	7339	7672	Debris in pipe run	12		
	7672	7848	No repairs recommended	12		
	7848	7783	No repairs recommended	12		
	7783	7786	No repairs recommended	18		
	7339	7153	Debris in pipe run	15		
	7153	7063	Replace entire pipe length	18	299	$ 20,930.00
	7063	6731A	Replace entire pipe length	21	299	$ 23,920.00
	6731A	6731	Replace entire pipe length	21	298	$ 23,840.00
	6731	6682	Replace pipe from CB 6731 - 61 ft, 176 ft - CB 6682	24	185	$ 18,500.00
	6682	6426	Replace pipe from 11 - 16 ft, 236 - 271 ft	24	40	$ 4,000.00
	6426	6360	No repairs recommended	27		
	6360	4875	No repairs recommended	27		
	4875	4857	Replace pipe from CB 4875 to 22 ft	30	22	$ 3,080.00
Seven Hill Blvd.	4857	7993	Replace entire pipe length	30	461	$ 64,540.00
	7993	7981	Pipe from northwest is blocked with debris	30		$ -
	7981	outfall	Replace entire pipe length	30	30	$ 4,200.00

Table 3
Hemlock Creek
Storm Sewer Condition Assessment

Street Name	From CB	To CB	Comments	Pipe size	Replacement length (ft)	Replacement Cost
				(in)		
	Unknown	4711	No repairs recommended	12		
	4711	4678	No repairs recommended	12		
	4678	4490	No repairs recommended	12		
	4490	4466	Replace pipe from 85 - 105 ft	24	20	$ 2,000.00
	4466	4276	No repairs recommended	24		
	4276	outlet	No repairs recommended			
	4276	4290	Replace pipe @ 34 ft	24	6	$ 600.00
	4170	4133	Unable to televise, CB 4133 full of debris, unable to open CB 4170	12		
	4115	4133	Replace pipe from CB 4115 to 5 ft, @ 48', CB 4133 full of debris	12	20	$ 1,000.00
	4115	4115A	Replace pipe @ 48 ft, Debris in pipe run	12	12	$ 600.00
Shady Lane	4115	5017	No repairs recommended	12		
	5017	5017A	Replace pipe at 29 ft and from 100 ft to CB 5017A	12	185	$ 9,250.00
	5017A	5225	Replace entire pipe length	15	282	$ 16,920.00
	5225	5416	Replace entire pipe length	15	258	$ 15,480.00
	5416	outlet	Replace pipe from 78 - 158 ft	15	80	$ 4,800.00
	5416	5365	Pipe appears to be blocked at 80 ft from 5416. Further investigation needed. Televised section of pipe needs replacement	12	68	$ 3,400.00
N. Mary Lane	5581	5847	No repairs recommended	12		
	5847	5819	Unable to televise due to 4"- 6" of debris	12		
S. Mary Lane	6052	6052A	No repairs recommended	12		
	6052A	6307	No repairs recommended	12		
Mary Lane	6307	5786	Replace pipe @ 20 ft	12	6	$ 300.00
	5786	5819	Replace pipe @ 24 ft	12	6	$ 300.00
	5819	5707	No repairs recommended	12		
	5707	5707A	Repair pipe at joint @ 45 ft	12	6	$ 300.00
	5707A	Outlet	No repairs recommended	21		
				Totals	3,444	$ 291,340

Legend

(green)	Pipe repair needed
(orange)	Unable to televise
(pink)	Debris in pipe
(yellow)	No repairs recommended

In addition to restoring the storm sewer system and structures to original capacities, a preliminary analysis of the existing inlet basins, storm sewers, and roadside swales indicates that the current system is inefficient in capturing overland flow. It appears from the flooding incidents, field review of the project conditions and physical limitations of the existing structures that the more significant storm events are bypassing existing drainage structures and developing a flow path within the roadway, most notably on Shady Lane and the Mary Lanes. A series of drainage improvements to capture the overland flow is proposed including additional inlet basins, storm sewers, reconfigured roadside swales and roadway curbing improvements. These additional storm water facility improvements are shown in Figures 12 and 13.

Figure 12 – Shady Lane Drainage Improvements

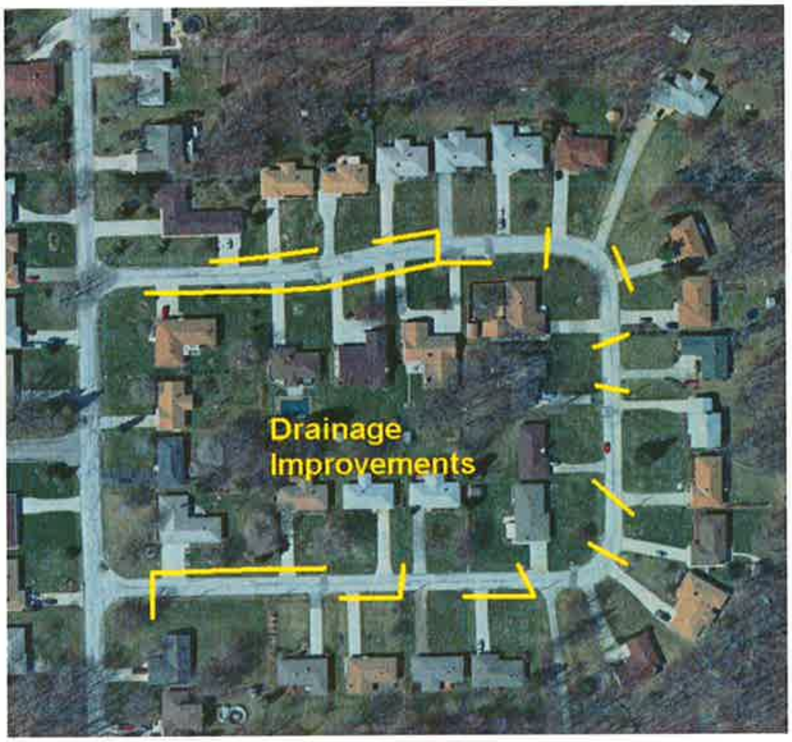

Figure 13 – Mary Lanes Drainage Improvements

Table 4 shows the estimated cost to provide these additional storm water management improvements.

Table 4
Hemlock Creek Storm Sewer Investigation
Preliminary Storm Sewer Improvements

Street Name	From Address	To Address	Pipe size (in)	Pipe length (ft)	Cost	Catch Basin 2-2B	Cost	Catch Basin 3A	Cost	Storm Manhole	Cost
Seven Hill Blvd.	7135	7127					$ -		$ -	1	$ 3,000.00
	7095	7085					$ -		$ -	1	$ 3,000.00
	7065	7065					$ -		$ -	1	$ 3,000.00
Shady Lane	7031	2263				1	$ 1,800.00		$ -		$ -
	2302	2263	12	44	$ 2,200.00	1	$ 1,800.00		$ -		$ -
	2364	2325	12	38	$ 1,900.00	1	$ 1,800.00		$ -		$ -
	2434	2500	12	73	$ 3,650.00	1	$ 1,800.00		$ -		$ -
	2500	2457	12	35	$ 1,750.00	2	$ 3,600.00		$ -		$ -
	2457	2457				1	$ 1,800.00		$ -		$ -
	2574	2527	12	36	$ 1,800.00	2	$ 3,600.00		$ -		$ -
	2658	2667	12	38	$ 1,900.00	2	$ 3,600.00		$ -		$ -
	2738	2737	12	38	$ 1,900.00	2	$ 3,600.00		$ -		$ -
	2738	2813	12	36	$ 1,800.00	2	$ 3,600.00		$ -		$ -
	2869	2879	12	36	$ 1,800.00	2	$ 3,600.00		$ -		$ -
	3014	3051	12	209	$ 10,450.00	3	$ 5,400.00	3	$ 7,500.00		$ -
N. Mary Lane	7105	2302	12	152	$ 7,600.00	1	$ 1,800.00		$ -		$ -
	2302	2302	12	75	$ 3,750.00	1	$ 1,800.00		$ -		$ -
	7095	2301	12	65	$ 3,250.00	1	$ 1,800.00		$ -		$ -
	2301	2301	12	66	$ 3,300.00	1	$ 1,800.00		$ -		$ -
	2302	2370	12	62	$ 3,100.00	1	$ 1,800.00		$ -		$ -
	2370	2450	12	95	$ 4,750.00	1	$ 1,800.00		$ -		$ -
	2363	2450	12	115	$ 5,750.00	2	$ 3,600.00		$ -		$ -
	2450	2700	12	65	$ 3,250.00	1	$ 1,800.00		$ -		$ -
	2567	2700	12	45	$ 2,250.00	2	$ 3,600.00		$ -		$ -
S. Mary Lane	7151	2303	12	193	$ 9,650.00	2	$ 3,600.00		$ -		$ -
	2303	2303	12	68	$ 3,400.00	1	$ 1,800.00		$ -		$ -
	2375	2375				1	$ 1,800.00		$ -		$ -
	2376	2449	12	116	$ 5,800.00	3	$ 5,400.00		$ -		$ -
	2450	2690	12	130	$ 6,500.00	3	$ 5,400.00		$ -		$ -
Mary Lane	2660	2690	12	40	$ 2,000.00	1	$ 1,800.00		$ -		$ -
	2687	2720	12	58	$ 2,900.00	2	$ 3,600.00		$ -		$ -
	2730	2701	12	38	$ 1,900.00	1	$ 1,800.00		$ -		$ -
	2701	2675	12	50	$ 2,500.00	1	$ 1,800.00		$ -		$ -
				2016	$ 100,800.00	46	$ 82,800.00	3	$ 7,500.00	3	$ 9,000.00
									Total All Improvements		$ 200,100.00

Pipe dia	Cost/lf		Catch Basin No. 2-2B		Catch Basin No. 3A		Storm Manhole
12	50		1800		2500		3000
15	60						
18	70						
21	80						
24	100						
27	120						
30	140						

In addition, it is recommended that the storm water runoff contributing to South Mary Lane from catchment S-SML4S be intercepted by a diversion swale at the south property lines of the sub lot along the southerly side of South Mary Lane. This diversion swale will be directed toward the existing ravine along the east side of Mary Lane. This will divert approximately 3.5 acres of storm water runoff away from South Mary Lane.

4. Water Quality: While BMP's are not expected to reflect a marked reduction in storm water quantity for less frequent storms, BMP's do have an impact on storm water quality. Studies indicate that pollutant reduction is accomplished through a combination of filtering, settling, and evaporation. Additionally, BMP's are required in accordance with the Chapter 1138 – Storm Water Management and Urban Sediment Pollution Abatement of the Seven Hills Codified Ordinances. The improvements associated with this project would be categorized as a Redevelopment Project requiring 20% of the contributing drainage areas to be incorporated into a BMP. The preliminary storm sewer computations have shown a reduction in peak flows of approximately 7% for a 5 year design storm event and a 6% for 10 year design storm event. These reduced flows are shown on Existing Conditions and Reduced i – Storm Sewer Computations in Appendix I.

   The peak flow reductions for the 5 year and 10 year storm events are provided in Table. 5

Table 5
Storm Sewer Peak Flow Calculations

Tributary Area/ Street	5 year Design Storm			10 year Design Storm		
	Existing Conditions (cfs)	Existing Conditions w/ Bio-Retention (cfs)	Peak Flow Reduction %	Existing Conditions (cfs)	Existing Conditions w/ Bio-Retention (cfs)	Peak Flow Reduction %
Cherry Lane	25.08	23.28	7.2	28.66	26.87	6.2
Nemet Drive	37.39	34.66	7.3	42.68	39.95	6.4
Twilight Drive	33.08	30.83	6.8	37.87	35.62	5.9
Mary Lane	18.9	17.69	6.4	21.06	19.86	5.7
Shady Lane	11.56	10.8	6.6	13.12	12.36	5.8

Further peak flow reductions can be attained with the addition of an oversized pipe at the discharge of each of the five outfalls in the project area. A SWMM simulation of a 188 foot long 72-inch diameter storage pipe (5,300 cf capacity) at the end of the Nemet Drive/Seven Hills Boulevard storm system indicates that the storage pipe reduces peak flows by another 60% in storms up to a 1 year event. Therefore, storage pipes will be added to each outfall. An illustration of the storage pipe outfall is shown in Figure 14.

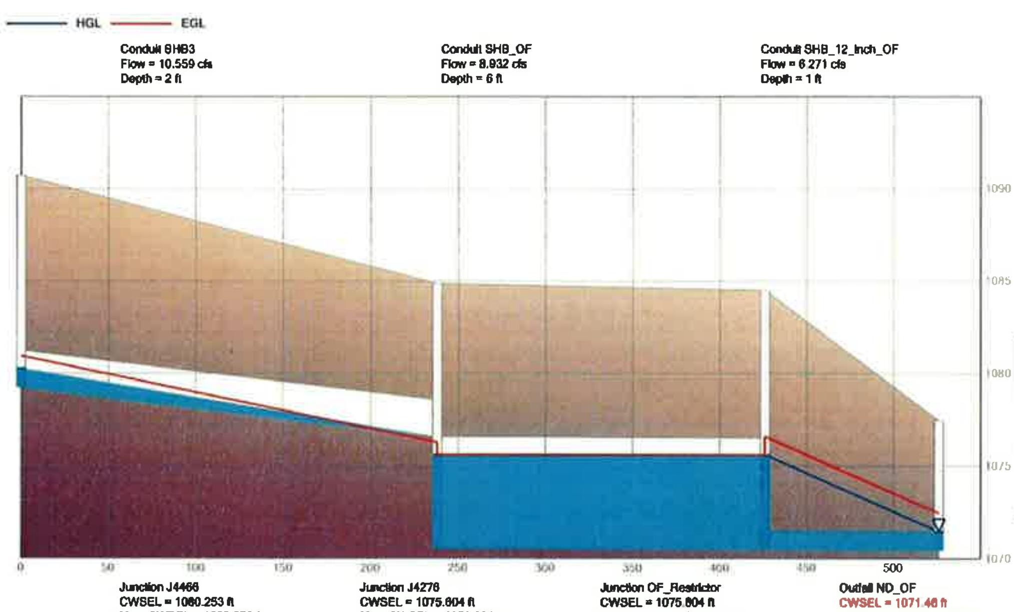

Figure 14 – Typical Storage Pipe Outfall

An illustration of the reduction in peak flow is shown in Figure 15.

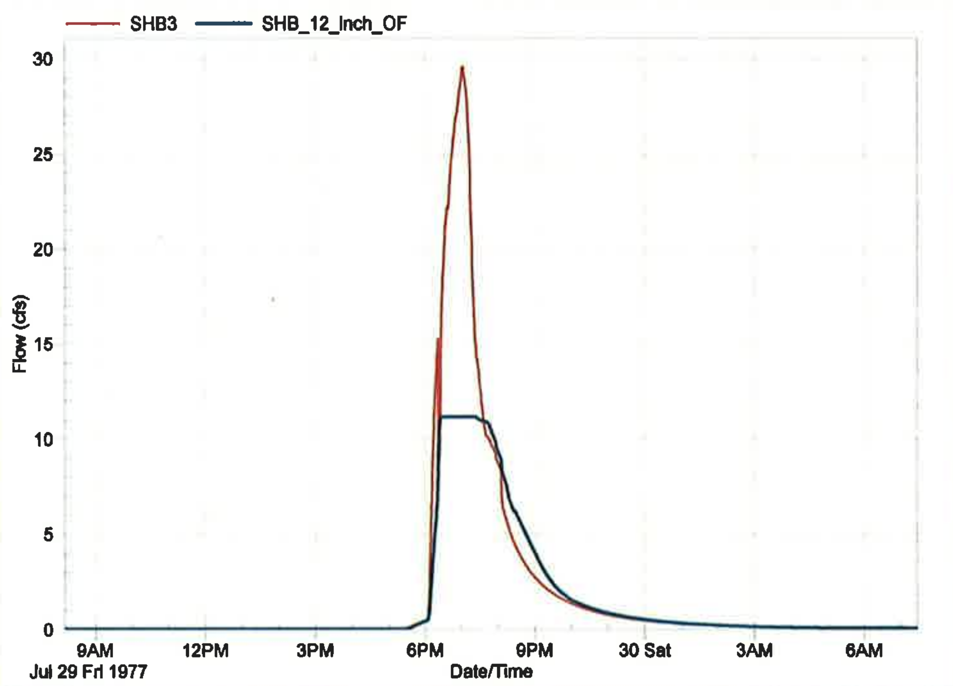

Figure 15 – Peak Flow Reduction

5. Feasible BMP's Within the Right of Way: The right of way throughout the project area is 60 feet wide, with pavement of typically 22 feet of the available width. This leaves approximately 19 feet on either side of the roadway for BMP's without requiring acquisition of additional right of way. Assuming that property acquisition is not desirable for this project, the BMP's must fit into the available19 feet of space on either side of the pavement. Based on the existing roadways within the project area consisting of an uncurbed/roadside swale configuration, the BMP's that are appropriate for this project point toward a bioswale/bioretention system.

A typical section showing how bioswales/bioretention areas fit within the right of way is shown in Figure 16. The typical section assumes the Water Quality Volume (WQV) for contributing drainage areas is 20% of the required WQV since this project should be classified as a redevelopment. Bio-Retention Cell areas and costs are provided in Table 6.

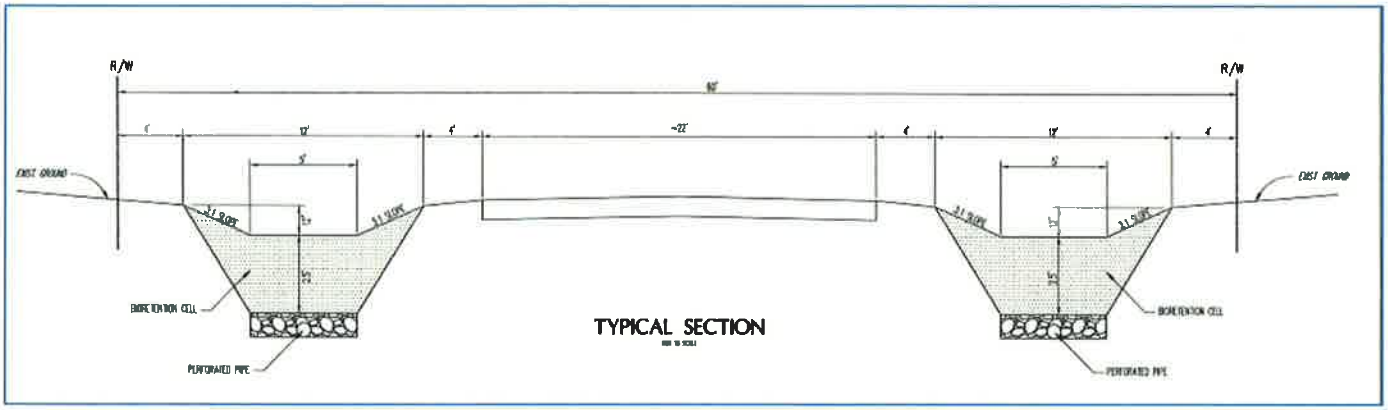

Figure 16 – Typical Roadway Section

A cross section of the bioswale/bioretention is shown in Figure 17.

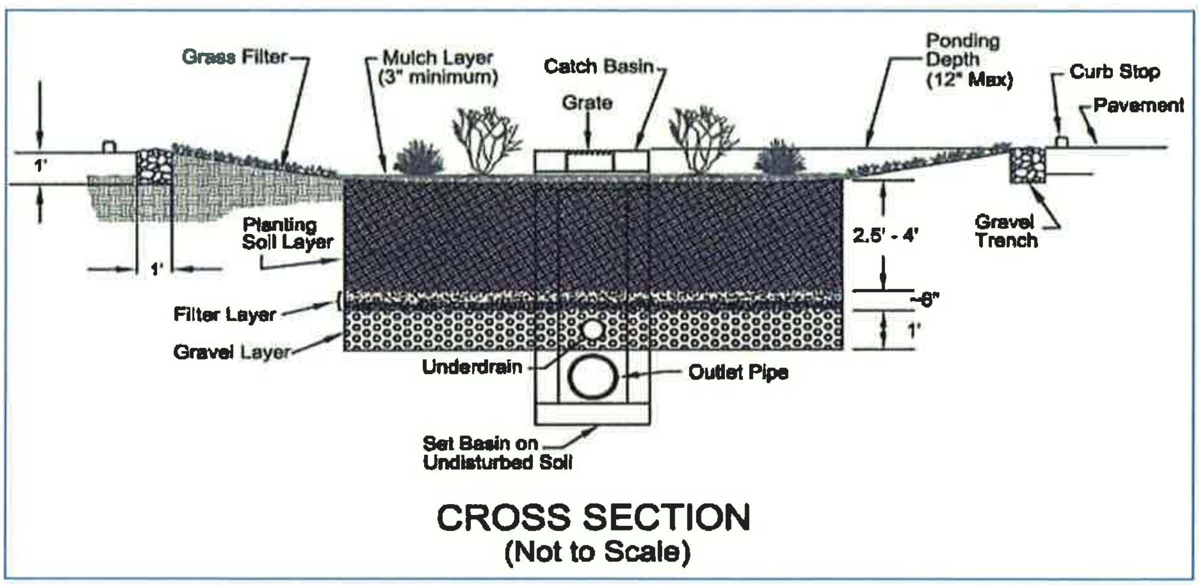

Figure 17 – Bioretention/Bioswale Cross Section

A computer model using SWMM (Version 5.0.022) was developed to compute the expected pollution load reduction on the receiving streams from construction of the bioswales/bioretention. The pollutants evaluated were Total Suspended Solids (TSS), Phosphorous (P) and Nitrogen (N). A mean concentration of 100 mg/l of TSS, 0.26 mg/l of P and 1.86 mg/l of N was assigned as the washoff concentrations of pollutants during rainfall events that produce runoff [1]. The model calculated an annual reduction of 73% for TSS, 46% for Phosphorous, and 33% for Nitrogen using conventional treatment efficiency. The SWMM input and output files are included in Appendix J and K respectively.

Rain gardens could also be incorporated into the overall project improvements on a voluntary basis. However, the rain gardens should not be considered as a primary BMP system for this project due to the poor infiltration characteristics of the underlying clayey soils within the project area. If incorporated into the project, rain gardens maintenance would be the responsibility of the individual property owner.

[1] The reported range of pollutant concentrations varies widely in the literature. The concentrations used in the analysis appear to be a median value and are used only to quantify potential pollutant load reduction.

Table 6
Storm Sewer Drainage Area and Water Quality Calculations

CB #	Drainage Area (Ac.)	To storm sewer	Water Quality Volume (cf)	Re-development WQv (CF)	Bioretention Area (SF)	Length Required for an 8' wide basin (FT)	Length Required for a 12' wide basin (FT)	Water Quality Flow WQF (cfs)	Re-development WQF (cfs)	8' wide Bio-retention cell cost $100/LF	12' wide Bio-retention cell cost $150/LF	Enhanced Bankfull Width (FT)
Mary Lane												
5530	0.37		302.20	60.44	61	8	5	0.07	0.014	$800	$750	2.1
5581	0.66	1.03	539.06	107.81	108	14	9	0.13	0.026	$1,400	$1,350	2.6
5847	1.82		1486.49	297.30	298	37	25	0.35	0.071	$3,700	$3,750	3.8
5847A	0.79	2.61	645.23	129.05	130	16	11	0.15	0.031	$1,600	$1,650	2.8
5819	2.06	2.85	1682.51	336.50	338	42	28	0.40	0.080	$4,200	$4,200	3.9
6052	0.28		228.69	45.74	46	6	4	0.05	0.011	$600	$600	1.9
6223	1.05	1.33	857.59	171.52	172	22	14	0.20	0.041	$2,200	$2,100	3.1
5953	5.91	6.96	4826.99	965.40	969	121	81	1.15	0.230	$12,100	$12,150	5.7
6052A	0.69	6.6	563.56	112.71	113	14	9	0.13	0.027	$1,400	$1,350	2.7
5786	0.68	1.37	555.39	111.08	112	14	9	0.13	0.027	$1,400	$1,350	2.7
5769	1.26	1.94	1029.11	205.82	207	26	17	0.25	0.049	$2,600	$2,550	3.3
5707	1.41	2.67	1151.62	230.32	231	29	19	0.27	0.055	$2,900	$2,850	3.4
Shady Lane												
5017	0.58	0.58	473.72	94.74	95	12	8	0.11	0.023	$1,200	$1,200	2.5
5017A	0.65		530.89	106.18	107	13	9	0.13	0.025	$1,300	$1,350	2.6
5094	1.58	2.23	1290.47	258.09	259	32	22	0.31	0.062	$3,200	$3,300	3.6
5225	0.62		506.39	101.28	102	13	8	0.12	0.024	$1,300	$1,200	2.6
5206	0.72	1.34	588.06	117.61	118	15	10	0.14	0.028	$1,500	$1,500	2.7
5416	1.74	1.74	1421.15	284.23	285	36	24	0.34	0.068	$3,600	$3,600	3.7
Twilight Drive												
3922	1.27		1037.27	207.45	208	26	17	0.25	0.050	$2,600	$2,550	3.3
3718	1.16	2.43	947.43	189.49	190	24	16	0.23	0.045	$2,400	$2,400	3.2
3496	1.5		1225.13	245.03	246	31	21	0.29	0.059	$3,100	$3,150	3.5
3406	3.3	4.8	2695.28	539.06	541	68	45	0.64	0.129	$6,800	$6,750	4.7
3225	1.12		914.76	182.95	184	23	15	0.22	0.044	$2,300	$2,250	3.2
3286	4.14	5.26	3381.35	676.27	679	85	57	0.81	0.161	$8,500	$8,550	5.0
3165	1.11		906.59	181.32	182	23	15	0.22	0.043	$2,300	$2,250	3.2
3353	2.59	3.7	2115.38	423.08	425	53	35	0.51	0.101	$5,300	$5,250	4.3
3000	1.12		914.76	182.95	184	23	15	0.22	0.044	$2,300	$2,250	3.2
3069	2.8	3.92	2286.90	457.38	459	57	38	0.55	0.109	$5,700	$5,700	4.4
2942	1.09		890.26	178.05	179	22	15	0.21	0.043	$2,200	$2,250	3.1
3139	2.86	3.95	2335.91	467.18	469	59	39	0.56	0.112	$5,900	$5,850	4.4
2863	1.19		971.93	194.39	195	24	16	0.23	0.046	$2,400	$2,400	3.2
2769	2.57	3.76	2099.05	419.81	421	53	35	0.50	0.100	$5,300	$5,250	4.3
2657	1.22		996.44	199.29	200	25	17	0.24	0.048	$2,500	$2,550	3.3
2689	2.89	4.11	2360.41	472.08	474	59	39	0.56	0.113	$5,900	$5,850	4.4
2614	0.68		555.39	111.08	112	14	9	0.13	0.027	$1,400	$1,350	2.7
2727	0.65	1.33	530.89	106.18	107	13	9	0.13	0.025	$1,300	$1,350	2.6

Table 6
Storm Sewer Drainage Area and Water Quality Calculations

CB #	Drainage Area (Ac.)	To storm sewer	Water Quality Volume (cf)	Re-development WQv (CF)	Bioretention Area (SF)	Length Required for an 8' wide basin (FT)	Length Required for a 12' wide basin (FT)	Water Quality Flow WQF (cfs)	Re-development WQF (cfs)	8' wide Bio-retention cell cost $100/LF	12' wide Bio-retention cell cost $150/LF	Enhanced Bankfull Width (FT)
Nemet Drive												
2332	1.33		1086.28	217.26	218	27	18	0.26	0.052	$2,700	$2,700	3.4
2363	0.79	2.12	645.23	129.05	130	16	11	0.15	0.031	$1,600	$1,650	2.8
2197	0.87		710.57	142.11	143	18	12	0.17	0.034	$1,800	$1,800	2.9
2167	1.97	2.84	1609.00	321.80	323	40	27	0.38	0.077	$4,000	$4,050	3.9
2263							0	0.00	0.000			
1939	1.1		898.43	179.69	180	23	15	0.21	0.043	$2,300	$2,250	3.1
2040	3.1	4.2	2531.93	506.39	508	64	42	0.60	0.121	$6,400	$6,300	4.6
1784	1.31		1069.94	213.99	215	27	18	0.26	0.051	$2,700	$2,700	3.4
1810	2.99	4.3	2442.08	488.42	490	61	41	0.58	0.117	$6,100	$6,150	4.5
1718	1.24		1012.77	202.55	203	25	17	0.24	0.048	$2,500	$2,550	3.3
1872	1.95	3.19	1592.66	318.53	320	40	27	0.38	0.076	$4,000	$4,050	3.9
1660	1.03		841.25	168.25	169	21	14	0.20	0.040	$2,100	$2,100	3.1
1526	5.14	6.17	4198.10	839.62	843	105	70	1.00	0.200	$10,500	$10,500	5.5
1607	1.17		955.60	191.12	192	24	16	0.23	0.046	$2,400	$2,400	3.2
1468	2.74	3.91	2237.90	447.58	449	56	37	0.53	0.107	$5,600	$5,550	4.4
1336	1.71		1396.64	279.33	280	35	23	0.33	0.067	$3,500	$3,450	3.7
1431	3.07	4.78	2507.42	501.48	503	63	42	0.60	0.120	$6,300	$6,300	4.5
1265	1.2		980.10	196.02	197	25	16	0.23	0.047	$2,500	$2,400	3.2
1192	3.32	4.52	2711.61	542.32	545	68	45	0.65	0.129	$6,800	$6,750	4.7
Cherry Lane												
7469	3		2450.25	490.05	492	62	41	0.59	0.117	$6,200	$6,150	4.5
7339	1.32	4.32	1078.11	215.62	216	27	18	0.26	0.051	$2,700	$2,700	3.4
7195	3.4		2776.95	555.39	558	70	46	0.66	0.133	$7,000	$6,900	4.7
7153	1.23	4.63	1004.60	200.92	202	25	17	0.24	0.048	$2,500	$2,550	3.3
7264	3.32		2711.61	542.32	545	68	45	0.65	0.129	$6,800	$6,750	4.7
7063	1.16	4.48	947.43	189.49	190	24	16	0.23	0.045	$2,400	$2,400	3.2
7045	0.91		743.24	148.65	149	19	12	0.18	0.035	$1,900	$1,800	2.9
6731	0.85	1.76	694.24	138.85	139	17	12	0.17	0.033	$1,700	$1,800	2.9
6601	1.26		1029.11	205.82	207	26	17	0.25	0.049	$2,600	$2,550	3.3
6682	1.37	2.63	1118.95	223.79	225	28	19	0.27	0.053	$2,800	$2,850	3.4
6467	1.17		955.60	191.12	192	24	16	0.23	0.046	$2,400	$2,400	3.2
6426	1.3	2.47	1061.78	212.36	213	27	18	0.25	0.051	$2,700	$2,700	3.3
6528	1.15		939.26	187.85	189	24	16	0.22	0.045	$2,400	$2,400	3.2
6360	1.15	2.3	939.26	187.85	189	24	16	0.22	0.045	$2,400	$2,400	3.2
6236	1.36		1110.78	222.16	223	28	19	0.27	0.053	$2,800	$2,850	3.4
4875	1.38	2.74	1127.12	225.42	226	28	19	0.27	0.054	$2,800	$2,850	3.4

Table 6
Storm Sewer Drainage Area and Water Quality Calculations

CB #	Drainage Area (Ac.)	To storm sewer	Water Quality Volume (cf)	Re-development WQv (CF)	Bioretention Area (SF)	Length Required for an 8' wide basin (FT)	Length Required for a 12' wide basin (FT)	Water Quality Flow WQF (cfs)	Re-development WQF (cfs)	8' wide Bio-retention cell cost $100/LF	12' wide Bio-retention cell cost $150/LF	Enhanced Bankfull Width (FT)
Seven Hills Blvd												
Cherry Lane drains into 4857												
4857	2.61	2.61	2131.72	426.34	428	54	36	0.51	0.102	$5,400	$5,400	4.3
7993	0.22	0.22	179.69	35.94	36	5	3	0.04	0.009	$500	$450	1.8
7981	0.27	0.27	220.52	44.10	44	6	4	0.05	0.011	$600	$600	1.9
4711	0.55	0.55	449.21	89.84	90	11	8	0.11	0.021	$1,100	$1,200	2.5
4779	1.85	1.85	1510.99	302.20	303	38	25	0.36	0.072	$3,800	$3,750	3.8
4678	0.08	0.08	65.34	13.07	13	2	1	0.02	0.003	$200	$150	1.2
4526	2.76	2.76	2254.23	450.85	453	57	38	0.54	0.108	$5,700	$5,700	4.4
Seven Hills Blvd												
Nemet Drive drains into 4490												
4490	0.76	0.76	620.73	124.15	125	16	10	0.15	0.030	$1,600	$1,500	2.8
4601	0.44	0.44	359.37	71.87	72	9	6	0.09	0.017	$900	$900	2.3
4466	0.31	0.31	253.19	50.64	51	6	4	0.06	0.012	$600	$600	2.0
4290	3.1	3.1	2531.93	506.39	508	64	42	0.60	0.121	$6,400	$6,300	4.6
4276	0.31	0.31	253.19	50.64	51	6	4	0.06	0.012	$600	$600	2.0
Seven Hills Blvd												
Drains into Shady Lane												
4170	0.43	0.43	351.20	70.24	71	9	6	0.08	0.017	$900	$900	2.3
4133	0.08	0.08	65.34	13.07	13	2	1	0.02	0.003	$200	$150	1.2
4398	0.8		653.40	130.68	131	16	11	0.16	0.031	$1,600	$1,650	2.8
4115	0.04	0.99	32.67	6.53	7	1	1	0.01	0.002	$100	$150	1.0
4115A	0.15		122.51	24.50	25	3	2	0.03	0.006	$300	$300	1.5
Total:	132.25					2716	1805		5	**$271,600**	**$270,750**	

A supplemental BMP methodology to reduce storm water runoff is the consideration of a pavement width reduction along Nemet Drive from the existing width of 28 feet to a 22 foot pavement section. This change in pavement width would provide a reduced impervious area of approximately 5% for the contributing drainage areas on Nemet Drive.

An alternative BMP practice that could be incorporated as part of this redevelopment project would be to provide a 20% reduction in the impervious area. This could be accomplished by removing and replacing the existing pavement with permeable pavement along the entire length of the improvement area and constructing a non-curbed roadway and roadside swale system with the new permeable pavement 24 feet in width. This based on a typical residential lot width of 75 feet, a driveway of 15 feet x 100 feet and a house footprint 40 feet x 60 feet.

6. Pavement Drainage/BMP Relationship

The pavement in the project area is severely deteriorated, most likely due to poor or inadequate base and drainage. Therefore, one goal of the project is to install free draining base material which is not impacted by the selected BMPs used within the right of way. We would strongly recommend that a well defined pattern of pavement corings be completed along each of the roadways to obtain a clearer understanding of the existing pavement composition and underlying soil conditions. These pavement corings are critical in completing a pavement design for each of the roadways for the project.

D. Water Mains

1. Location: By agreement with the Cleveland Division of Water, the water mains in the following streets will be replaced:
   - Seven Hills Boulevard, Cherry Lane to 7021 Seven Hills Boulevard (2,040 lf)
   - Shady Lane (1,240 lf)
   - Oak Lane (1,480 lf)
   - South Mary Lane
   - North May Lane
   - Mary Lane

   (South Mary Lane, North May Lane, Mary Lane: 1,900 lf)

   These water mains were installed in the 1950's and are beyond their useful life.

2. Water Main Sizes: Water mains will be 8-inch diameter.

3. Water Main Materials: All water mains shall be cement lined ductile iron Grade 60-42-10, Class 52. Joints shall be push-on or restrained where indicated on the plans. All fittings shall be Grade 70-50-05 and shall have retained mechanical push-on joints. All pipe shall be polyethylene encased.

4. Valve Specifications: Gate valves shall be designed for 200 psi working pressure. Gate valves shall be either double disc valves complying with ANSI/AWWA C500-93 or shall be preapproved resilient seated valves (per CWD approved list).

5. Hydrants: Hydrants shall be 6-inch Kennedy 5-1/4 Fig. K-81A Guardian Hydrant with STORZE fittings.