



Snohomish County

Swamp Creek Drainage Needs Report

APPENDIX B5

Hydraulic Model Development and Application for South Swamp Creek Subbasin

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Appendix B5. Hydraulic Model Development and Application for South Swamp Creek Subbasin

B5.1 Introduction

Two hydraulic models were selected to perform a detailed analysis of the south reach of the Swamp Creek main stem and drainage systems. Model selection was based on the primary type of drainage system being analyzed. A Hydrologic Engineering Center's River Analysis System (HEC-RAS) model was created for South Swamp Creek Subbasin starting at the top of the reach where the Middle Swamp Creek reach ends, near Filbert Road (approximately 6.7 river miles [RM] upstream of the mouth of Swamp Creek) and then extending to the bottom of the reach where the stream passes into King County just downstream of Lockwood Road (approximately 2.4 RM upstream of the mouth of Swamp Creek).

Several tributaries join the Swamp Creek main stem within the South Swamp Creek Subbasin. After several basin meetings with County staff and reviews of drainage complaints, Logan Road was selected for a more detailed hydraulic analysis. Logan Road system joins Swamp Creek near Larch Way (approximately at RM 5.7). The Environmental Protection Agency's (EPA) Storm Water Management Model (SWMM) was used to evaluate the hydraulics along Logan Road.

B5.2 Data Collection and Field Observation

Data collection included basin reconnaissance and field survey as well as a meeting with County staff to review historic flooding problems. Also, historic drainage complaints occurring within the last six years were compiled. A summary of the drainage complaints is given in Table B5-1.

An initial field reconnaissance was conducted to field locate the stream and to observe the stream conditions and surrounding areas. The initial field reconnaissance was followed by a field survey to obtain geometric data for the hydraulic analysis. Pipe system, culvert, and stream channel data were collected and used to analyze the system capacity of the identified drainage systems in the South Swamp Creek Subbasin. Figure 3-1e shows the locations where the stream channels and road culverts were surveyed to provide input data for use in the HEC-RAS and SWMM models.

**Table B5-1
Drainage Complaints for South Swamp Creek Subbasin
(1996 through 2001)**

SWM Number	Address	Drainage Basin	General Problem	Problem Resolution
20000163	21316 11th Place W	South Swamp	Excessive groundwater	Private property, no County action.
20000145	21123 Locust Way	South Swamp	Private property flooding	Private property, no County action.
20000127	23618 Locust Way	South Swamp	Roadway flooding	Problem needs to be assessed during rainy weather before being placed on Roads list for routine maintenance.
20000120	24304 Lockwood Road	South Swamp	Property flooding from road runoff	Private property, no County action.
20000114	1200 Logan Road	South Swamp	Roadway flooding	Service request to clean and maintain drainage system.
20000067	1023 234th Place SW	South Swamp	Sidewalk flooding from groundwater seep	Service request to Roads to install a drain through the sidewalk.
19990327	825 Logan Road	South Swamp	Property flooding from road runoff	Private property, no County action.
19990305	1700 196th Place SW	South Swamp	Property flooding from road runoff	Private property, no County action.
19990242	23123 9th Place W	South Swamp	Property impacted by new groundwater seep from hillside	Redirected flow into existing drainage system.
19990130	1133 235th Place SW	South Swamp	Flooding of neighborhood sidewalk	Problem ranked as a potential project.
19990096	20817 Locust Way	South Swamp	Roadway flooding	Problem ranked as a potential project.
19990083	20426 12th Place W	South Swamp	Excessive groundwater	Private property, no County action.
19990047	21510 8th Place W	South Swamp	Property flooding from road runoff	Private property, no County action.
19980401	1010 228th Street SW	South Swamp	Roadway flooding	Service request to Roads to regrade the road shoulder and maintain drainage.
19980379	22819 Locust Way	South Swamp	Excessive groundwater	Private property, no County action.
19980376	1908 204th Street SW	South Swamp	Private property flooding	Private property, no County action.
19980367	23726 23rd Avenue W	South Swamp	Private property flooding	Private property, no County action.
19980361	1820 200th Place SW	South Swamp	Private property flooding	Private property, no County action.
19980308	23426 9th Place W	South Swamp	Private property flooding	Private property, no County action.
19980296	19707 Cypress Way	South Swamp	Property flooding from road runoff	Problem will be addressed as part of the Cypress Way paving project.
19980289	1122 213th Place SW	South Swamp	Property flooding	Service request to Roads to replace and maintain catch basin grating
19980283	21204 8th Place W	South Swamp	Property flooding and erosion	Service request to Roads to clean nearby culvert and ditch.
19980282	21100 Damson Road	South Swamp	Property flooding and erosion	Site was placed on a potential project list to do analysis the drainage system and replace it if needed.
19980278	23029 13th Place W	South Swamp	Roadway flooding	Road Maintenance cleared debris from culvert.
19980271	1922 204th Street SW	South Swamp	Private property flooding	Private property, no County action.
19980097	22825 Locust Way	South Swamp	Private property flooding	Private property, no County action.
19980096	22911 Locust Way	South Swamp	Private property flooding	Private property, no County action.

Table B5-1 (continued)				
Drainage Complaints for South Swamp Creek Subbasin (1996 through 2001)				
SWM Number	Address	Drainage Basin	General Problem	Problem Resolution
19980035	20719 14th Place W	South Swamp	Excessive groundwater	Private property, no County action.
19970566	20703 Olympic Place	South Swamp	Property flooding	Service request to Roads to upgrade catch basin.
19970490	20430 20th Place W	South Swamp	Private property flooding	Private property, no County action.
19970367	825 Logan Road	South Swamp	Private property flooding	Private property, no County action.
19970322	21119 7th Avenue W	South Swamp	Private property flooding	Private property, no County action.
19970107	24003 8th Place W	South Swamp	Property flooding from overtopping stormwater pond	Pond needs resizing, ownership of pond must be established.
19970053	2203 208 Street SW	South Swamp	Increase in water flow across private property	Private property, no County action.
19960583	1224 222nd Place SW	South Swamp	Roadway erosion	Problem ranked as a potential 1997 project.
19960253	24118 Lockwood Road	South Swamp	Erosion around catch basin	Problem is in King County, no Snohomish County action taken.
19960242	2018 Atlas Road	South Swamp	Roadway and property flooding	Service request to Roads for upgrade and maintenance of drainage.
19960228	21125 8th Place W	South Swamp	Excessive groundwater	Private property, no County action.
19960201	1230 233rd Place SW	South Swamp	Excessive groundwater	Private property, no County action.
19960147	1705 237th Place SW	South Swamp	Flooding from silted in catch basin	Private property, no County action.
19960138	1804 207th Place SW	South Swamp	Water quality concern from potential failed septic	Private property, no County action.
19960114	23911 Locust Way	South Swamp	Private property flooding	Private property, no County action.
19960102	1611 215th Street SW	South Swamp	Erosion at stormwater outfall	Problem rated as a project to repair erosion.
19960086	1210 228th Place W	South Swamp	Private property flooding	Private property, no County action.
19960066	23724 23rd Avenue W	South Swamp	Private property flooding	Private property, no County action.
19960012	23422 Locust Way	South Swamp	Private property flooding	Private property, no County action.

The survey data included road culverts, enclosed pipe systems, and stream channel cross sections. Road culvert data consisted of culvert upstream and downstream inverts, culvert length, culvert size and shape, culvert material, and top of road (for use in road flooding analysis). Enclosed pipe system survey data included pipe inverts, rim elevations, pipe diameter, shape, and material. Stream channel cross section data defined the geometry of the natural stream channels immediately upstream and downstream of the road culverts. The field survey data were input into the County's Geographic Information System (GIS).

B5.2.1 Drainage System Survey

Global Positioning System (GPS) equipment was used to conduct surveys of existing surface water facilities within the basins. This process allows rapid and accurate data collection and the ability for the data to be downloaded into computers and viewed within a GIS environment. GPS data were reviewed to find any potential problems that might require verification.

The surveys were conducted using high accuracy, survey-grade GPS equipment, with a horizontal accuracy of ± 2 centimeters and a vertical accuracy of ± 4 centimeters relative to control. In addition, all drainage facilities were directly measured.

GIS coverages were created from the survey data that were downloaded from the GPS equipment. Data processing program routines were developed by the County to assist in the construction of the drainage network from the point features collected by the GPS units. Cross section and drainage feature information that was collected from the survey was then extracted from the GIS coverage and used in the hydraulic analyses. Table 3-2 and Figure 3-1f show the existing drainage facilities that were surveyed as well as the drainage network that connects these facilities.

The surveys were conducted using high accuracy, survey grade GPS equipment, with a horizontal accuracy of ± 2 centimeters and a vertical accuracy of ± 4 centimeters relative to control. GIS coverages were created from survey data downloaded from the GPS equipment. Data processing program routines were developed by the County to assist in constructing the drainage network from the point features collected by the GPS units. Cross section and drainage feature information collected from the survey were extracted from the GIS coverage and used in the hydraulic analyses.

B5.2.2 Basin Reconnaissance

Basin reconnaissance was conducted by project staff to review surveyed data and other collected basin information. Project staff visited the South Swamp Creek Subbasin and Logan Road Subbasin on several occasions during fall and winter 2001. The purpose of these reconnaissance visits was to make qualitative observations to supplement the survey data collected by survey crews. Observations often resulted in an additional survey requests. Activities performed during the field visits included:

- Observing the drainage system being modeled.
- Assisting in coordinating the survey and data collection effort.
- Assessing the condition of hydraulic structures and stream reaches for model input parameter development.
- Observing identified and suspected problem areas.

Following is a brief summary of the basin information based on available information and field visits.

The south reach of the Swamp Creek hydraulic model encompasses the portion of the stream extending from just downstream of the Filbert Road bridge to just downstream of Lockwood Road at the King County border. The length of the reach is 4.3 miles and has many road crossings, the most significant of which are the Larch Way crossing and multiple crossings under Locust Way.

B5.3 HEC-RAS Development and Results

The purpose of the HEC-RAS modeling was to:

- Develop FTABLEs for input to the HSPF model.
- Evaluate culvert capacity based on preselected performance standards for channel flooding along the South Swamp Creek reach for existing and future flows.
- Analyze potential Capital Improvement Program (CIP) projects that would reduce predicted flooding.

B5.3.1 Existing Condition Model

The extent of the HEC-RAS model was defined at a basin meeting with the County. The model encompasses the main stem of Swamp Creek from the end of the Middle Swamp Creek reach near Filbert Road (approximately 6.7 RM upstream of the mouth of Swamp Creek), to the Snohomish County border with King County just downstream from Lockwood Road (approximately 2.4 RM from the mouth of Swamp Creek). The total length of South Swamp Creek reach is approximately 4.3 miles.

HEC-RAS is a one-dimensional hydraulic model that was employed to determine the stage-storage relationship of the main stem of Swamp Creek. These relationships were incorporated into the Hydrological Simulation Program—Fortran (HSPF) model used to simulate the response of the basin to different hydrologic events as a part of the Snohomish County DNR project. Figure B5-1 shows the HEC-RAS model schematic for the portion of South Swamp Creek that was modeled.

B5.3.1.1 Hydraulic Structures

Twelve bridges of varying sizes are located along the South Swamp Creek reach. Some are high-use road bridges; some are private residence access crossings. To model each span in HEC-RAS, four cross sections are needed.

To accomplish this, the two surveyed cross sections near the bridge opening had to be copied upstream and downstream to areas where the cross sections were removed from any influences of flow contraction or expansion resulting from the bridge. The elevations of these copied cross sections were adjusted according to the average slope of the reach. This slope was determined as approximately 1 percent for a large portion of the South Swamp Creek reach model. The coefficients of contraction and expansion used for all bridges were 0.3 and 0.5, respectively. These coefficients estimate the losses around the bridge that result from turbulences incurred from flow contraction and expansion.

The computational methods used to simulate the losses that occur through a bridge were the standard energy equation and the momentum equation. The highest energy

result was used. The coefficient of drag of 1.2 and a pier shape factor of 0.9 was used for the momentum equation.

All of the twelve road crossings on South Swamp Creek are bridges. No culverts are included as part of the model for this reach.

B5.3.1.2 Channel Cross Sections

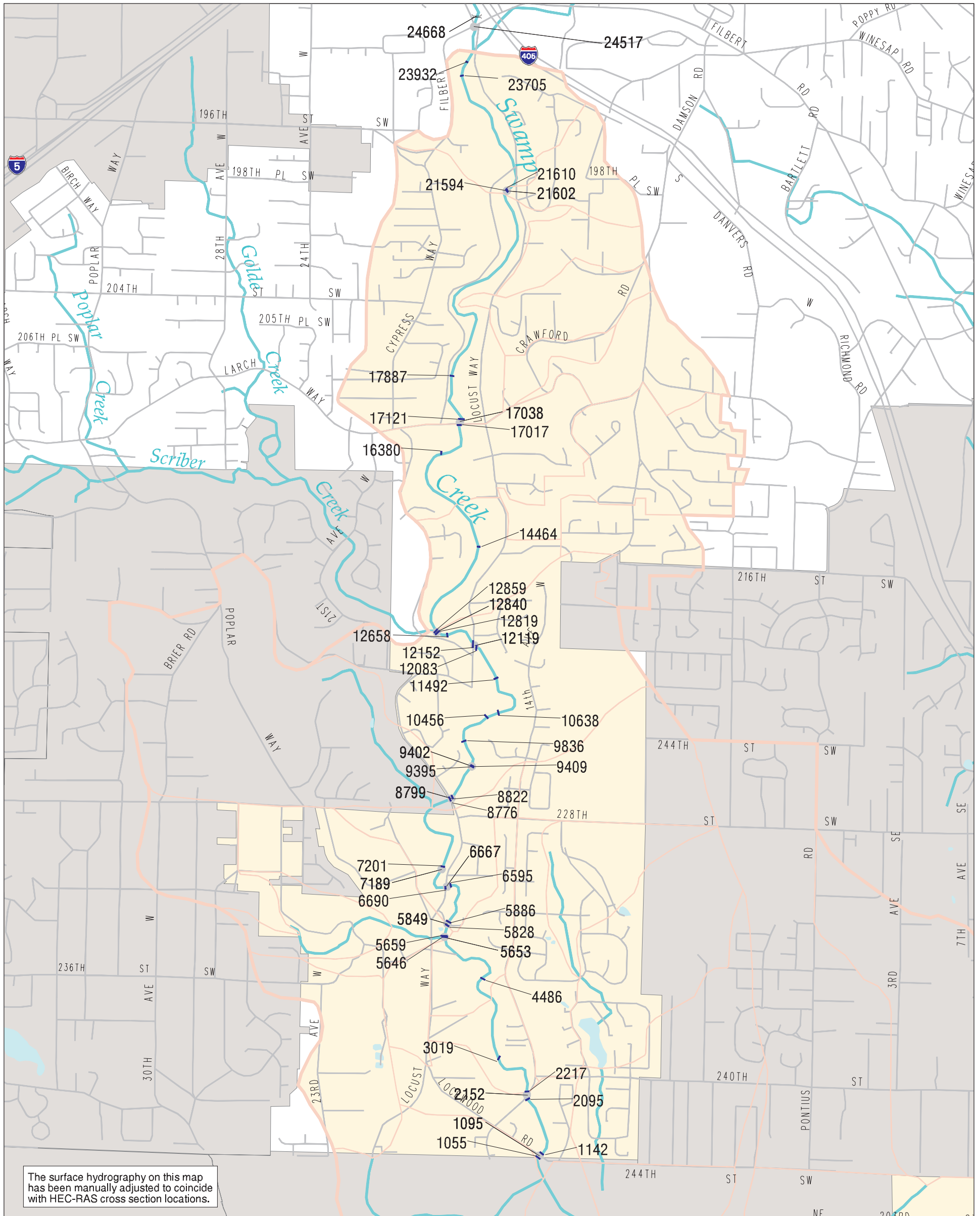
Channel cross sections were input into the HEC-RAS model from the survey data collected for this project. Occasionally, it was necessary to interpolate additional cross sections when a significant data gap occurred between survey cross sections, or to extend the cross section extent based on available topography. Figure B5-1 shows the locations where stream cross sections were established to provide data for input into the hydraulic model. The river station numbers used in the model also are shown on the figure. Table B5-2 lists the HEC-RAS cross sections used in the model.

Some cross sections were added to the model by interpolating between two known cross sections in the HEC-RAS model. Although not based on actual survey information, these additional cross sections help improve model results in areas with relatively steep water surface profiles, or in areas in which the channel or the overbank conditions change significantly between surveyed cross sections.











Much of the data used to build the models was organized in a GIS system. Other data were in the form of field notes. To initiate the modeling process, a station line for the river reach had to be defined. The information for the river alignment was taken from the GIS watercourse lines. Because the resolution was inadequate, this line was refined by overlaying it on the U.S. Geologic Survey (USGS) 7.5-foot quadrangles and adjusting it to the mapped alignment. In this process, the station line was forced through the surveyed data to obtain the stationing for that cross section.

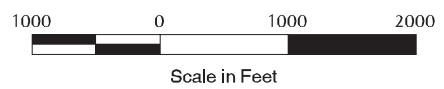
Cross-sectional geometry was derived from surveyed point data, and under post processing, was projected onto a straight line to accurately delineate the cross-sectional geometry of the channel. Surveyed data also included information as to where changes in channel beds and banks were located on the cross section. These were incorporated into the HEC-RAS model as bank station information.

At bridge locations, geometry was surveyed or measured. Cross-sectional information was surveyed upstream and downstream of each bridge within the area of contraction and expansion of flow. The surveyed centerline of the road was used to determine the top chord elevation or the elevation where weir flow would occur under high-flow events. Measured bridge geometry included the width of upstream and downstream openings, the length of the flow path through the bridge, the height of the openings, and the chord thickness for each bridge modeled.



Legend

-  Subbasin Boundary
-  HSPF Subbasin Boundary
-  Major Road
-  Secondary Road
-  Stream
-  Water Body
-  Incorporated Area
-  Surveyed Cross Section
-  Culvert Crossing
-  Bridge Crossing



Snohomish County

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Figure B5-1
South Swamp Creek
Hydraulic Model Schematic
for HEC-RAS Model

Swamp Creek Drainage Needs Report



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Table B5-2		
HEC-RAS Model Cross Sections		
River Station ID	Culvert ID	Cross Section Source
23932		Surveyed Cross Section EA4178
23705		Surveyed Cross Section EA4187
21710		Copy of Surveyed Cross Section EA3981
21610		Surveyed Cross Section EA3981
21602	1	Copy of Surveyed Cross Section EA3981
21602		Copy of Surveyed Cross Section EA3990
21594		Surveyed Cross Section EA3990
21494		Copy of Surveyed Cross Section EA3990
17887		Surveyed Cross Section EA4139
17121		Surveyed Cross Section EA3095
17056		Copy of Surveyed Cross Section EA3819
17038	2	Copy of Surveyed Cross Section EA3819
17038		Copy of Surveyed Cross Section EA3819
17017		Surveyed Cross Section EA3819
16917		Copy of Surveyed Cross Section EA3819
16380		Surveyed Cross Section EA4196
15244		Interpolated
14464		Surveyed Cross Section EA4014
13711*		Interpolated
12959		Copy of Surveyed Cross Section EA4160
12859		Surveyed Cross Section EA4160
12840	3	Copy of Surveyed Cross Section EA4160
12840		Copy of Surveyed Cross Section EA4169
12819		Surveyed Cross Section EA4169
12719		Copy of Surveyed Cross Section EA4169
12658		Surveyed Cross Section EA4148
12252		Copy of Surveyed Cross Section EA3877
12152		Surveyed Cross Section EA3877
12119	4	Copy of Surveyed Cross Section EA3877
12119		Copy of Surveyed Cross Section EA3860
12083		Surveyed Cross Section EA3860
11983		Copy of Surveyed Cross Section EA3860
11492		Surveyed Cross Section EA4242
10638		Surveyed Cross Section EA4231
10456		Surveyed Cross Section EA4221
9836		Surveyed Cross Section EA3953
9509		Copy of Surveyed Cross Section EA3800
9409		Surveyed Cross Section EA3800
9402	5	Copy of Surveyed Cross Section EA3800
9402		Copy of Surveyed Cross Section EA3808
9395		Surveyed Cross Section EA3808
9295		Copy of Surveyed Cross Section EA3808
8922		Copy of Surveyed Cross Section EA4030
8822		Surveyed Cross Section EA4030

Table B5-2 (continued)
HEC-RAS Model Cross Sections

River Station ID	Culvert ID	Cross Section Source
8799	6	Copy of Surveyed Cross Section EA4030
8799		Copy of Surveyed Cross Section EA4043
8776		Surveyed Cross Section EA4043
8676		Copy of Surveyed Cross Section EA4043
8463		Interpolated
7301		Copy of Surveyed Cross Section EA4122
7201		Surveyed Cross Section EA4122
7189	7	Copy of Surveyed Cross Section EA4122
7189		Copy of Surveyed Cross Section EA4128
7180		Surveyed Cross Section EA4128
7080		Copy of Surveyed Cross Section EA4128
6790		Copy of Surveyed Cross Section EA4112
6690		Surveyed Cross Section EA4112
6667	8	Copy of Surveyed Cross Section EA4112
6667		Copy of Surveyed Cross Section EA4104
6650		Copy of Surveyed Cross Section EA4105
6595		Surveyed Cross Section EA4105
5986		Copy of Surveyed Cross Section EA4078
5886		Copy of Surveyed Cross Section EA4078
5849	9	Copy of Surveyed Cross Section EA4078
5849		Copy of Surveyed Cross Section EA4088
5828		Surveyed Cross Section EA4088
5759		Copy of Surveyed Cross Section EA4407
5659		Surveyed Cross Section EA4407
5653	10	Copy of Surveyed Cross Section EA4407
5653		Copy of Surveyed Cross Section EA4416
5646		Surveyed Cross Section EA4416
5546		Copy of Surveyed Cross Section EA4416
4486		Surveyed Cross Section EA3943
3998		Interpolated
3019		Surveyed Cross Section EA3917
2317		Copy of Surveyed Cross Section EA3927
2217		Surveyed Cross Section EA3927
2152	11	Copy of Surveyed Cross Section EA3927
2152		Copy of Surveyed Cross Section EA3964
2095		Surveyed Cross Section EA3964
1995		Copy of Surveyed Cross Section EA3964
1242		Copy of Surveyed Cross Section EA4053
1142		Surveyed Cross Section EA4053
1095	12	Copy of Surveyed Cross Section EA4053
1095		Copy of Surveyed Cross Section EA4064
1055		Surveyed Cross Section EA4064
1000		Copy of Surveyed Cross Section EA4064
700		Copy of Surveyed Cross Section EA4065

B5.3.1.3 Boundary Conditions

The Swamp Creek main stem was divided into three separate reaches for modeling purposes, North, Middle, and South Swamp. North Swamp is discussed in Appendix B3 and Middle Swamp in Appendix B4. A single model was constructed for Middle and South reaches of Swamp Creek because these reaches really represent one continuous reach of Swamp Creek.

The upper boundary of the combined Middle and South Swamp hydraulic model starts near Jefferson Way. The lower boundary for the combined model ends at the Snohomish/King county line, which coincidentally also marks the upper boundary of a hydraulic study of Swamp Creek performed by the Federal Emergency Management Agency (FEMA). Surface water elevations and flows at the county line for 10-, 50-, and 100-year events were published in the King County Flood Insurance Study (FEMA, 1995). Tailwater elevations of the downstream boundary condition were based on a rating curve produced by FEMA data and input into the combined model. The downstream condition can affect channel capacity. The upstream boundary condition was set at normal depth based on an estimated slope for the channel.

B5.3.1.4 Manning's Roughness Coefficients

Manning's roughness coefficients for natural channels were determined from observations made during field reconnaissance. Natural channel roughness coefficients were developed based on the USGS 1967 report entitled *Roughness Characteristics of Natural Channels*. Hydraulic structures were assigned a roughness coefficient as described in the Hydraulic Modeling Protocols.

B5.3.1.5 FTABLE Development

FTABLEs describe the stage-discharge-area-storage relationship of the drainage system and are used in HSPF to represent flow routing (Appendix A3). The HEC-RAS model was used to develop FTABLEs for nine subbasins in the South Swamp Creek reach in accordance with the procedures defined in the Hydraulic Modeling Protocols.

In addition to the FEMA study, a study by KCM was developed in 1992. The flows generated by this study were redistributed based on the area weighted method and used as initial flows for the HEC-RAS model. From these results, FTABLEs were generated for the initial HSPF model.

A more refined flow range was produced after the initial HSPF run for the South Swamp Creek reach. This refined range of flows was input into the HEC-RAS model to produce a second generation of FTABLEs. This iterative process helps HSPF to improve the flow prediction accuracy.

FTABLE development used 13 flows in an attempt to encompass flows below the initial estimation of the 2-year event and above the 100-year event.

The upstream and downstream limits (extents) of the FTABLEs for the South Swamp Creek reach are described in Table B5-3.

B5.3.1.6 Existing and Future Conditions Flood Frequency

The flows used in the model were those established from the HSPF hydrologic analysis for recurrence frequencies, and consist of the 2-, 10-, 25-, and 100-year flows for both existing and future land use conditions. The HSPF hydrologic analysis generated flows that were input into the HEC-RAS model at nine locations to represent changes in flow

along the stream due to the contributions of the downstream drainage basins. In general, the flow calculated for an HSPF subbasin was input into HEC-RAS at the upstream end of the subbasin.

Table B5-4 shows the existing and future condition peak discharge rates used in the HEC-RAS modeling. The existing and future conditions flood frequency analysis is described in Appendix A3.

B5.3.1.7 Additional Modeling Assumptions

Several assumptions were used in developing the HEC-RAS model. These assumptions are described below.

- During the bridge modeling process, some assumptions had to be made regarding the placement of the bridge over the surveyed channel. None of the survey points were recognized as indicating the location of bridge abutments. For this reason, bridges were centered over the upstream and downstream surveyed channel.
- An assumption was made in determining the areas around bridges that experience flow contraction and expansion. A 1:1 ratio of contraction and a 2:1 ratio of expansion were used to determine how far upstream and downstream the copied cross section had to be placed to ensure that these cross sections were removed from the effects of bridge turbulence. These same ratios of contraction and expansion were used to determine the stationing at the ineffective flow areas for the bridge surveyed cross section.
- The vertical placement of the ineffective flow areas were at the top chord of the bridge on the upstream cross section and at the low chord on the downstream cross section.

B5.3.2 Model Results and Problem Identification with Existing Conditions Flows

Water surface profiles were computed at 2-, 10-, 25-, and 100-year peak discharge rates for the existing land use conditions. Problem areas in this HEC-RAS model are those locations where the stream water surface profile exceeds the elevation of the bridge deck and flooding occurs. Problem areas also include locations where flows overtop channel banks and flood property. HEC-RAS model results are summarized in Table B5-5. This table compares water surface elevations to road flooding elevations for all bridges in the model. It lists bridge identification and location, river station, flooding elevation, and water surface elevations at the upstream end of each culvert in the stream system for the 2-, 10-, 25-, and 100-year events under existing flow conditions.

Results of the HEC-RAS model predict that one of the 12 bridges will experience flooding during the 100-year event under existing conditions.

Areas where property flooding may occur are based on comparing available topography mapping with the water surface elevations generated by the model. It was assumed that if the water surface elevation is equal to the topographic elevation shown in the vicinity of a property or structure, flooding might occur. The one bridge that is predicted to flood under existing conditions is a pedestrian bridge in a non-residential area. Flooding in this area does not appear to threaten private property.

**Table B5-3
Physical Extents of FTABLES Generated from HEC-RAS**

HSPF Reach	Location	Downstream Control	FTABLE Extent	
			Downstream River Station (ft)	Upstream River Station (ft)
65	DS of Lockwood Rd. Bridge to U/S Carter Rd. Bridge	Channel	700	2217.2
75	U/S of Carter Rd. Bridge to 237 PL SW	Carter Road Bridge	2217.2	3998.3
90	237 PL SW to Trickle Creek	Channel	3998.3	5646.1
110	Trickle Creek to 22800 Locust Way	Unnamed Bridge	5646.1	8463.24
120	22800 Locust Way to Scriber Lake Creek	Channel	8463.24	12859
125	Scriber Lake Creek to 213th St.	Private Drive Bridge	12859	15243.7
140	213th St. to Larch Way	Channel	15243.7	17017.25
145	Larch Way to 20,000 Locust Way	Larch Way Bridge	17017.25	21593.73
170	20000 Locust Way to Filbert Rd.	Unnamed Wood Bridge	21593.73	24109

Notes:

Rd. = Road, St. = Street U/S = upstream D/S = downstream

1. FTABLE depth computed at downstream cross section.
2. FTABLE volume and area computed between downstream and upstream cross sections.

Table B5-4

HEC-RAS Flow Model Input for Existing and Future Land Use Conditions – South Swamp Creek Subbasin

HSPF Reach	River Station (ft)	Location	Existing Land Use Conditions				Future Land Use Conditions			
			2-Year Q (cfs)	10-Year Q (cfs)	25-Year Q (cfs)	100-Year Q (cfs)	2-Year Q (cfs)	10-Year Q (cfs)	25-Year Q (cfs)	100-Year Q (cfs)
65	700	D/S of Lockwood Rd. Bridge to U/S Carter Rd. Bridge	542	873	1000	1142	605	953	1100	1279
75	2217.2	U/S of Carter Rd. Bridge to 237 PL SW	542	873	1000	1142	605	953	1100	1279
90	3998.3	237 PL SW to Trickle Creek	542	873	1000	1132	600	942	1084	1258
110	5646.1	Trickle Creek to 22800 Locust Way	535	869	970	1074	596	935	1074	1211
120	8463.24	22800 Locust Way to Scriber Lake Creek	517	856	962	1047	578	910	1047	1189
125	12859	Scriber Lake Creek to 213th St.	226	322	411	561	250	343	426	637
140	15243.7	213th St. to Larch Way	218	300	381	553	250	327	408	649
145	17017.25	Larch Way to 20,000 Locust Way	215	294	387	518	237	316	407	593
170	21593.73	20000 Locust Way to Filbert Rd.	204	276	344	496	226	300	380	600

cfs = cubic feet per second
D/S = downstream U/S = upstream

Figure 8-1e shows the location of each existing problem predicted by the hydraulic analyses.

B5.3.3 Model Results and Problem Identification with Future Conditions Flows

Water surface profiles were computed at 2-, 10-, 25-, and 100-year peak discharge rates for the future land use conditions. HEC-RAS model results are summarized in Table B5-5. This table shows how water surface elevations compare to road flooding elevations for all bridges in the model. Table B5-5 also lists bridge identification and location, river station, flooding elevation, and water surface elevations at the upstream end of each bridge in the stream system for the 2-, 10-, 25-, and 100-year events under future flow conditions.

Results of the HEC-RAS model predict that under future conditions two of the twelve bridges will experience some flooding. One of these is a bridge that floods at a 100-year level under existing conditions but floods at the 25-year level under future conditions. The other shows no flooding under existing conditions but shows flooding at the 100-year level under future conditions.

Figure 8-1e shows the location of each future flooding problem predicted by the hydraulic analyses.

B5.4 SWMM Development and Results

The purpose of SWMM modeling was to:

- Facilitate development of FTABLEs for input into the HSPF model.
- Quantify flooding in drainage systems for predicted existing and future flows.
- Develop solutions to reduce predicted flooding.

Note that for this DNR, the model and modeling results were developed using XP-SWMM 2000 Version 7.5, which is a modified version of SWMM developed by XP Software. After the analysis was complete, the model was converted to SWMM 2000 Version 8.0. Due to the differences in the XP-SWMM and SWMM computer programs, the future results computed by SWMM may vary slightly from the reported XP-SWMM results presented in this DNR.

B5.4.1 Model Development

SWMM 2000 Version 8.0 was used to model Logan Road system, a tributary to South Swamp Creek. The Logan Road system flows east to west between Damson Road and Locust Road. This system was also modeled to include the Crawford Road drainage. The model was used to analyze the system for the 2-, 10-, and 25-year flood events for existing and future land use conditions. The various components used to model the system are described next. A model schematic is shown in Figure B5-2.

Table B5-5

HEC-RAS Hydraulic Model Results for Existing System With Existing and Future Land Use Conditions for South Swamp Creek Subbasin

Problem ID ^a	Culvert ID/ Location ^b	Modeled Culvert Size and Material	River Station ^c (ft)	Flooding Elevation ^d (ft)	2-Year Water Surface Elevation (ft)		10-Year Water Surface Elevation (ft)		25-Year Water Surface Elevation (ft)		100-Year Water Surface Elevation (ft)		Flooding Frequency ^e	
					Existing	Future	Existing	Future	Existing	Future	Existing	Future	Existing	Future
	No. 1 – Unnamed Wooden Bridge	Bridge	21602	290.39	284.8	284.94	285.21	285.26	285.89	286.01	286.39	286.49	None	None
	No. 2 – Larch Way Bridge #1	Bridge	17038	249.9	245.14	245.28	245.58	245.72	245.99	246.15	246.74	247.24	None	None
	No. 3 – Private Drive Bridge	Bridge	12840	207.4	204.2	204.3	204.71	204.8	205.13	205.2	205.36	205.64	None	None
	No. 4 – Locust Way Bridge 3rd	Bridge	12119	207.03	196.87	197.02	197.41	197.51	197.84	197.91	198.49	198.78	None	None
	No. 5 – Pedestrian Bridge	Bridge	9402	175.95	168.88	168.98	169.29	169.38	169.58	169.66	170.05	170.31	None	None
	No. 6 – Locust Way Bridge 2nd	Bridge	8799	174.7	164.29	164.5	165.39	165.57	165.81	166.06	166.23	166.68	None	None
SW-SO-F-Ex-1	No. 7 – Pedestrian Bridge	Bridge	7189	155.05	152.63	152.88	154.28	154.57	154.83	155.25	155.25	156.11	100	25
	No. 8 - Locust Way Bridge 1st	Bridge	6667	154.09	147.15	147.4	148.41	148.58	148.74	148.98	148.98	149.37	None	None
	No. 9 – Unnamed Bridge	Bridge	5849	143.19	140.94	141.27	142.69	142.96	142.49	142.91	142.91	143.63	None	100
	No. 10 – Unnamed Bridge	Bridge	5653	144	137.94	138.27	139.65	139.9	140.14	140.51	140.51	141.12	None	None
	No. 11 – Carter Road Bridge	Bridge	2152	103.64	98.87	99.15	100.17	100.45	100.6	100.92	101.05	101.46	None	None
	No. 12 – Lockwood Road Bridge	Bridge	1095	91.51	86.17	86.39	87.21	87.43	87.56	87.85	87.96	88.32	None	None

^a See Section 8.0 for problem ID key.

^b Culvert ID numbers assigned downstream to upstream for HEC-RAS.

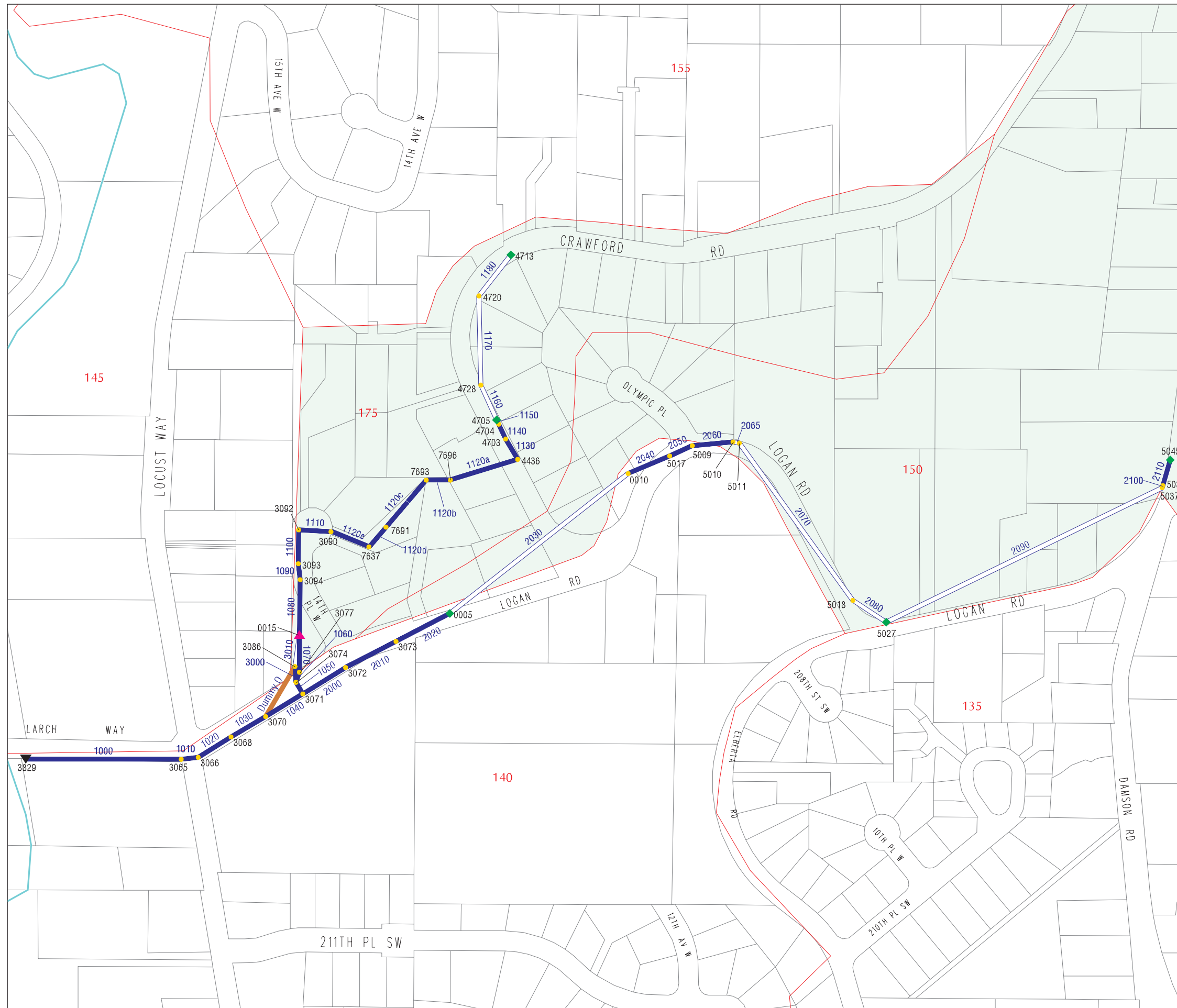
^c See Figure B5-1 for HEC-RAS schematic showing river stationing.

^d Refers to elevation of roadway, property, or channel flooding.

^e Minimum storm event (of events analyzed) when flooding is expected to occur. The roadway/driveway floods if the water surface elevation is within 0.2' of the flood elevation.

CMP = corrugated metal pipe

Datum = NAVD 88



Legend

- Basin Boundary
- HSPF Subbasin Boundary
- Parcel Boundary
- Stream

SWMM Model Catchments

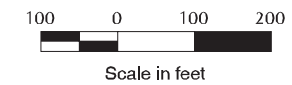
- Logan Road

Conveyance System

- Open Channel
- Closed Conduit
- Dummy Conduit

Model Nodes

- Storage
- Flow
- Junction
- Outfall



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Figure B5-2

South Swamp Creek

Hydraulic Model Schematic

for SWMM Model

Swamp Creek Drainage Needs Report

Snohomish County disclaims any warranty of merchantability or warranty of fitness of this map for any particular purpose, either express or implied. No representation or warranty is made concerning the accuracy, currency, completeness or quality of data depicted on this map. Any user of this map assumes all responsibility for use thereof, and further agrees to hold Snohomish County harmless from and against any damage, loss, or liability arising from any use of this map.

B5.4.1.1 Structure, Cross Section and Pond Data

The conveyance system is comprised of enclosed storm drain pipe, reaches of ditch and culvert, and a stormwater pond. The data input for the SWMM model used to define these features included: pipe diameter, material, inverts, and length, channel inverts, channel cross sections, and overflow elevations. For enclosed pipe, the overflow elevation was defined as the rim elevation; for culverts, the overflow elevation was defined as the top of road elevation less 0.2 ft ; and for ditches, the overflow was defined as the top of bank.

One stormwater detention pond located in the northwest corner of the intersection with 14th Place W and Logan Road was included in the model. Data input to describe the stormwater pond included: the pond’s stage and volume relationship- , control structure orifice diameter and elevation, the riser diameter and elevation, and the emergency spillway cross section and elevation.

The primary sources of data used to model the system were a survey performed as part of this project and a survey by Snohomish County. In addition, as-built plans were used to define the storage volume, orifice sizes of the control structure, emergency spillway cross section and elevation, and check elevations of nearby catch basins. The NAVD 88 datum was used for the basin survey and the Alderwood Water District datum was used for the as-built plans. Therefore, a conversion factor of 3.67 was added to the Alderwood Water District datum to convert the as-built elevations to the basin survey elevations. In the case where the as-built and survey elevation did not correlate, the survey elevation was used.

Specific sources of model input data are listed in Table B5-6.

B5.4.1.2 Boundary Conditions

The downstream boundary for this system is the outfall to South Swamp Creek. The outfall is high enough above the streambed that there is no tailwater effect for the system at low flows. High flows in South Swamp Creek will create a tailwater effect for the system although it is expected that the tailwater effect will be relatively low. As a result, the high flows in South Swamp Creek will not affect the hydraulics of the Logan Road system.

Table B5-6		
Sources of SWMM Input Data		
Type	Description	Year
Surveys	Consultant Drainage Survey	2001
	Snohomish County Drainage System Inventory	1993
Mapping	Topographic Orthophotos	1998
	Alderwood Water District 5-foot contours	
As-Builts	As-builts for Skylark Development, Snohomish Count Project #93-448, McArdle Murry Inc., October 4, 1991.	1991

B5.4.1.3 Dummy Links

There is one dummy link in the Logan Road SWMM model. The dummy link represents overflow across Logan Road from the emergency spillway. This dummy link was used in developing the FTABLES, but it was not used for the final model runs. The flows that were produced from the HSPF model did not activate the dummy link.

B5.4.1.4 Roughness Coefficients

Roughness coefficients for the ditch reaches were determined from field observation. Roughness coefficients for the pipes were established as described in the Hydraulic Modeling Protocols. The roughness coefficients used for the channels were determined based on information in USGS Water-Supply Paper 2339, *Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains* (Arcement and Schneider 1989) and *Open-Channel Hydraulics* (Chow 1959).

B5.4.1.5 Flood Hydrograph Routing

Flows used in the model were established from the hydrologic analysis for recurrence frequencies, and consist of the 2-, 10-, and 25-year flows for both existing and future land use conditions. The 96-hour hydrographs produced by the HSPF hydrologic analysis are described in Appendix A3. These hydrographs were input into the model at the nodes identified on the model schematic (see Figure B5-2).

B5.4.2 FTABLE Development

For the areas covered by SWMM modeling, the model was used to develop the stage-storage-discharge relationships contained within FTABLEs for input into the HSPF hydrologic model. To determine the stage-storage-discharge relationship, constant flow at various locations was input into the model. Preliminary flow ranges for FTABLE generation was based on Rational Method. The flow was proportioned over the system based on contributing drainage area. The model then was run for an extended period of time to allow the system to reach equilibrium. The process was repeated for a range of flows to provide sufficient data points for FTABLE development. Stage, storage, and discharge results were extracted from the SWMM output as described in the Hydraulic Modeling Protocols. Refer to Table B5-7 for the extents of the FTABLEs developed using SWMM for the South Swamp Creek Subbasin.

Routing a constant flow through the SWMM model over several days requires a large volume of water to be passed through the system. This often resulted in the system overflowing, even at portions of the system not known or expected to flood. To contain the flood volume and more accurately assess the storage at a particular flow, additional modifications of the SWMM model were required. The modifications to the SWMM model were to define overflow paths or storage areas where flow would pond until sufficient head was built up to force the flow through the system. The additional overflow paths and storage areas are approximate and are included in the model for the sole purpose of estimating storage for the FTABLEs. The overflow paths were defined as trapezoidal channels and are summarized in Table B5-8.

**Table B5-7
Physical Extents of FTABLEs Generated from SWMM for the South Swamp Creek Subbasin**

HSPF Reach	Location of Controlling Structure	SWMM Model Coverage	SWMM File Name	FTABLE Extent		Additional Area/Volume Data Source
				Downstream Node ID	Upstream Node ID	
150	Catch basin south of Logan Road	Crawford Road near 12th Place W. to Logan Road near 14th Place W.	Swa3_orig	3071	4713	N/A
175	Catch basin south of Logan Road	Damson/Logan Road intersection to Logan Road west of 14th Place W.	Swa3_orig	3071	5045	N/A

**Table B5-8
Overflow Paths and Ponding Nodes Defined for FTABLE Generation for the South Swamp Creek Subbasin**

Link	Upstream Node	Downstream Node	Location	Method for Handling Overflow
1140	4705	4704	East of Crawford Road	Trapezoidal channel with 10% side slopes and 20-foot bottom width
1130	4704	4703	East of Crawford Road	Trapezoidal channel with 10% side slopes and 20-foot bottom width
2110	5045	5036	Damson/Logan Road intersection	Trapezoidal channel with 10% side slopes and 10-foot bottom width
2100	5036	5037	Damson/Logan Road intersection	Trapezoidal channel with 10% side slopes and 10-foot bottom width
2090	5037	5027	North of Logan Road	Trapezoidal channel with 10% side slopes and 20-foot bottom width
2080	5027	5018	North of Logan Road	Trapezoidal channel with 10% side slopes and 10-foot bottom width
2065	5011	5010	North of Logan Road	Trapezoidal channel with 10% side slopes and 10-foot bottom width
2060	5010	5009	North of Logan Road	Trapezoidal channel with 10% side slopes and 10-foot bottom width
2050	5009	5017	North of Logan Road	Trapezoidal channel with 10% side slopes and 10-foot bottom width
1040	3071	3070	South of Logan Road	Trapezoidal channel with 10% side slopes and 15-foot bottom width
1030	3070	3068	South of Logan Road	Trapezoidal channel with 10% side slopes and 15-foot bottom width

B5.4.3 Model Results and Problem Identification with Existing Condition Flows

Peak water surface elevations were computed for the 2-, 10-, and 25-year existing land use conditions events. Figure 8-1e shows flooding locations and frequencies. Table B5-9 lists the resulting water surface elevations for the entire model.

Under existing land use conditions, the SWMM model indicates flooding occurs at six catch basin locations within the Logan Road system. All flooding occurs during the 10-, or 25-year events.

The SWMM model indicates flooding would occur during the 10-year event at the intersection of Damson Road and Logan Road, due to insufficient conveyance capacity. This flooding problem is consistent with resident complaints and is confirmed by the County staff.

The model also indicates that for the 25-year event, pipe network along Crawford Road downstream of the roadside ditch would flood. This system flows west down a steep grade to the Skylark Development where a backyard drainage system also floods during the 25-year event.

Finally, the pipe system situated along 14th Place West and immediately upstream of the existing detention pond also floods during the 25-year event. This flooding problem is consistent with resident's complaints.

B5.4.4 Model Results and Problem Identification with Future Conditions Flows

Peak water surface elevations were computed for the 2-, 10-, and 25-year events for future land use conditions. Most flooding locations and frequencies are the same as those for the existing condition analysis and are shown in Table B5-9. The SWMM model results show problems for future conditions at the same locations as for existing conditions.

The SWMM model results for the future conditions are summarized below.

Flooding occurs at the system near the intersection of Damson Road and Logan Road for the 10-year and 25-year events with future land use conditions. The model also indicates the pipe networks paralleling Crawford Road would flood at the 10-year event for the future land use condition. This system flows west down a steep grade to the Skylark Development where a backyard drainage system also floods during the 10-year event.

Finally, the pipe system situated along 14th Place West and upstream of the existing detention pond floods at the 10-year event.

B5.5 CIP Alternatives

B5.5.1 CIP Alternative 1

The objective of CIP Alternative 1 for the South Swamp Creek Subbasin was to address flooding problems along the Logan/Crawford tributary of the South Swamp Creek system through conveyance improvements.

Table B5-9
SWMM Hydraulic Model Results for Existing System/Existing and Future Land Use Conditions - South Swamp Creek Subbasin

Problem ID ^a	Location	Model Node ^b	Node Invert	Flooding Elevation (ft) ^c	2-Year Water Surface Elevation(ft)		10-Year Water Surface Elevation (ft)		25-Year Water Surface Elevation (ft)		Flooding Frequency ^d	
					Existing	Future	Existing	Future	Existing	Future	Existing	Future
						Ditch along Crawford Road	4713	420.64	425.87	420.95	420.95	421.05
	Ditch along Crawford Road	4720	412.97	414.93	413.21	413.21	413.34	413.30	413.34	413.34	none	none
	Ditch along Crawford Road	4728	406.55	412.58	406.88	406.87	407.02	407.17	407.19	407.17	none	none
	Ditch along Crawford Road	4705	404.87	410.02	405.58	405.92	406.73	407.17	407.19	407.17	none	none
SW-SO-F-Ex-2	Culvert inlet along Crawford Road	4704	405.07	406.93	405.10	405.87	406.72	407.16	407.17	407.15	25-yr	10-yr
SW-SO-F-Ex-3	Catch basin along Crawford Road	4703	404.43	406.93	405.03	405.87	406.72	407.16	407.17	407.15	25-yr	10-yr
	Catch basin along Crawford Road	4436	403.86	407.66	404.01	404.08	404.11	404.17	404.21	404.38	none	none
	Catch Basin west of Crawford Road over steep ground	7637	319.99	322.37	320.24	320.36	320.46	320.57	320.75	320.61	none	none
	Catch Basin west of Crawford Road over steep ground	7691	323.86	328.39	324.12	324.25	324.43	324.52	324.54	324.50	none	none
	Catch Basin west of Crawford Road over steep ground	7693	373.10	376.57	373.29	373.38	373.42	373.51	373.56	373.53	none	none
	Catch Basin west of Crawford Road over steep ground	7696	376.08	377.89	376.39	376.55	376.62	376.82	377.22	376.86	none	none
SW-SO-F-Ex-4	Catch basin on 14th Place W.	3090	313.62	316.86	314.16	314.52	315.68	317.12	317.14	317.13	25-yr	10-yr
	Catch basin on 14th Place W.	3092	312.66	316.14	312.91	313.04	313.11	313.22	313.31	313.22	none	none
SW-SO-F-Ex-5	Catch basin on 14th Place W.	3093	304.43	307.18	304.77	304.96	305.06	306.36	307.21	306.86	25-yr	none
	Stormwater pond inlet	3094	302.95	305.75	303.58	303.92	304.09	304.96	305.55	305.22	none	none
	Skylark Development Stormwater Pond	0015	300.77	306.21	302.01	303.22	303.63	303.75	303.83	304.02	none	none
	Stormwater pond outfall	3077	300.62	307.42	302.00	303.05	303.27	303.34	303.38	303.44	none	none
	Emergency spillway outfall	3086	300.77	306.21	301.04	301.11	301.39	301.30	301.36	301.43	none	none
	Catch basin along Logan Road	3074	300.32	304.57	301.04	301.11	301.39	301.30	301.36	301.43	none	none
	Catch basin along Logan Road	3071	300.23	306.63	301.04	301.08	301.34	301.25	301.33	301.35	none	none
SW-SO-F-Ex-6	Catch basin at Damson/Logan Road intersection	5045	462.12	463.87	462.61	462.60	463.81	463.55	464.16	464.13	25-yr	25-yr
SW-SO-F-Ex-7	Catch basin at Damson/Logan Road intersection	5036	460.26	462.06	461.18	461.16	462.35	462.26	463.29	462.99	10-yr	10-yr
	Ditch along Logan Road	5037	460.28	463.14	460.66	460.66	460.74	460.74	460.75	460.75	none	none
	Ditch along Logan Road	5027	434.22	436.75	435.10	435.09	435.34	435.35	435.45	435.43	none	none
	Ditch along Logan Road	5018	433.55	435.30	434.52	434.51	434.59	434.59	434.61	434.60	none	none
	Ditch along Logan Road	5011	431.24	432.98	432.30	432.29	432.69	432.66	432.73	432.68	none	none
	Ditch along Logan Road	5010	431.18	433.98	431.92	431.91	432.62	432.59	432.66	432.61	none	none
	Catch basin along Logan Road	5009	426.36	428.26	426.92	426.91	427.00	427.00	427.00	427.00	none	none
	Catch basin along Logan Road	5017	421.33	422.93	422.09	422.09	422.20	422.20	422.20	422.20	none	none
	Ditch along Logan Road	0010	411.81	413.61	412.25	412.24	412.30	412.30	412.30	412.30	none	none
	Ditch along Logan Road	0005	335.72	337.52	336.46	336.45	336.62	336.61	336.64	336.64	none	none
	Catch basin along Logan Road	3073	324.35	326.29	324.97	324.97	325.10	325.09	325.12	325.11	none	none
	Catch basin along Logan Road	3072	308.95	312.55	309.66	309.65	309.81	309.80	309.83	309.83	none	none
	Catch basin along Logan Road	3071	300.23	304.83	301.04	301.08	301.34	301.25	301.33	301.35	none	none
	Catch basin along Logan Road	3070	294.77	300.07	295.81	295.87	296.93	296.50	296.92	296.96	none	none
	Catch basin along Logan Road	3068	291.90	296.10	292.74	292.78	293.01	292.97	293.01	293.02	none	none
	Catch basin along Logan Road	3066	287.62	290.21	288.55	288.59	288.87	288.81	288.86	288.87	none	none
	Catch basin along Logan Road	3065	285.70	289.20	286.35	286.38	286.52	286.50	286.52	286.53	none	none
	Outfall to Swamp Creek	3829	244.44	246.74	245.09	245.12	245.26	245.24	245.26	245.27	none	none

^a See Section 8.0 for problem ID key.
^b See Figure B5-2 for SWMM schematic showing river stationing.
^c Refers to elevation of roadway, property, or channel flooding.
^d Minimum storm event (of events analyzed) when flooding is expected to occur.
Datum = NAVD 88

B5.5.1.1 CIP Alternative 1 Hydraulic Model Changes

CIP Alternative 1 includes replacing two existing pipe systems identified as flooding problems to increase the capacity of the existing conveyance system. The two pipe systems were designed to meet conveyance requirements. The SWMM model was modified with the conveyance improvements as described above and shown on Table B5-10.

The modified SWMM model was used to develop new FTABLEs for the HSPF model to reflect the loss in storage resulting from the improved conveyance. Updated HSPF flows were entered into the SWMM model to verify the final sizing of the proposed solutions and to evaluate the effects of the conveyance improvements on downstream flooding and flows. More details on the HSPF analysis can be found in Appendix A3.

The specific CIP projects included in CIP Modeling Alternative 1 are summarized on Table 9-2. Figure 9-1e shows the locations of each project.

B5.5.1.2 Model Results with Future Conditions Flows

The results of the SWMM model using the conveyance improvements that comprise CIP Alternative 1 are presented in Table B5-11. This table compares the water surface elevations at the catch basins in the system for the existing conveyance system under existing and future land use conditions with CIP alternatives 1 and 2. It is important to note that conveyance improvements reduce flooding, but they also reduce flood storage. The reduction in flood storage results in an increase in downstream peak flows. An increase in downstream flow may cause increases in downstream flooding, erosion, and impacts to wetlands. The increase in downstream flows is insignificant along South Swamp Creek because the pipe systems that are being upgraded for flooding problems do not store a significant amount of water upstream. The flow increases for this alternative are shown on Table 9-3e.

The SWMM model results show a decrease in water surface elevations throughout the system for the 2-, 10-, and 25-year events between the future land use results and the CIP Alternative 1 results. The results showed no additional pipe systems would need to be replaced because they do not become flooding problems with the proposed culvert upgrades in place.

B5.5.2 CIP Alternative 2

The objective of CIP Alternative 2 for the South Swamp Creek Subbasin was to address flooding problems along the Logan/Crawford tributary of South Swamp Creek through a combination of conveyance and detention improvements, and to address problems within the subbasin associated with loss of storage and increased flows.

B5.5.2.1 CIP Alternative 2 Hydraulic Model Changes

CIP Alternative 2 for the South Swamp Creek Subbasin includes the same two pipe system upgrades proposed in CIP Alternative 1, as well as upgrading the Skylark subdivision detention facility. The purpose of the detention facility is to address increased flows resulting from the proposed conveyance improvements and land use changes proposed for future conditions. The detention facility will also provide water quality treatment. The detention facility included in this alternative is described in Section 9.0 and Appendix A3.

**Table B5-10
SWMM Model Changes for Modeling CIP Alternatives 1 and 2**

Modeling Alternative		CIP Project ID ^a	Problem ID ^b	Project Title	Project Description	Summary of Changes to XP-SWMM Model
1	2					
X	X	SW-SO-1	SW-SO-F-EX-2 SW-SO-F-EX-3 SW-SO-F-EX-4 SW-SO-F-EX-5 SW-SO-F-EX-6 SW-SO-F-EX-7	Logan & Crawford Roads Pipe Conveyance Upgrade	Replace existing 625 lf of 12-inch-dia. enclosed pipe system with 24-inch-dia CMP enclosed pipe system, and 66 lf of 12-inch-dia. pipe with 18-inch-dia. Conc. Pipe.	Pipe systems between nodes 4703 and 7693 and between node 3090 and 0015 was upsized to 24-inch. Pipe system between nodes 5040 and 5036 was upsized to 18-inch.
	X	SW-SO-2	SW-SO-F-EX-2 SW-SO-F-EX-3 SW-SO-F-EX-4 SW-SO-F-EX-5 SW-SO-F-EX-6 SW-SO-F-EX-7	Logan Road Detention Facility Improvements	Retrofit the detention facility in the northwest corner of 14th Place and Logan Road to maximize storage.	Storage node 0015 was modified to represent the retrofit of the detention facility in the northwest corner of 14th Place and Logan Road.

^a SW-SO-01
 SW = Swamp Creek DNR Area
 SO = South Swamp Creek
 01 = CIP project number

^b SW-SO-F-Ex-01
 SW = Swamp Creek DNR Area
 SO = South Swamp Creek
 F = flooding (H = habitat, Q = water quality, E = erosion)
 Ex = existing (Fu = future)
 01 = problem

Table B5-11
SWMM Hydraulic Model Results for Existing System With Existing and Future Land Use for South Swamp Creek Subbasin for CIP Alternatives 1 and 2

Problem ID ^a	Study Area (same as Modeling Area)	Location	Model Node	Node Invert	Flooding Elevation ^b (ft NAVD)	2-Year Water Surface Elevation (ft NAVD)				10-Year Water Surface Elevation (ft NAVD)				25-Year Water Surface Elevation (ft NAVD)				Flooding Frequency ^c			
						Existing	Future	Alt 1	Alt 2	Existing	Future	Alt 1	Alt 2	Existing	Future	Alt 1	Alt 2	Existing	Future	Alt 1	Alt 2
							5	Ditch along Crawford Road	4713	420.64	425.87	420.95	420.95	420.94	420.95	421.05	421.02	421.11	421.02	421.05	421.05
	5	Ditch along Crawford Road	4720	412.97	414.93	413.21	413.21	413.21	413.21	413.34	413.30	413.43	413.30	413.34	413.34	413.33	413.35	none	none	none	none
	5	Ditch along Crawford Road	4728	406.55	412.58	406.88	406.87	406.87	406.88	407.02	407.17	407.11	406.97	407.19	407.17	407.01	407.03	none	none	none	none
	5	Ditch along Crawford Road	4705	404.87	410.02	405.58	405.92	405.83	405.84	406.73	407.17	406.10	406.03	407.19	407.17	406.10	406.13	none	none	none	none
SW-SO-F-Ex-2	5	Culvert inlet along Crawford Road	4704	405.07	406.93	405.10	405.87	405.13	405.13	406.72	407.16	405.50	405.37	407.17	407.15	405.47	405.52	25-yr	10-yr	none	none
SW-SO-F-Ex-3	5	Catch basin along Crawford Road	4703	404.43	406.93	405.03	405.87	405.12	405.13	406.72	407.16	405.50	405.38	407.17	407.15	405.48	405.53	25-yr	10-yr	none	none
	5	Catch basin along Crawford Road	4436	403.86	407.66	404.01	404.08	404.16	404.17	404.11	404.17	404.33	404.28	404.21	404.38	404.32	404.34	none	none	none	none
	5	Catch Basin west of Crawford Road	7637	319.99	322.37	320.24	320.36	320.42	320.43	320.46	320.57	320.77	320.63	320.75	320.61	320.74	320.82	none	none	none	none
	5	Catch Basin west of Crawford Road	7691	323.86	328.39	324.12	324.25	324.31	324.32	324.43	324.52	324.72	324.54	324.54	324.50	324.68	324.78	none	none	none	none
	5	Catch Basin west of Crawford Road	7693	373.10	376.57	373.29	373.38	373.43	373.43	373.42	373.51	373.64	373.57	373.56	373.53	373.63	373.66	none	none	none	none
	5	Catch Basin west of Crawford Road	7696	376.08	377.89	376.39	376.55	374.68	374.69	376.62	376.82	375.04	374.92	377.22	376.86	375.02	375.07	none	none	none	none
SW-SO-F-Ex-4	5	Catch basin on 14th Place W.	3090	313.62	316.86	314.16	314.52	314.28	314.30	315.68	317.12	314.67	314.54	317.14	317.13	314.64	314.69	25-yr	10-yr	none	none
	5	Catch basin on 14th Place W.	3092	312.66	316.14	312.91	313.04	313.00	313.00	313.11	313.22	313.19	313.13	313.31	313.22	313.18	313.20	none	none	none	none
SW-SO-F-Ex-5	5	Catch basin on 14th Place W.	3093	304.43	307.18	304.77	304.96	304.88	304.89	305.06	306.36	305.15	305.06	307.21	306.86	305.14	305.17	25-yr	none	none	none
	5	Stormwater pond inlet	3094	302.95	305.75	303.58	303.92	303.81	303.83	304.09	304.96	304.31	304.14	305.55	305.22	304.28	304.35	none	none	none	none
	5	Skylark Development Stormwater Pond	15	300.77	306.21	302.01	303.22	301.49	301.49	303.63	303.75	301.93	301.76	303.83	304.02	301.89	301.89	none	none	none	none
	5	Stormwater pond outfall	3077	300.62	307.42	302.00	303.05	301.28	301.28	303.27	303.34	301.68	301.53	303.38	303.44	301.65	301.65	none	none	none	none
	5	Emergency spillway outfall	3086	300.77	306.21	301.04	301.11	301.03	301.02	301.39	301.30	301.38	301.27	301.36	301.43	301.37	301.37	none	none	none	none
	5	Catch basin along Logan Road	3074	300.32	304.57	301.04	301.11	301.03	301.02	301.39	301.30	301.38	301.27	301.36	301.43	301.37	301.37	none	none	none	none
	5	Catch basin along Logan Road	3071	300.23	306.63	301.04	301.08	300.97	300.96	301.34	301.25	301.28	301.20	301.33	301.35	301.30	301.29	none	none	none	none
SW-SO-F-Ex-6	5	Catch basin at Damson/Logan Road intersection	5045	462.12	463.87	462.61	462.60	462.49	462.49	463.81	463.55	462.59	462.58	464.16	464.13	462.62	462.62	25-yr	25-yr	none	none
SW-SO-F-Ex-7	5	Catch basin at Damson/Logan Road intersection	5036	460.26	462.06	461.18	461.16	460.92	460.91	462.35	462.26	461.06	461.04	463.29	462.99	461.11	461.10	10-yr	10-yr	none	none
	5	Ditch along Logan Road	5037	460.28	463.14	460.66	460.66	460.63	460.62	460.74	460.74	460.72	460.71	460.75	460.75	460.74	460.74	none	none	none	none
	5	Ditch along Logan Road	5027	434.22	436.75	435.10	435.09	434.80	434.79	435.34	435.35	434.98	434.95	435.45	435.43	435.02	435.01	none	none	none	none
	5	Ditch along Logan Road	5018	433.55	435.30	434.52	434.51	434.48	434.47	434.59	434.59	434.58	434.57	434.61	434.60	434.60	434.60	none	none	none	none
	5	Ditch along Logan Road	5011	431.24	432.98	432.30	432.29	432.24	432.23	432.69	432.66	432.43	432.41	432.73	432.68	432.46	432.46	none	none	none	none
	5	Ditch along Logan Road	5010	431.18	433.98	431.92	431.91	431.69	431.69	432.62	432.59	431.86	431.84	432.66	432.61	431.89	431.89	none	none	none	none
	5	Catch basin along Logan Road	5009	426.36	428.26	426.92	426.91	426.77	426.77	427.00	427.00	426.90	426.89	427.00	427.00	426.92	426.92	none	none	none	none
	5	Catch basin along Logan Road	5017	421.33	422.93	422.09	422.09	422.01	422.00	422.20	422.20	422.26	422.23	422.20	422.20	422.31	422.31	none	none	none	none
	5	Ditch along Logan Road	10	411.81	413.61	412.25	412.24	412.21	412.20	412.30	412.30	412.32	412.31	412.30	412.30	412.34	412.34	none	none	none	none
	5	Ditch along Logan Road	5	335.72	337.52	336.46	336.45	336.39	336.38	336.62	336.61	336.63	336.60	336.64	336.64	336.68	336.67	none	none	none	none
	5	Catch basin along Logan Road	3073	324.35	326.29	324.97	324.97	324.91	324.91	325.10	325.09	325.11	325.09	325.12	325.11	325.14	325.14	none	none	none	none
	5	Catch basin along Logan Road	3072	308.95	312.55	309.66	309.65	309.59	309.58	309.81	309.80	309.82	309.79	309.83	309.83	309.86	309.86	none	none	none	none
	5	Catch basin along Logan Road	3071	300.23	304.83	301.04	301.08	300.97	300.96	301.34	301.25	301.28	301.20	301.33	301.35	301.30	301.29	none	none	none	none
	5	Catch basin along Logan Road	3070	294.77	300.07	295.81	295.87	295.69	295.67	296.93	296.50	296.11	296.00	296.92	296.96	296.13	296.13	none	none	none	none
	5	Catch basin along Logan Road	3068	291.90	296.10	292.74	292.78	292.66	292.65	293.01	292.97	292.99	292.90	293.01	293.02	293.00	293.00	none	none	none	none
	5	Catch basin along Logan Road	3066	287.62	290.21	288.55	288.59	288.46	288.45	288.87	288.81	288.81	288.72	288.86	288.87	288.83	288.82	none	none	none	none
	5	Catch basin along Logan Road	3065	285.70	289.20	286.35	286.38	286.30	286.30	286.52	286.50	286.55	286.49	286.52	286.53	286.56	286.56	none	none	none	none
	5	Outfall to Swamp Creek	3829	244.44	246.74	245.09	245.12	245.04	245.04	245.26	245.24	245.29	245.23	245.26	245.27	245.30	245.30	none	none	none	none

^aSee Section 8.0 for Problem ID key.

^bRefers to elevation of roadway, property, or channel flooding.

^cMinimum storm event (of events analyzed) when flooding is expected to occur.

The detention facility is located west of 14th Place W and north of Logan Road. The pond is an in-channel facility designed to pass low flows and detain high flows from the Crawford branch and then discharge back into the Logan branch further downstream. The detention pond upgrade would provide 0.12 acre-feet of live storage in addition to the existing live storage volume of 0.25 acre-feet. Also, the retrofit would provide dead storage of 3 feet in depth for water quality treatment.

The SWMM model was modified with the conveyance improvements as described in Alternative 1 and shown on Table B5-10. Additionally, the detention facility was expanded to maximize the storage. The SWMM model was run to generate new FTABLEs to reflect the change in storage resulting from the improved conveyance. The revised HSPF flows, including the discharge from the pond were then entered into SWMM to verify the final sizing of the proposed solutions and to evaluate the effects of the conveyance and detention improvements on downstream flooding and flows. More details on the HSPF analysis can be found in Appendix A3.

The specific CIP projects included in Alternative 2 are indicated in Table 9-2. This table summarizes each CIP project and its benefits. Figure 9-1e shows the location of each project.

B5.5.2.2 Model Results with Future Conditions Flows

The results of the SWMM model using the conveyance improvements and detention facility that comprise CIP Alternative 2 are presented in Table B5-11. This table compares the water surface elevations at the catch basins in the system for the existing conveyance system under existing and future land use conditions as well as for CIP alternatives 1 and 2.

The results show that with the detention pond in place, the flow from the system was reduced by approximately 30 percent from Alternative 1 to Alternative 2. However, since the locations of flooding are upstream of the detention pond, the detention expansion is largely a water quality improvement with the added benefit that it moderates downstream flow. The flow decreases are shown on Table 9-3e and summarized in Section 9.2.5. The SWMM model results show a decrease in water surface elevations throughout the system for the 2-, 10-, and 25-year events between the future land use and the CIP Alternative 2. The modeling results showed no additional pipe systems in the system would need to be replaced because they do not become flooding problems with the proposed pipe system upgrades in place.

B5.6 References

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