Snohomish County

Swamp Creek Drainage Needs Report

APPENDIX A4

HSPF Model Development and Application for Chase Lake Subbasin

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Appendix A4. HSPF Model Development and Application for Chase Lake Subbasin

A4.1 Introduction

The hydrologic analysis for the Chase Lake Subbasin was performed with the Hydrologic Simulation Program–FORTRAN (HSPF) model. This model was selected because it uses historical rainfall records to generate a long-term series of stormwater flows, making it well suited to address issues related to the cumulative impacts of development on water resources. The long-term flow record will help answer the question of whether flows that cause stream channel erosion will occur for longer periods of time due to upstream development. Another benefit of creating a long-term series is that this gives a more accurate estimate of flood frequency at a given location than the use of single-event design storms. This is particularly true in the Puget Sound region, where flooding is often caused by a series of smaller storms that occur back-to-back rather than by a single, isolated major storm event.

This appendix describes the HSPF model development and application for the Chase Lake Subbasin. The purpose of the HSPF modeling was to determine the long-term flood frequency and runoff characteristics for the Chase Lake watershed. The model was also used to simulate streamflow for two alternatives that include proposed Capital Improvement Projects (CIP) to solve flooding problems. (Statistical analysis of the simulated streamflow record for the existing and future land use conditions, as well as for the two CIP alternatives.) The analysis includes only flood frequency. The 10 percent exceedance flows were not developed because habitat does not exist in this study area. The results of the HSPF analysis are used as input to the habitat, water quality, and hydraulics analyses.

A4.2 Review of Previous Work

No previous study has developed an HSPF model for the Chase Lake Subbasin.

A4.3 Basin Characteristics

This section provides a general description of the Chase Lake Subbasin and the methods used to delineate the subbasins for hydrologic modeling.

A4.3.1 Subbasin Delineation

The three separate flow paths that comprise the Chase Lake Subbasin were delineated into subbasins in accordance with the guidelines established in the Snohomish County Drainage Needs Report Hydrologic Modeling Protocols (Hydrologic Protocols, Section 2.0) and are shown in Figure A4-1. The northern drainage comprises Chase Lake and the areas that contribute drainage to both the lake and the downstream reaches of the lake discharge. This section has been subdivided into 27 subbasins. The southwestern section that flows into the Puget Sound Basin was subdivided into five subbasins. The remaining southern section that flows south toward Hall Creek contains three subbasins. The subbasins range in size from 45 acres to less than one acre.

A4.3.2 Soils and Geology

For the HSPF model, the soils in Snohomish County are classified into four major categories: glacial till, glacial outwash, Custer-Norma, and saturated (wetland). Soils in a basin play a pronounced role in the hydrology and runoff processes that affect natural and constructed conveyance systems. The United States Geological Survey (USGS) has established specific HSPF parameter values for each of these soil types.

Figure A4-2 shows the soils underlying the Chase Lake drainage area. This basin covers less than a square mile and is underlain entirely by glacial till with the exception of a saturated area at the location of Chase Lake. Till soils are moderately well drained soils with low infiltration and overlie a relatively impermeable hardpan.

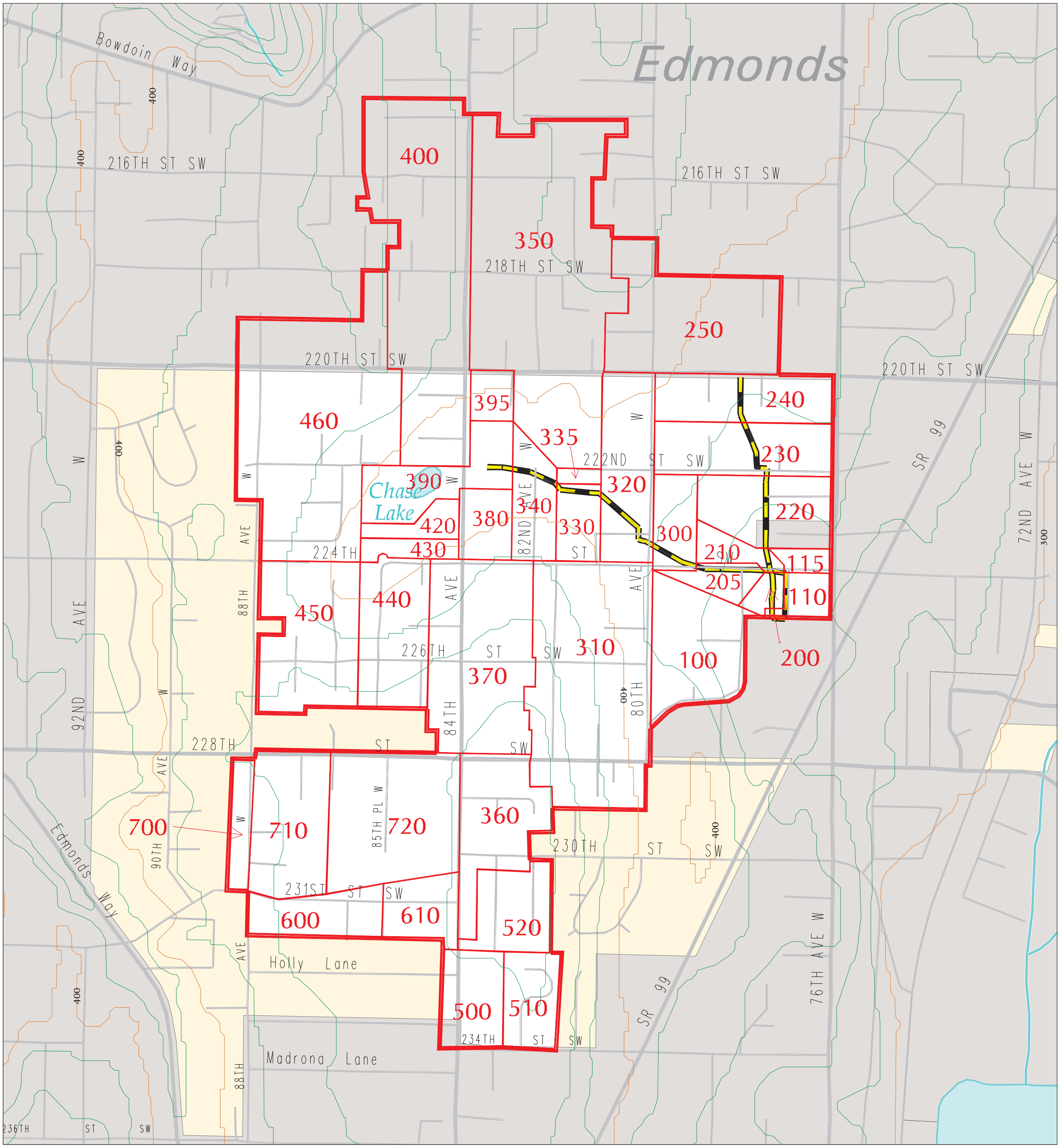
A4.3.3 Topography and Slope

Figure A4-1 shows the 20-foot contour topography of the Chase Lake study area. The highest elevation in the Chase Lake Subbasin is 460 feet at the top of a small rise at the south end of the area. From this rise, the topography slopes downward most rapidly toward the northeast, descending to an elevation of 360 feet near the vicinity of Chase Lake in the northeast corner. The Chase Lake Subbasin sits on the basin boundary between the Puget Sound Basin and the Hall Creek Basin. This boundary runs roughly from the northwest corner to the southwest corner of this area.

The areas that were modeled with HSPF were classified according to these categories:

1. Flat: 0 to 6 percent
2. Moderate: 6 to 15 percent
3. Steep: 15 to 40 percent
4. Very Steep: > 40 percent

Slopes in the Chase Lake Subbasin are typically flat to moderate with a steep slope found only in one small area of less than half an acre.



Legend

- Subbasin Boundary
- HSPF Subbasin Boundary
- Major Road
- Secondary Road
- 20' Contour
- 100' Contour
- Drainage System
- Stream
- Water Body
- DNR Study Area
- Incorporated Area

500 0 500 1000

Scale in Feet

N

Snohomish County

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Figure A4-1

Chase Lake Drainage System and Subbasin Delineation

Swamp Creek Drainage Needs Report

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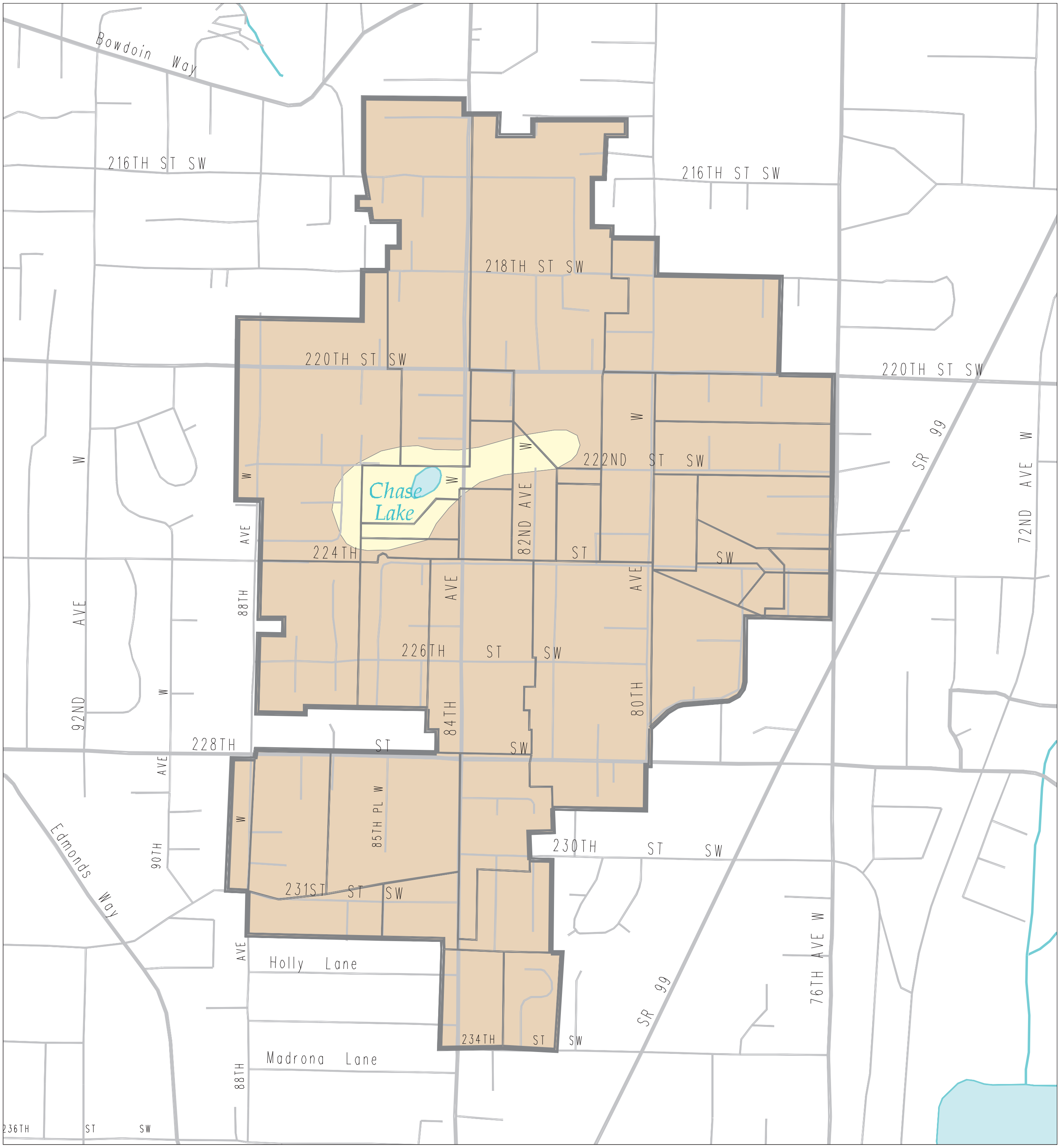


Legend

Subbasin Boundary

HSPF Subbasin Boundary

Major Road

Secondary Road

Stream

Water Body

Soil Type

Till

Custer-Norma

Outwash

Saturated

500 0 500 1000

Scale in Feet

Snohomish County
PUBLIC WORKS
SURFACE WATER MANAGEMENT

N

Figure A4-2

Chase Lake

Soils

Swamp Creek Drainage Needs Report

A4.3.4 Land Use and Cover

Land use and land cover play an important role in generating runoff and peak streamflow. A watershed with forest cover and little development will have lower flows than a watershed with other vegetation and/or development. Impervious surfaces (i.e., pavement) convert nearly all precipitation to runoff almost immediately after it hits the ground (or melts, in the case of snow). Areas with little forest and a high percentage of development will experience high peak streamflows from even a relatively small amount of precipitation.

What controls the rainfall's fate is the land on which it falls. This can be simplified into three major components: soil, vegetation, and topography. In the HSPF model, the soil, vegetation, and topographic information are combined into different land types. Each land type has a different set of hydrologic parameter values (as described below) that produces a unique runoff response to rainfall. Some land types produce more runoff than others.

Land Types

In the Snohomish County DNR Study, 19 specific land types have different hydrologic parameter values assigned (see Hydrologic Modeling Protocols). These land types have been identified and used in the HSPF models for the Chase Lake Subbasin. These land types are:

1. EIA: effective impervious area, no vegetation, all slopes
2. TFF: till soil, forest vegetation, flat slope terrain (0-6%)
3. TFM: till soil, forest vegetation, moderate slopes (6-15%)
4. TFS: till soil, forest vegetation, steep slopes (>15%)
5. TPF: till soil, pasture vegetation, flat slopes (0-6%)
6. TPM: till soil, pasture vegetation, moderate slopes (6-15%)
7. TPS: till soil, pasture vegetation, steep slopes (>15%)
8. TGF: till soil, grass vegetation, flat slopes (0-6%)
9. TGM: till soil, grass vegetation, moderate slopes (6-15%)
10. TGS: till soil, grass vegetation, steep slopes (>15%)
11. OF: outwash soil, forest vegetation, all slopes
12. OP: outwash soil, pasture vegetation, all slopes
13. OG: outwash soil, grass vegetation, all slopes
14. CNF: Custer Norma, forest vegetation, all slopes
15. CNP: Custer Norma, pasture vegetation, all slopes
16. CNG: Custer Norma, grass vegetation, all slopes
17. SF: saturated soil, forest vegetation, all slopes
18. SP: saturated soil, pasture vegetation, all slopes
19. SG: saturated soil, grass vegetation, all slopes

Soil Types

Till soils have been compacted by glacial action. As a result, under a layer of newly formed soil lies a compressed soil layer commonly called hardpan. Because this hardpan has very poor infiltration capacity, till soils produce a relatively large amount of surface runoff and interflow. A typical example of a till soil is an Alderwood soil (Soil Conservation Service [SCS] class C).

Outwash soils have a high infiltration capacity due to their sand and gravel composition. Outwash soils have little or no surface runoff or interflow. Instead, almost all of their runoff is in the form of groundwater. An Everett soil (SCS class A) is a typical outwash soil.

Custer-Norma soils typically drain well when dry, but in the winter have a high groundwater table that restricts infiltration. Custer soils are SCS class C soils; Norma soils are class SCS D soils.

Saturated soils are usually found in wetlands. They have a low infiltration rate and a high groundwater table. When dry, saturated soils have a high storage capacity and produce very little runoff. However, once they become saturated, they produce surface runoff, interflow, and groundwater in large quantities. Mukilteo muck (SCS class D) is a typical saturated soil.

Vegetation

Forest vegetation represents the typical second-growth Douglas fir found in the Puget Sound lowlands. Forest vegetation has a large interception storage capacity. This means that a large amount of precipitation is caught in the forest canopy before reaching the ground and becoming available for runoff. Precipitation intercepted in this way later evaporates into the atmosphere. Forest vegetation also has the ability to transpire moisture from the soil via its root system. This leaves less water available for runoff.

Pasture vegetation is typically found in rural areas where the forest has been cleared and replaced with large hay and grass lots. Often, these pasture areas are used to graze livestock. The interception storage and soil evapotranspiration capacity of pasture is less than forest. Soils have also been compressed by mechanized equipment during clearing activities. Livestock can also compact soil. Pasture areas typically produce more runoff (particularly surface runoff and interflow) than forest areas.

Grass vegetation represents the suburban vegetation found in typical residential developments. Soils have been compacted by earth-moving equipment, often with a layer of topsoil removed. Sod and ornamental bushes have replaced native vegetation. The interception storage and evapotranspiration of grass vegetation is less than pasture, resulting in more runoff.

Slope

The slope of the land or terrain affects the speed at which surface runoff reaches the stream. Steep slopes (slopes greater than 15 percent grade) speed up the surface runoff. Flat slopes (zero to 6 percent) slow the water. Because outwash and saturated soils have little surface runoff compared to till soils, no attempt is made to separate the different slopes for these two categories of soil. Only till soils are separated into flat, moderate, and steep slope categories.

Effective Impervious Area

Impervious land, as the name implies, allows no infiltration of water into the pervious soil. All runoff is surface runoff. Impervious land typically consists of paved roads, sidewalks, driveways, and parking lots. Building roofs are also usually impervious.

For the purposes of hydrologic modeling, only effective impervious area (EIA) is categorized as impervious. EIA is the area where there is no opportunity for surface runoff from an impervious site to infiltrate into the soil before it reaches a conveyance system. An example of an EIA is a shopping center parking lot, where the water runs off the pavement and directly into a catch basin, where it then flows into a pipe, and eventually to a stream. In contrast, some homes with impervious roofs collect the roof runoff into roof gutters and send the water to downspouts. When the water reaches the base of the downspout, it can be directed into a pipe or dumped on a splash block. Roof water dumped on a splash block then has the opportunity to spread into the yard and infiltrate into the soil. Such roofs are not considered to be effective impervious area.

Other situations where impervious surfaces are not considered EIA include driveways, sidewalks, and patios that slope such that the runoff drains onto grass or landscaped areas instead of to ditches or storm sewer systems.

Because it is extremely expensive and time-consuming to look at every impervious surface in a watershed to determine whether or not it is an EIA, average values are used instead. Each average EIA value is based on the land use (forest, low-density residential, high-density residential, multifamily, commercial, etc.) and previous experience in other Puget Sound lowland watersheds.

Both gross impervious area and EIA are dependent, to some extent, on the age of development. Older residential areas frequently have a smaller EIA because, for example, roof downspouts might be discharged to splashblocks rather than the storm drain system. Roads in older areas might have a smaller area of pavement but the same overall width of right-of-way (smaller gross impervious area). Roads in older areas might have relatively ineffective open-ditch drainage (low effective percentage) as compared to curb and gutter for new developments. To account for these variations, three EIA tables have been defined. Proposed impervious and EIA percentages are provided in the Hydrologic Modeling Protocols (Table 2 for existing land uses, and in Table 3 for future land use).

EIA percentages for new development or redevelopment under the future land use scenario are provided for each future land use class in Table 3 of the Hydrologic Modeling Protocols. Note that since future land use does not separately identify roads, the EIA values for future development are assumed to incorporate the paved area of new roadways.

The non-effective impervious area uses the adjacent or underlying soil, vegetation, and slope properties. Vegetation often varies by the type of land use. Medium- and high-density residential, multifamily, school, roads, and commercial and industrial land uses are all assumed to have grass as their typical pervious area vegetation.

Information Sources

The model of existing land use conditions was based on available land information as of 1998. Future land use conditions were based on buildout of the General Policy Plan (GPP) (Snohomish County, 2001). Development of existing and future land use scenarios for modeling are discussed in detail below.

A4.3.4.1 Existing Land Use

Medium-density, single-family residences predominantly cover the Chase Lake Subbasin with only a few small areas of high-density, single-family residences. Roughly a dozen city blocks of commercial and manufacturing land and about 14 acres of grass are interspersed throughout the basin. The majority of roadways in the area are for residential use. A few higher use roadways cross through this area including 84th Avenue W and 220th Street SW. The Chase Lake Subbasin has approximately 27 percent, or 104 acres, of EIA. The entire subbasin is within the Urban Growth Area (UGA). Future development is to be focused on UGAs as mandated by the Washington Growth Management Act. These development patterns will affect the subbasin over time.

Existing land uses are based on the county assessor files and were validated with available aerial photographs. The different land uses in this area are displayed in Figure 2-1f with a breakdown of existing land use acreage in Table A4-1.

Existing land uses are divided into the categories described in the Hydrologic Modeling Protocols. These categories are:

- forest
- pasture
- grass
- rural single-family residential (less than or equal to 1 unit per 5 acres)
- low-density single-family residential (1 unit per 5 acres to 2 units per acre)
- medium-density single-family residential (2 to 6 units per acre)
- high-density single-family residential (greater than 6 units per acre)
- multifamily residential
- commercial/industrial
- roads

The County-provided assessor information was converted into a GIS coverage representing existing land use. Correspondence between land use categories in the assessor files and HSPF land use classes was established for project-wide use (Section 3.0 of Hydrologic Modeling Protocols).

Rural and low-density residential lots have a high percentage of forest cover in some areas. The percentage of existing forest cover was specified for rural and low-density lots by subbasin. This information was included in the subbasin attributes defined in the Hydrologic Modeling Protocols. Together with the soils and topography information, the subbasin attribute information was used in the computation of the number of acres for each land type for input to the HSPF Schematic Block used in the model. Table A4-1 presents the division of the existing land use in the HSPF model by subbasin, showing the number of acres for each of the land types in each subbasin.

As mentioned previously, three standard EIA tables were prepared to account for variations in EIA for the age and types of development. The three EIA tables are numbered (ranging in value from 1 to 3) to represent an appropriate area-averaged EIA for each subbasin. EIA 1 generally represents old residential neighborhoods with relatively low impervious area and a low proportion of rooftops tied into the storm drain system. EIA 2 generally represents more recent development where roads have curb and gutter and rooftops are more likely tied into the storm drain system. Finally, EIA 3 generally represents very recent development with high impervious coverage and high-level connectivity to the storm drain system. Table 3 in the Hydrologic Modeling Protocols specifies the future conditions EIA table number for all possible existing to future land use conversions. Given the existing conditions EIA table numbers assigned to each by subbasin and using the conversion rules in Table 3, future conditions EIA table numbers for each subbasin were assessed as part of the GIS land use analysis.

Table A4-1
Existing Land Use

Sub-basin	Land Use (acres)											Total Acres
	Water	Forest	Pasture	Parks	Rural	SFR-L	SFR-M	SFR-H	MFR	Comm	Utility	
100	0.00	0.00	0.00	0.00	0.00	0.00	8.30	0.00	0.30	1.00	2.20	11.80
110	0.00	0.00	0.00	0.20	0.00	0.00	1.80	0.00	0.00	0.00	0.40	2.40
115	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.20	0.00	0.00	0.40	1.40
200	0.00	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.00	0.10	1.40
205	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.90	1.00	2.60
210	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	1.80	0.20	2.40
220	0.00	0.20	1.80	0.60	0.00	0.00	4.10	1.20	0.00	0.80	0.80	9.50
230	0.00	0.00	0.00	0.20	0.00	1.40	5.40	0.00	1.10	0.00	2.00	10.10
240	0.00	0.00	0.00	0.00	0.00	0.00	7.20	0.10	0.30	0.00	1.60	9.20
250	0.00	0.90	0.00	0.00	0.00	6.50	8.00	0.00	0.30	0.00	3.50	19.20
300	0.00	1.90	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.30	4.40
310	0.00	0.00	0.00	0.00	0.00	1.70	19.30	0.00	2.90	0.60	6.60	31.10
320	0.00	0.70	0.30	0.00	0.00	0.40	7.20	0.00	0.00	0.00	2.10	10.70
330	0.00	0.20	0.00	0.00	0.00	0.70	0.70	0.00	0.00	2.10	0.00	3.70
335	0.00	0.10	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.50	0.00	0.80
340	0.00	1.30	0.00	0.70	0.00	0.00	3.00	0.00	0.00	0.00	0.60	5.60
350	0.00	0.90	0.00	7.20	0.00	0.90	22.00	0.00	0.00	7.70	6.10	44.80
360	0.00	0.00	0.00	0.00	0.00	0.60	8.00	0.00	0.00	0.40	2.30	11.30
370	0.00	0.00	0.00	0.10	0.00	2.10	14.50	0.00	1.20	0.40	2.90	21.20
375	0.00	0.00	0.00	0.00	0.00	0.10	1.60	0.00	0.00	0.00	0.00	1.70
380	0.00	0.00	0.00	0.00	0.00	0.40	1.70	0.00	0.00	0.00	0.10	2.20
390	0.00	2.70	0.00	0.40	0.00	0.00	0.40	0.00	0.00	0.00	0.00	3.50
395	0.00	0.00	0.00	0.10	0.00	0.00	1.20	0.00	0.00	0.60	0.40	2.30
400	0.00	1.30	0.20	0.00	0.00	0.60	24.10	0.00	0.00	0.50	7.50	34.20
410	0.00	4.60	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.40	5.10
420	0.00	1.70	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.50	2.40
430	0.00	0.10	0.00	0.00	0.00	0.00	1.70	0.00	0.00	0.00	0.30	2.10
440	0.00	0.00	0.00	0.00	0.00	0.00	7.90	0.00	0.00	0.00	3.40	11.30
450	0.00	0.00	0.00	0.00	0.00	0.00	12.90	0.00	0.00	0.00	2.70	15.60
460	0.00	1.00	0.00	1.90	0.00	2.30	22.60	0.00	0.70	1.70	7.30	37.50
500	0.00	0.00	0.00	0.00	0.00	0.70	4.50	0.00	0.60	0.00	0.70	6.50
510	0.00	0.00	0.00	0.00	0.00	0.00	4.60	0.00	0.00	0.00	1.20	5.80
520	0.00	0.00	0.00	0.00	0.00	0.00	5.60	0.00	0.00	0.00	1.40	7.00
600	0.00	0.00	0.00	0.20	0.00	2.60	2.20	0.10	0.00	0.00	1.20	6.30
610	0.00	0.70	0.00	0.40	0.00	0.30	2.50	0.00	0.00	0.30	0.90	5.10
700	0.00	0.00	0.00	0.00	0.00	0.10	2.00	0.00	0.00	0.00	1.00	3.10
710	0.00	0.20	0.00	0.00	0.00	2.40	7.00	0.00	0.30	0.60	1.50	12.00
720	0.00	1.60	0.00	0.90	0.00	2.30	9.30	0.10	0.20	0.60	3.20	18.20

SFR = single-famly residential
MFR = multifamily residential
Comm = commercial and manufacturing
Utility = utility and transportation

The subbasin attributes table, Table A4-2, was constructed using an orthophoto map of the Chase Lake Subbasin together with the existing land use map to determine the appropriate EIA table number for each subbasin. Rural and low-density parcels within each subbasin were examined. In addition to assigning the EIA table number, the subbasin attribute table is used to assign percent forest-cover for rural density and low density residential parcels as well as percent retention of forest cover when converting uses to future developed conditions for each subbasin. All rural-density parcels were isolated and visually inspected to determine the percent forest cover remaining. If several rural-density parcels existed within a single subbasin, the percent forest cover remaining was averaged on an area-weighted basis. The area-weighted percent forest cover remaining for the rural-density class was then reported in the attributes table on a subbasin-by-subbasin basis. The same procedure was followed for low-density residential parcels.

A4.3.4.2 Existing to Future Land Use Changes

The future land use condition of the Chase Lake Subbasin remains predominantly medium-density, single-family residential. According to the assumptions of the model, forest and pasture areas will be lost as urbanization increases, bringing larger areas of grass and impervious area. In its future condition, the Chase Lake Subbasin is anticipated to have about 31 percent EIA, a four-percent increase, over existing conditions. Table A4-3 shows the EIA and forest cover for both existing and future land use conditions. The future land uses are displayed in Figure 2-2f with a breakdown of future land use acreage in Table A4-4.

A4.3.4.3 Future Land Use

Future land use was calculated based on buildout under the County General Policy Plan (GPP). Figure 2-2f and Table A4-4 show the future land use for the Chase Lake Subbasin. Related to this, Table A4-3 identifies the changes in land cover (i.e., types of vegetation, pavement, and open water; as distinct from land uses, which are categorized differently for existing and future conditions) between the existing and future land uses. Land use conversion for the Chase Lake Subbasin is predicted to result in an EIA increase of 15.6 acres, from 26.9 percent of the basin currently to 30.9 percent. In addition, 20 acres of forest will be converted to a medium-density residential area. This limited land use conversion is anticipated from forest and pasture because this area is already well developed.

A4.3.5 Drainage Network, Hydrologic, and Groundwater Features

Drainage Network

The drainage network that collects Chase Lake's urban runoff is composed of a combination of swales, culverts, and minor stormwater systems. There are no natural streams in the Chase Lake study area.

Hydrologic Features

Chase Lake is the only major detention facility in the Chase Lake study area. Chase Lake is divided into two sections by 84th Avenue W. The Chase Lake section east of 84th Avenue W was reconstructed into a detention facility during the early 1990s. A weir constructed from steel sheet piles controls the detention facility. The Chase Lake section west of 84th Avenue W was left untouched.

Wetlands and water quality are discussed in Sections 4.0 and 5.0.

Table A4-2
Chase Lake Subbasin Attributes

HSPF Subbasin	EIA Table	HSPF Target	Stream Channel	Detention Pond	% Forest Cover[a]	
					Rural	Density
100	3	RCHRES	100	101	N/A	N/A
110	3	RCHRES	110	111	N/A	N/A
115	1	RCHRES	115	116	N/A	N/A
200	3	RCHRES	200	201	N/A	N/A
205	1	RCHRES	205	206	N/A	N/A
210	3	RCHRES	210	211	N/A	N/A
220	3	RCHRES	220	221	N/A	N/A
230	1	RCHRES	230	231	N/A	42
240	1	RCHRES	240	241	N/A	40
250	1	RCHRES	250	251	N/A	42
300	1	RCHRES	300	301	N/A	N/A
310	1	RCHRES	310	311	N/A	N/A
320	1	RCHRES	320	321	N/A	100
330	1	RCHRES	330	331	N/A	28
335	1	RCHRES	335	336	N/A	100
340	1	RCHRES	340	341	N/A	N/A
350	3	RCHRES	350	351	N/A	50
360	1	RCHRES	360	361	N/A	24
370	1	RCHRES	370	371	N/A	71
380	1	RCHRES	380	381	N/A	N/A
390	1	RCHRES	390	391	N/A	N/A
395	1	RCHRES	395	396	N/A	N/A
400	3	RCHRES	400	401	N/A	61
420	1	RCHRES	420	421	N/A	N/A
430	1	RCHRES	430	431	N/A	N/A
440	1	RCHRES	440	441	N/A	N/A
450	1	RCHRES	450	451	N/A	N/A
460	1	RCHRES	460	461	N/A	73
500	1	RCHRES	500	501	N/A	40
510	1	RCHRES	510	511	N/A	4
520	1	RCHRES	520	521	N/A	N/A
600	1	RCHRES	600	601	N/A	53
610	1	RCHRES	610	611	N/A	24
700	1	RCHRES	700	701	N/A	44
710	1	RCHRES	710	711	N/A	33
720	1	RCHRES	720	721	N/A	N/A

[a] Refer to Table 2 and Section 3.5 of the Hydrologic Modeling Protocols

Note: Some detention ponds might not be used.

Table A4-3
Land Cover Changes from Existing to Future Land Use Conditions

HSPF Sub-basin	Total Subbasin Area (ac)	Forest (ac)	Change (%)	Pasture (ac)	Change (%)	Grass (ac)	Change (%)	Impervious (ac)	Change (%)
100	11.70	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
110	2.40	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
115	1.40	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
200	1.40	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
205	2.60	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
210	2.40	0.00	---[a]	0.00	0%	0.00	0%	0.00	0%
220	9.50	0.00	0.00	0.00	0%	0.00	0%	0.00	0%
230	10.10	-0.59	-1.00	-0.62	-100%	0.58	9%	0.64	27%
240	9.20	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
250	19.20	-3.60	-1.00	-2.85	-100%	3.12	33%	3.34	100%
300	4.50	0.00	0.00	0.00	0%	0.00	0%	0.00	0%
310	31.10	0.00	---[a]	-1.29	-100%	0.55	3%	0.74	9%
320	10.70	-0.70	-0.65	0.00	0%	0.37	5%	0.33	16%
330	3.70	-0.41	-0.98	-0.40	-100%	0.39	39%	0.43	23%
335	0.70	-0.16	-0.73	0.00	---[a]	0.08	100%	0.07	16%
340	5.50	-1.14	-0.88	0.00	---[a]	0.41	12%	0.11	17%
350	44.70	-0.83	-0.62	-0.31	-100%	0.49	2%	0.56	3%
360	11.20	-0.14	-1.00	-0.33	-100%	0.22	3%	0.26	10%
370	21.20	-1.50	-1.00	-0.44	-100%	0.99	7%	0.95	22%
375	1.80	0.00	0.00	0.00	0%	0.00	0%	0.00	0%
380	2.20	0.00	0.00	-0.24	-77%	0.10	6%	0.14	52%
390	3.40	-1.13	-0.42	0.36	---[a]	-0.29	-43%	0.06	150%
395	2.30	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
400	34.10	-0.89	-0.53	-0.33	-100%	0.63	3%	0.59	4%
410	5.20	-1.45	-0.31	0.00	0%	0.75	375%	0.70	269%
420	2.50	-0.44	-0.25	0.21	---[a]	0.00	0%	0.20	59%
430	2.10	-0.03	-0.50	0.00	---[a]	0.02	1%	0.02	5%
440	11.20	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
450	15.60	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
460	37.60	-2.66	-1.00	-0.44	-100%	1.49	6%	1.51	17%
500	6.50	-0.27	-1.00	-0.31	-100%	0.27	6%	0.30	25%
510	5.80	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
520	7.00	0.00	---[a]	0.00	---[a]	0.00	0%	0.00	0%
600	6.30	-1.38	-1.00	-0.92	-100%	1.12	39%	1.17	107%
610	5.10	-0.77	-1.00	-0.15	-100%	0.46	15%	0.46	41%
700	3.10	-0.03	-1.00	-0.03	-100%	0.03	1%	0.03	4%
710	12.10	-0.97	-1.00	-1.24	-100%	1.04	14%	1.18	50%
720	18.30	-1.58	-1.00	-1.82	-100%	1.58	14%	1.81	50%

[a] Cannot be calculated because existing acreage is 0.

Note: Positive change indicates increase in land cover; negative change indicates decrease in land cover

Table A4-4
Future Land Use

Subbasin	Land Use (acres)													Total Acres
	City	Comm	Mixed Use	Utility	Tribal	MFR	UHD	UMD	ULD	Rural	Parks	Pasture	Forest	
100	1.30	0.00	0.00	0.00	0.00	0.00	0.00	10.40	0.00	0.00	0.00	0.00	0.00	11.70
110	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	2.50
115	0.00	0.20	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	1.40
200	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00	0.00	1.40
205	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	0.00	2.60
210	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.00	0.00	0.00	0.00	0.00	2.40
220	2.20	0.00	0.00	0.00	0.00	0.00	0.00	7.30	0.00	0.00	0.00	0.00	0.00	9.50
230	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.10	0.00	0.00	0.00	0.00	0.00	10.10
240	0.90	0.00	0.00	0.00	0.00	0.00	0.00	8.40	0.00	0.00	0.00	0.00	0.00	9.30
250	19.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.20
300	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00	0.00	0.00	0.00	4.50
310	0.40	0.00	0.00	0.00	0.00	0.00	0.00	30.60	0.00	0.00	0.00	0.00	0.00	31.00
320	0.20	0.00	0.00	0.00	0.00	0.00	0.00	10.50	0.00	0.00	0.00	0.00	0.00	10.70
330	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.00	0.00	0.00	0.00	0.00	3.70
335	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.70
340	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.50	0.00	0.00	0.00	0.00	0.00	5.50
350	37.10	0.00	0.00	0.00	0.00	0.00	0.00	7.70	0.00	0.00	0.00	0.00	0.00	44.80
360	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.20	0.00	0.00	0.00	0.00	0.00	11.20
370	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.20	0.00	0.00	0.00	0.00	0.00	21.20
375	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.00	0.00	0.00	0.00	1.80
380	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.00	0.00	0.00	0.00	2.20
390	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.40	0.00	0.00	0.00	0.00	0.00	3.40
395	0.20	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	2.30
400	27.20	0.00	0.00	0.00	0.00	0.00	0.00	6.90	0.00	0.00	0.00	0.00	0.00	34.10
410	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.20	0.00	0.00	0.00	0.00	0.00	5.20
420	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.50	0.00	0.00	0.00	0.00	0.00	2.50
430	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	2.10
440	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.20	0.00	0.00	0.00	0.00	0.00	11.20
450	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.60	0.00	0.00	0.00	0.00	0.00	15.60
460	9.80	0.00	0.00	0.00	0.00	0.00	0.00	27.80	0.00	0.00	0.00	0.00	0.00	37.60
500	0.80	0.00	0.00	0.00	0.00	0.00	0.00	5.70	0.00	0.00	0.00	0.00	0.00	6.50

Table A4-4 (continued)
Future Land Use

Subbasin	Land Use (acres)													Total Acres
	City	Comm	Use	Utility	Tribal	MFR	UHD	UMD	ULD	Rural	Parks	Pasture	Forest	
510	0.10	0.00	0.00	0.00	0.00	0.00	0.00	5.70	0.00	0.00	0.00	0.00	0.00	5.80
520	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.00	0.00	0.00	0.00	0.00	0.00	7.00
600	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.30	0.00	0.00	0.00	0.00	0.00	6.30
610	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.10	0.00	0.00	0.00	0.00	0.00	5.10
700	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.10	0.00	0.00	0.00	0.00	0.00	3.10
710	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.10	0.00	0.00	0.00	0.00	0.00	12.10
720	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.30	0.00	0.00	0.00	0.00	0.00	18.30

Comm = commercial and manufacturing
MFR = multifamily residential
UHD = urban high-density residential
ULD = urban low-density residential
UMD = urban medium-density residential
Utility = utility and transportation

Groundwater
Groundwater was assumed to flow in a northwest direction from the Chase Lake Subbasin towards Puget Sound. For modeling purposes, groundwater was not connected to the surface water systems.

A4.3.6 Hydrometeorologic Data

HSPF processes data to simulate the components of the hydrologic cycle on a 15-minute time step. Recorded 15-minute precipitation data and daily evaporation data are input to the model. The model uses the recorded 15-minute precipitation data and daily evaporation to compute the amount of water in the soil, the amount that returns to the atmosphere by evaporation and transpiration, and the amount that becomes runoff.

A4.3.6.1 Rainfall Data

Figure A4-3 shows the location of the precipitation gages used in modeling the Chase Lake Subbasin.

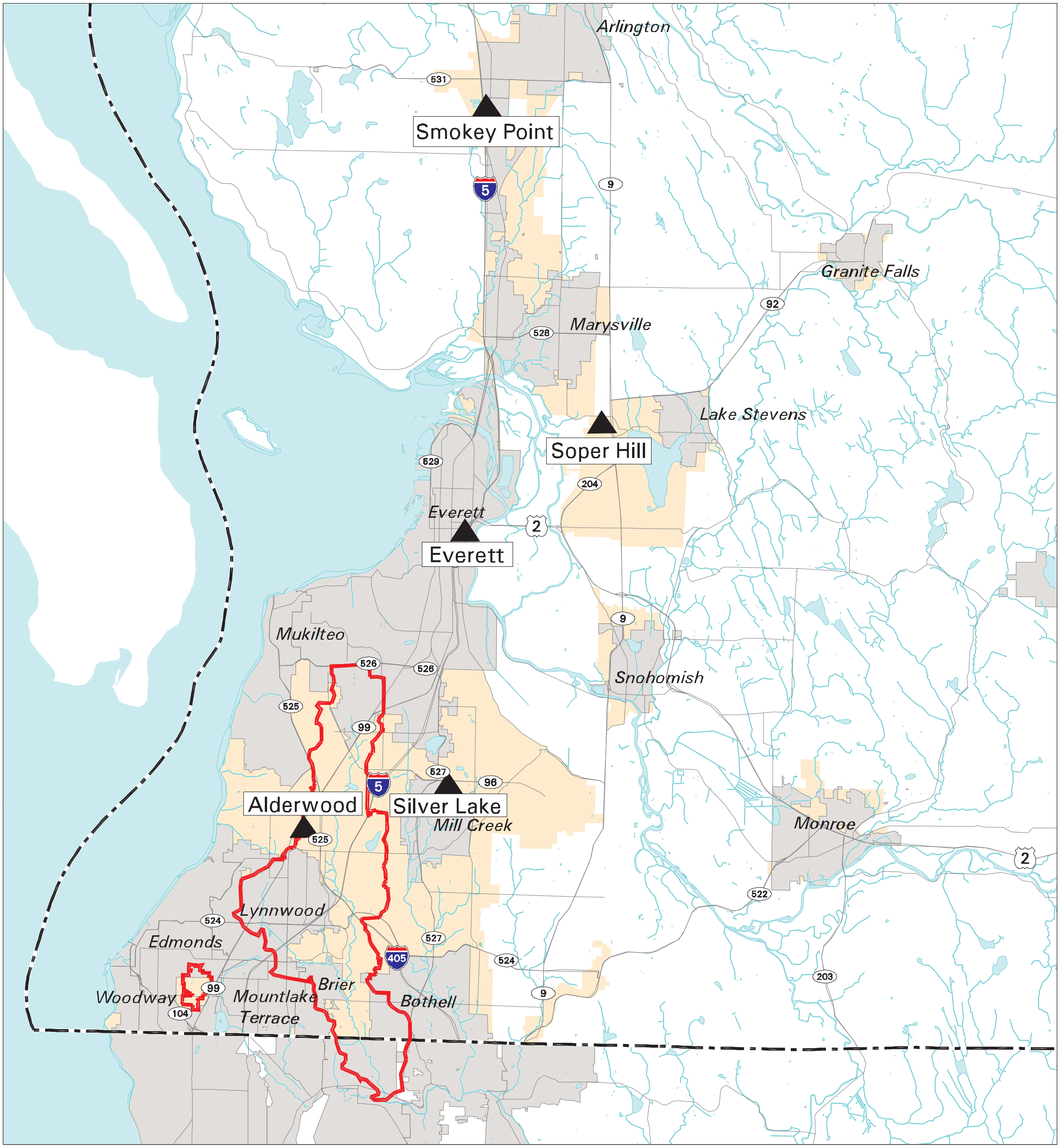
The Alderwood precipitation gage was used as the primary basis for the Chase Lake HSPF modeling effort, due to its proximity to the study area. The Alderwood precipitation gage is located at the Alderwood Water District offices near the intersection of 35th Avenue W and 156th Street SW. The Alderwood precipitation gage is owned and operated by Snohomish County. The Alderwood precipitation gage has 15-minute recorded data for the time period of November 20, 1987 to September 30, 2000.

To generate a long-term precipitation record, the Everett precipitation gage information was transposed and added to the Alderwood data. The Everett precipitation gage has 15-minute recorded data from October 1, 1948 to November 20, 1987. The Everett precipitation gage contained data gaps that were filled in using data from the Arlington precipitation gage. The Everett and Arlington precipitation gages are owned and operated by the National Oceanic and Atmospheric Administration (NOAA). The Everett precipitation gage data were disaggregated and transposed to Silver Lake by Aqua Terra Consultants. The data were then transposed from Silver Lake to Alderwood using the transposition factor of 0.91, based on Silver Lake and Alderwood cumulative precipitation totals between December 1987 and September 2000. The result was a composite 52-year record from October 1, 1948 through September 30, 2000. Table A4-5 shows the gages used to create this record.

Table A4-5

Precipitation Gages Near Swamp Creek Watershed

Station Name/Location	Source	Period of Record	Temporal Resolution
Alderwood Water District Office @ 35th	Snohomish County	November 1987 – present	15-minute
Silver Lake Water District Office @132nd	Snohomish County	November 1987 – present	15-minute
Everett	National Weather Service	October 1948 – present	1-hour



Legend

- Precipitation Gage
- Basin Boundary
- Major Road
- County Boundary
- Stream
- Water Body
- Urban Growth Area
- Incorporated Area

2 0 2

Scale in Miles

N

Snohomish County
PUBLIC WORKS
SURFACE WATER MANAGEMENT

Figure A4-3

Precipitation Gage Locations

Swamp Creek Drainage Needs Report

precip

A4.3.6.2 Evaporation Data

Evaporation is a major factor in the hydrologic cycle. A typical watershed in the Puget Sound lowlands receives 40 inches of precipitation a year. Of these 40 inches, approximately half returns to the atmosphere as evaporation or transpiration (transpiration is the act of vegetation removing moisture from the soil and returning it to the atmosphere). The other half becomes runoff.

Evaporation is input to the HSPF model as potential evapotranspiration (or PET). PET is the maximum amount of water that can be returned to the atmosphere at any one time. Actual evapotranspiration is calculated in the model based on the PET demand and the amount of water available in the soil and on the land surface for evaporation and transpiration.

PET is input to the HSPF model in the form of pan evaporation data. This is evaporation data measured in a standard Class A pan. The nearest Class A pan is located in Puyallup at the Washington State University Experimental Field Station. Puyallup is approximately 40 miles south of the Chase Lake Subbasin, but because evaporation does not vary greatly in the Puget Sound lowland watersheds, the distance from the study area is not significant.

The Puyallup experimental pan evaporation station was used for pan evaporation data. The period of record for the pan evaporation data was October 1948 to September 2001. Pan evaporation data were converted to equivalent PET using a pan evaporation coefficient of 0.8 as stated in the Hydrologic Modeling Protocols.

A4.3.6.3. Streamflow Data

No streamflow data exist for the Chase Lake study area.

A4.4 HSPF Model Development

Design and construction of the Chase Lake HSPF model generally follow the protocols described in the Hydrologic Modeling Protocols, with minor changes noted below. The drainage system (HSPF Reach), pervious land segments (PERLNDs), and impervious segments (IMPLNDs) were numbered in accordance with the protocols. Following these protocols, the Chase Lake HSPF model was constructed using HSPF, Version 12 (March 2001).

As previously described, the Chase Lake HSPF model was divided into 35 subbasins. Subbasin boundaries were selected based on desired points of analysis, topographic mapping, development drawings, drainage system inventory data, and field observations.

Specific ARC-INFO GIS program routines were written for this project to convert land use coverages into pervious and impervious distributions and then to define the pervious areas according to the different soils, vegetation, and slope categories.

The following steps were taken in developing the Chase Lake HSPF model:

1. A watershed data management file (WDM) was created for the subbasin.
2. Alderwood precipitation data were imported to the WDM.
3. Puyallup pan evaporation data were imported to the WDM.

4. Specific model output attributes were imported to the WDM for each output location of interest.
5. The user control input (UCI) file was created for the subbasin.
6. Appropriate PERLND, IMPLND, and Reach parameter values were selected for the subbasin in accordance with the Hydrologic Modeling Protocols.
7. SCHEMATIC Block input, provided by the GIS, was added to the UCI file. The SCHEMATIC Block lists the number of acres of each PERLND and IMPLND type for each subbasin and links the runoff from these PERLNDs/IMPLNDs to the appropriate stream reach (Reach).
8. FTABLEs, developed from hydraulics analysis (simple Manning's equation or SWMM models), were added to the UCI file. An FTABLE defines the stage-storage-discharge relationship for each Reach and is used to route the flow from one Reach to the next. For a specific Reach, the FTABLE and Reach number are identical to the subbasin number.
9. PERLND/IMPLND input linkages from the WDM to the UCI file were set for the precipitation and evaporation data (External Sources Block). No Reach in the model was linked to the precipitation and evaporation input data except Chase Lake, which has a surface area of approximately two acres.
10. Reach output linkages to the WDM from the UCI file were set in the External Targets Block. This is where the simulated streamflow data are written to the WDM.
11. The model was tested and checked for errors. Each FTABLE was checked to make sure that the depths and volume values increased, as required by HSPF. The HSPF UCI file was run and the HSPF-produced message file was examined for error and warning messages.

Separate HSPF models, representing the existing and future conditions, were developed for the Chase Lake Subbasin. Table A4-6 shows the parameters used in the HSPF model for Chase Lake.

A4.4.1 Existing Conditions Model Configuration

A4.4.1.1 Existing Conditions Model Schematic

The existing conditions Chase Lake HSPF model is composed of 35 subbasins (see Figure A4-1). These 35 subbasins encompass three major drainage systems. The three drainage pathways include the North Chase Lake drainage system, the Southwest Chase Lake drainage system, and the Southeast Chase Lake drainage system.

Figure A4-4 shows the existing conditions model schematic.

A4.4.1.2 Definition of PERLNDs/IMPLNDs

The subbasin areas for each of the 19 PERLNDs/IMPLNDs listed in the Hydrologic Modeling Protocols (which represent combinations of land use, soils, and slope coverages) have been generated from the project's GIS database and inserted directly into the input files for the HSPF model. This information is shown in Tables A4-7 and A4-8.

Figure A4-4a
Chase Lake HSPF Schematic for Existing Conditions of North Chase Lake Drainage

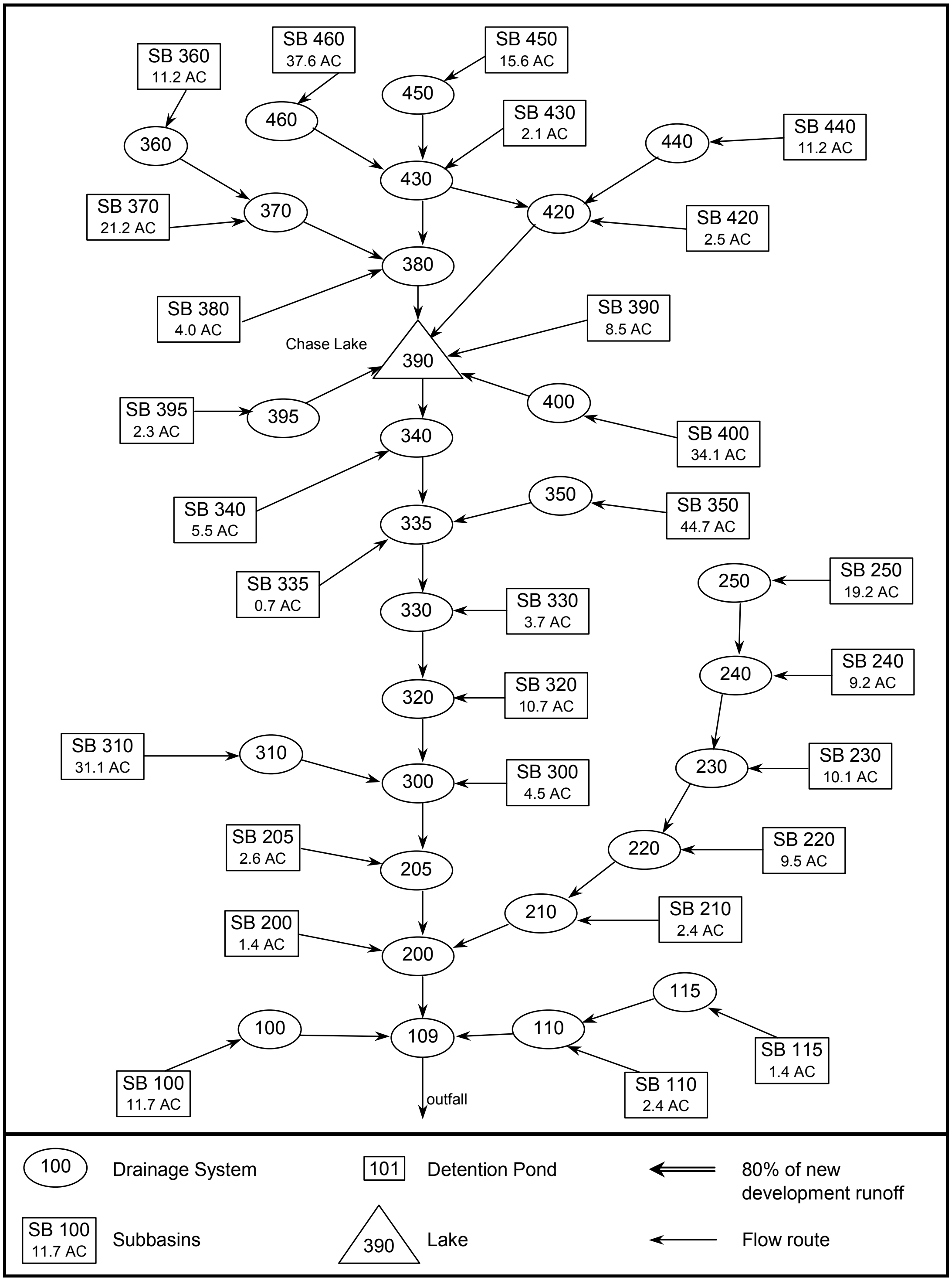


Figure A4-4b
Chase Lake HSPF Schematic for Existing Conditions of Southwest Chase Lake Drainage

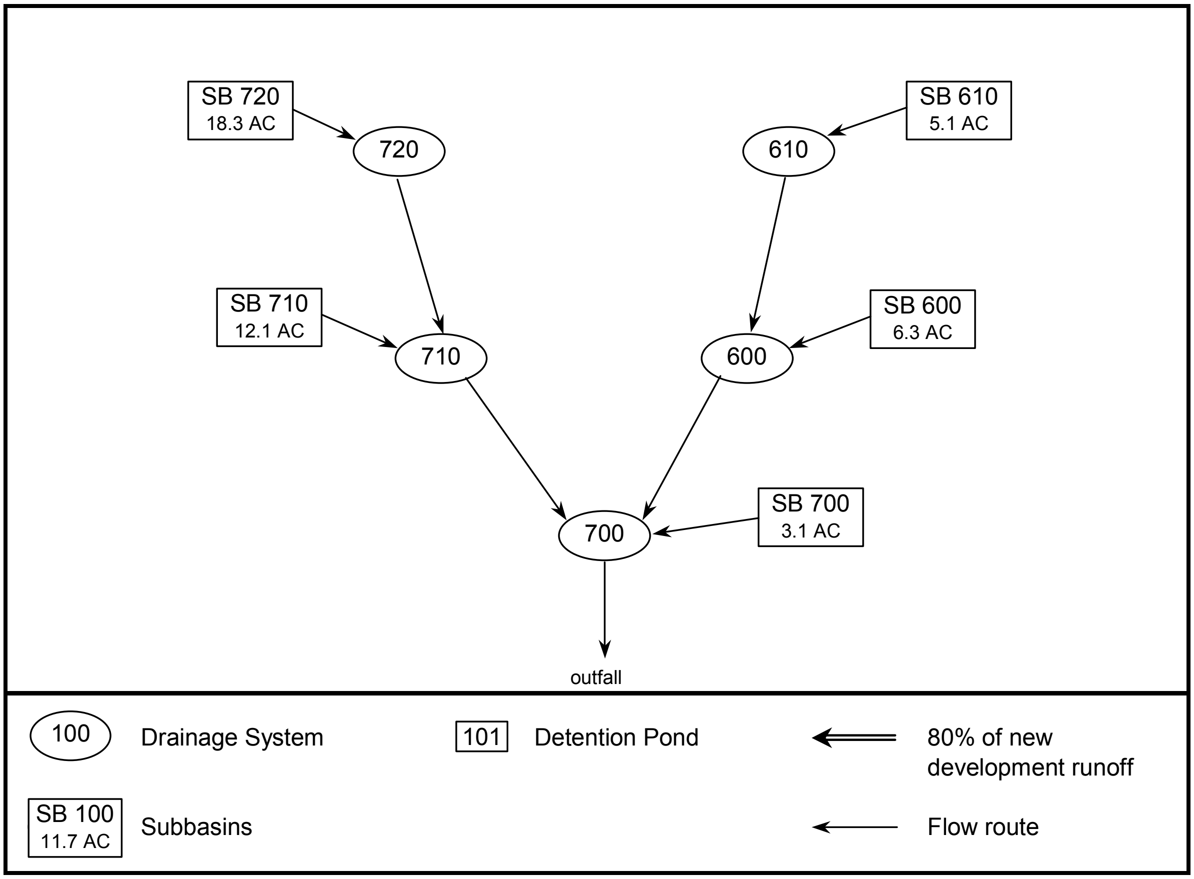


Figure A4-4c
Chase Lake HSPF Schematic for Existing Conditions of Southeast Chase Lake Drainage

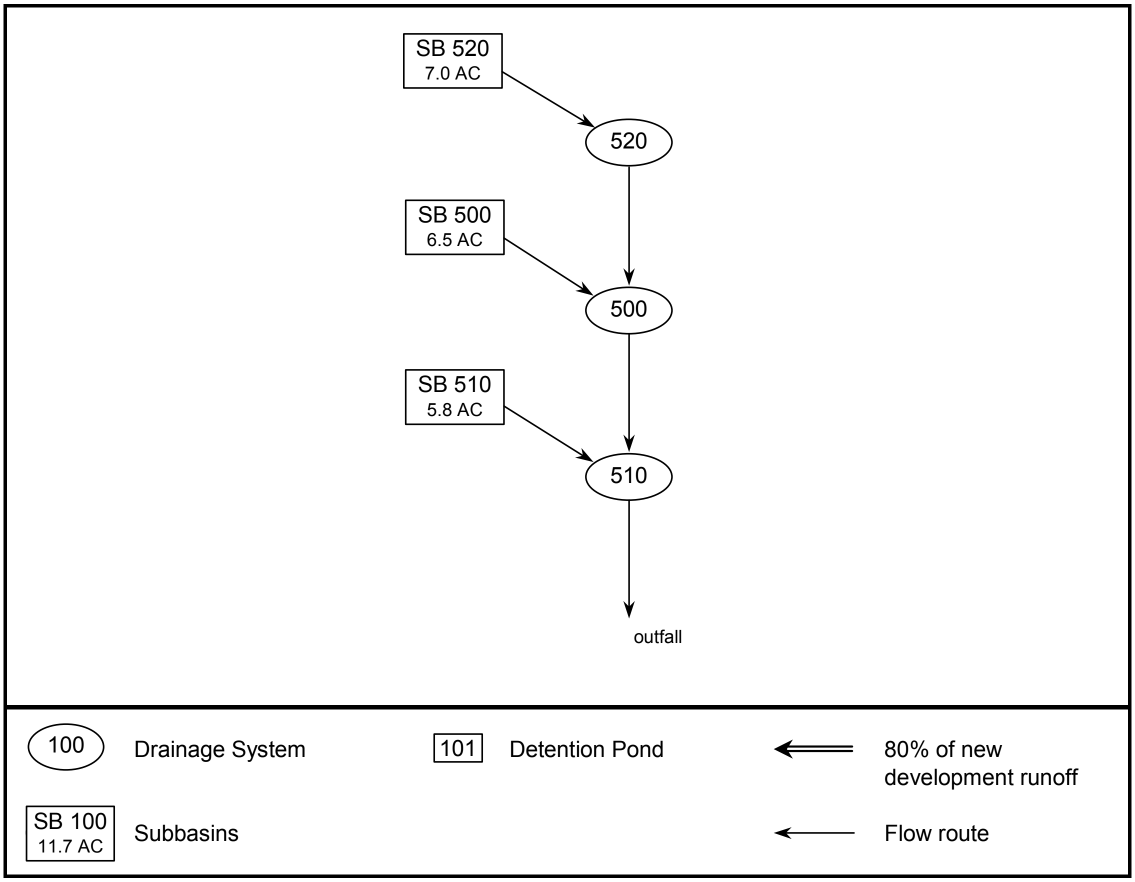


Table A4-6
HSPF Parameter Values for Chase Lake Subbasin

Land Segment	LZSN (in.)	INFILT (in./hr.)	LSUR (ft)	SLSUR	KVARY (1/in.)	AGWRC	INFEXP	INFILD	DEEPFR	BASETP	AGWETP	CEPSC (in.)	UZSN (in.)	NSUR	INTFW	IRC (1/day)	LZETP	RETSC (in.)
510 TFF	5.5	0.08	400	0.050	0.5	0.996	3.5	2.0	0.00	0.0	0.15	0.20	1.00	0.35	3.0	0.700	0.90	n/a
520 TFM	5.5	0.08	400	0.110	0.5	0.996	2.0	2.0	0.00	0.0	0.15	0.20	0.50	0.35	6.0	0.500	0.90	n/a
530 TFS	5.5	0.08	200	0.200	0.5	0.996	1.5	2.0	0.00	0.0	0.15	0.20	0.30	0.35	7.0	0.300	0.90	n/a
540 TPF	5.5	0.06	400	0.050	0.5	0.996	3.5	2.0	0.00	0.0	0.05	0.10	0.60	0.30	3.0	0.700	0.45	n/a
550 TPM	5.5	0.06	400	0.110	0.5	0.996	2.0	2.0	0.00	0.0	0.05	0.10	0.30	0.30	6.0	0.500	0.45	n/a
560 TPS	5.5	0.06	200	0.200	0.5	0.996	1.5	2.0	0.00	0.0	0.05	0.10	0.20	0.30	7.0	0.300	0.45	n/a
570 TGF	5.5	0.03	400	0.050	0.5	0.996	3.5	2.0	0.00	0.0	0.05	0.10	0.50	0.25	3.0	0.700	0.45	n/a
580 TGM	5.5	0.03	400	0.110	0.5	0.996	2.0	2.0	0.00	0.0	0.05	0.10	0.25	0.25	6.0	0.500	0.45	n/a
590 TGS	5.5	0.03	200	0.200	0.5	0.996	1.5	2.0	0.00	0.0	0.05	0.10	0.15	0.25	7.0	0.300	0.45	n/a
600 OF	6.0	2.00	400	0.050	0.3	0.996	2.0	2.0	0.00	0.0	0.15	0.20	0.50	0.35	0.0	0.700	0.90	n/a
610 OP	6.0	1.40	400	0.050	0.3	0.996	2.0	2.0	0.00	0.0	0.05	0.10	0.50	0.30	0.0	0.700	0.45	n/a
620 OG	6.0	0.80	400	0.050	0.3	0.996	2.0	2.0	0.00	0.0	0.05	0.10	0.50	0.25	0.0	0.700	0.45	n/a
630 CNF	2.0	0.40	400	0.010	4.0	0.990	3.5	2.0	0.00	0.0	0.15	0.20	1.00	0.35	4.0	0.800	0.90	n/a
640 CNP	2.0	0.30	400	0.010	4.0	0.990	3.5	2.0	0.00	0.0	0.05	0.10	0.70	0.30	4.0	0.800	0.90	n/a
650 CNG	2.0	0.16	400	0.010	4.0	0.990	3.5	2.0	0.00	0.0	0.05	0.10	0.50	0.25	4.0	0.800	0.90	n/a
660 SATF	5.0	2.00	100	0.001	0.5	0.996	10.0	2.0	0.00	0.0	0.70	0.20	3.00	0.50	1.0	0.700	0.99	n/a
670 SATP	5.0	1.80	100	0.001	0.5	0.996	10.0	2.0	0.00	0.0	0.70	0.10	3.00	0.50	1.0	0.700	0.99	n/a
680 SATG	5.0	1.00	100	0.001	0.5	0.996	10.0	2.0	0.00	0.0	0.70	0.10	3.00	0.50	1.0	0.700	0.99	n/a
500 EIA	n/a	n/a	100	0.010	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	0.10	n/a	n/a	n/a	0.1

HSPF = Parameters
LZSN = Lower Zone Storage Nominal
INFILT = Infiltration rate
LSUR = Length of Surface runoff
SLSUR = Slope of Surface runoff
KVARY = Variable non-exponential groundwater release rate
AGWRC = Active Groundwater Recession Constant
INFEXP = Infiltration Exponent
INFILD = Ratio between mean and max infiltration
DEEPFR = Deep Fraction groundwater
BASETP = Baseflow Evapotranspiration
AGWETP = Active Groundwater Evapotranspiration
CEPSC = Interception Storage
UZSN = Upper Zone Storage Nominal
NSUR = Surface roughness coefficient
INTFW = Interflow
IRC = Interflow Recession Constant
LZETP = Lower Zone Evapotranspiration
RETSC = Retention Storage Capacity

Table A4-7
Existing Land Use HSPF PERLND and IMPLND Acreages

HSPF Subbasin	Land Type (acres)																			Total
	EIA 500	TFF 510	TFM 520	TFS 530	TPF 540	TPM 550	TPS 560	TGF 570	TGM 580	TGS 590	OF 600	OP 610	OG 620	CNF 630	CNP 640	CNG 650	SF 660	SP 670	SG 680	Water	
100	5.30	0.00	0.00	0.00	0.00	0.00	0.00	4.30	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.73
110	0.88	0.00	0.00	0.00	0.00	0.00	0.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.43
115	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.35
200	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
205	1.48	0.00	0.00	0.00	0.00	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.62
210	1.93	0.00	0.00	0.00	0.02	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.43
220	3.13	0.15	0.00	0.00	1.79	0.04	0.00	4.41	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.54
230	2.36	0.59	0.00	0.00	0.62	0.00	0.00	6.48	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.11
240	1.91	0.00	0.00	0.00	0.00	0.00	0.00	7.32	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.25
250	3.35	2.68	0.92	0.00	2.63	0.22	0.00	8.66	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.19
300	0.79	1.93	0.00	0.00	1.54	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.48
310	8.05	0.00	0.00	0.00	0.37	0.90	0.02	5.94	15.38	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.08
320	2.07	1.08	0.00	0.00	0.35	0.00	0.00	7.07	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.76
330	1.85	0.31	0.11	0.00	0.20	0.20	0.00	0.88	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.67
335	0.44	0.18	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04	0.00	0.74
340	0.66	0.64	0.09	0.00	0.00	0.00	0.00	1.90	0.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.64	0.00	5.49
350	18.31	0.99	0.00	0.00	0.31	0.00	0.00	23.32	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	1.27	0.00	44.75
360	2.57	0.12	0.02	0.00	0.29	0.04	0.00	8.10	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.23
370	4.29	0.91	0.59	0.00	0.27	0.17	0.00	12.49	2.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.25
375	0.19	0.00	0.00	0.00	0.05	0.00	0.00	0.51	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01	0.00	1.78
380	0.27	0.01	0.00	0.00	0.31	0.00	0.00	1.07	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	2.23
390	0.04	0.88	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.79	0.00	0.30	0.00	3.38
395	0.90	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33
400	13.58	1.39	0.00	0.00	0.33	0.00	0.00	15.87	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.61	0.00	34.09
410	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.65	0.05	0.20	0.00	5.16
420	0.34	0.18	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57	0.00	0.09	0.00	2.49
430	0.38	0.01	0.00	0.00	0.00	0.00	0.00	1.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.52	0.00	2.10
440	2.90	0.00	0.00	0.00	0.00	0.00	0.00	5.59	2.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.22
450	2.97	0.00	0.00	0.00	0.00	0.00	0.00	8.88	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.55
460	8.76	1.68	0.00	0.00	0.44	0.00	0.00	20.52	3.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	0.00	1.27	0.00	37.60
500	1.22	0.27	0.00	0.00	0.31	0.00	0.00	4.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.49
510	1.19	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.78
520	1.43	0.00	0.00	0.00	0.00	0.00	0.00	5.43	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.97
600	1.09	1.38	0.00	0.00	0.92	0.00	0.00	2.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.29
610	1.13	0.77	0.00	0.00	0.15	0.00	0.00	3.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13
700	0.82	0.03	0.00	0.00	0.03	0.00	0.00	2.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.09
710	2.38	0.97	0.00	0.00	1.24	0.00	0.00	7.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.05
720	3.64	1.58	0.00	0.00	1.82	0.00	0.00	11.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.30
Total	103.66	18.73	1.73	0.00	13.99	1.57	0.02	192.58	37.44	0.42	0.00	0.00	0.00	0.00	0.00	0.00	10.32	0.09	4.97	0.00	385.52

Table A4-8
Future Land Use HSPF PERLND and IMPLND Acreages

HSPF Subbasin	Land Type (acres)																				
	EIA 500	**TFF 510**	**TFM 520**	**TFS 530**	**TPF 540**	**TPM 550**	**TPS 560**	**TGF 570**	**TGM 580**	**TGS 590**	**OF 600**	**OP 610**	**OG 620**	**CNF 630**	**CNP 640**	**CNG 650**	**SF 660**	**SP 670**	**SG 680**	**Water**	**Total**
100	5.30	0.00	0.00	0.00	0.00	0.00	0.00	4.30	2.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.73
110	0.88	0.00	0.00	0.00	0.00	0.00	0.00	1.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.43
115	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.97	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	2.38
200	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39
205	1.48	0.00	0.00	0.00	0.00	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.62
210	1.93	0.00	0.00	0.00	0.02	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.43
220	3.13	0.15	0.00	0.00	1.79	0.04	0.00	4.41	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.54
230	3.00	0.00	0.00	0.00	0.00	0.00	0.00	7.06	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.12
240	1.91	0.00	0.00	0.00	0.00	0.00	0.00	7.32	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	9.25
250	6.69	0.00	0.00	0.00	0.00	0.00	0.00	11.21	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.20
300	0.79	1.93	0.00	0.00	1.54	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.48
310	8.79	0.00	0.00	0.00	0.00	0.00	0.00	6.10	15.76	0.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31.08
320	2.40	0.38	0.00	0.00	0.35	0.00	0.00	7.44	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.76
330	2.28	0.01	0.00	0.00	0.00	0.00	0.00	1.13	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.68
335	0.51	0.02	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.04	0.00	0.73
340	0.77	0.12	0.00	0.00	0.00	0.00	0.00	2.17	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.73	0.00	4.87
350	18.87	0.16	0.00	0.00	0.00	0.00	0.00	23.90	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	1.27	0.00	44.75
360	2.83	0.00	0.00	0.00	0.00	0.00	0.00	8.29	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.24
370	5.24	0.00	0.00	0.00	0.00	0.00	0.00	13.09	2.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.25
375	0.19	0.00	0.00	0.00	0.05	0.00	0.00	0.51	0.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.01	0.00	1.78
380	0.41	0.01	0.00	0.00	0.07	0.00	0.00	1.17	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	2.23
390	0.10	0.87	0.00	0.00	0.00	0.00	0.00	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.67	0.36	0.00	0.00	3.38
395	0.90	0.00	0.00	0.00	0.00	0.00	0.00	1.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.33
400	14.17	0.50	0.00	0.00	0.00	0.00	0.00	16.50	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.61	0.00	34.09
410	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.20	0.05	0.95	0.00	5.16
420	0.54	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.31	0.21	0.00	0.00	2.46
430	0.40	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.54	0.00	2.11
440	2.90	0.00	0.00	0.00	0.00	0.00	0.00	5.59	2.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.22
450	2.97	0.00	0.00	0.00	0.00	0.00	0.00	8.88	3.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	15.55
460	10.27	0.00	0.00	0.00	0.00	0.00	0.00	21.60	3.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	1.78	0.00	37.60
500	1.52	0.00	0.00	0.00	0.00	0.00	0.00	4.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.48
510	1.19	0.00	0.00	0.00	0.00	0.00	0.00	3.70	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.78
520	1.43	0.00	0.00	0.00	0.00	0.00	0.00	5.43	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.97
600	2.26	0.00	0.00	0.00	0.00	0.00	0.00	4.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.28
610	1.59	0.00	0.00	0.00	0.00	0.00	0.00	3.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.13
700	0.85	0.00	0.00	0.00	0.00	0.00	0.00	2.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.09
710	3.56	0.00	0.00	0.00	0.00	0.00	0.00	8.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.06
720	5.45	0.00	0.00	0.00	0.00	0.00	0.00	12.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.29
Total	119.26	4.15	0.00	0.00	3.82	0.04	0.00	204.62	39.00	0.43	0.00	0.00	0.00	0.00	0.00	0.00	6.96	0.66	5.95	1.03	385.92

A4.4.1.3 Definition of FTABLEs

FTABLEs are used by HSPF to represent the stage-storage-discharge relationships for different reaches of a given conveyance system and are used by the model to simulate the routing of stormwater runoff through each reach. These routing tables are input into the model by the user and are created by conducting additional analyses separate from the HSPF modeling. HSPF is not able to account for backwater, so hydraulic analysis is usually required to accurately model backwater effects. In some cases, simple hand calculations were used to develop FTABLEs.

The general methodology used to develop FTABLEs was as follows:

- Stage, storage, and area were computed for a given range of flows.
- Storage was computed as the volume in the channel/pipe between the downstream and upstream extent. For ponds, storage is the live storage volume between the stage and pond invert.

Area for channels was computed as the average top width multiplied by the reach length between upstream and downstream extents. For ponds, area was specified as the surface area at each stage.

FTABLEs were based on several different sources:

- Hydraulic analysis performed as part of this DNR
- Development drawings
- Field investigations

Several different hydraulic analysis tools were used to develop FTABLEs, including SWMM, Flowmaster, and Manning's equation. Generally, SWMM was used for the system downstream of Chase Lake and Manning's equation (Flowmaster) was used for the urban drainage systems. Detailed documentation of the hydraulic analysis used for the FTABLEs is summarized in Table A4-9.

FTABLES 110, 200, 205, 210, 220, 230, 240, 250, 300, 320, 330, 335, and 340 were developed using the consultant (R. W. Beck) SWMM model. The SWMM model was run with six different flows. The estimated 2-year, 10-year, 25-year, and 100-year flows from HSPF contributed to four of the six flows. The remaining two runs were performed with data extrapolated between the 2-year and 10-year estimated flows and between the 10-year and 25-year estimated flows. A flow versus volume curve was generated for each subbasin using the SWMM model results. Outliers were identified and removed to improve the curve definition. An equation describing each curve was developed and used to expand the FTABLE for each subbasin.

FTABLE 390 represents the Chase Lake detention facility. The lake volume was calculated based on drawings obtained from the County (County 1985, 1989). The lake east of 84th Avenue W was reconstructed during the early 1990s. The proposed drawings for the renovation of Chase Lake east of 84th Avenue W were used for volume estimation. There was no detailed contour drawing for Chase Lake west of 84th Avenue W. The volume of the western part of the lake was estimated based on the 1998 aerial photograph.

Table A4-9
FTABLE Definition

HSPF Reach	FTABLE Origin	Stream System	Downstream Extent	Upstream Extent
100	Mannings	Drainage System	East of 84th Ave. W on 227th Pl. SW	227th Place SW
110	SWMM	Drainage System	300 feet south of 224th Street SW	224th Street SW
115	SWMM	Drainage System	224th Street SW	150 feet north of 224th Street SW
200	SWMM	Drainage System	250 feet south of 244th Street SW	150 feet east of 78th Avenue W
205	SWMM	Drainage System	150 feet east of 78th Avenue W	300 feet east of 80th Avenue W
210	SWMM	Drainage System	224th Street SW	200 feet north of 224th Street SW
220	SWMM	Drainage System	200 feet north of 224th Street SW	222nd Street SW
230	SWMM	Drainage System	222nd Street SW	300 feet south of 220th Street SW
240	SWMM	Drainage System	300 feet south of 220th Street SW	220th Street SW
250	Mannings	Drainage System	220th Street SW	218th Street SW
300	SWMM	Drainage System	300 feet east of 80th Avenue W	80th Avenue W
310	Mannings	Drainage System	84th St W from 228th St SW to 224th St SW	228th Street SW
320	SWMM	Drainage System	80th Avenue W	west of 80th Avenue W to 82nd Place W
330	SWMM	Drainage System	west of 80th Avenue W to 82nd Place W	300 feet west of 80th Avenue W
335	SWMM	Drainage System	300 feet west of 80th Avenue W	150 feet east of 82nd Avenue W
340	SWMM	Drainage System	150 feet east of 82nd Avenue W	300 feet east of 84th Avenue W
350	Mannings	Drainage System	84th Ave W from 231st St SW to 228th St SW	215th Street W
360	Mannings	Drainage System	222nd Street SW	230th Street SW
370	Mannings	Drainage System	224th Street SW	222nd Street SW
380	Mannings	Drainage System	300 feet east of 84th Avenue W	224th Street SW
390	Mannings/weir equation	Chase Lake	300 feet east of 84th Avenue W	84th Avenue W
400	Mannings	Drainage System	600 feet south of 220th Street SW	215th Street W
420	Mannings	Swale to Chase Lake	84th Avenue W	224th Street SW
430	Mannings	Bypass Swales	84th Avenue W	224th Street SW
440	Mannings	Drainage System	224th Street SW	86th Avenue W
450	Mannings	Drainage System	224th Street SW, 222nd street SW, 86th Pl. W	88th Avenue W
460	Mannings	Drainage System	224th Street SW	220th Street SW
500	Mannings	Drainage System	234th Street SW	700 feet north of 234th Street W

Table A4-9 (continued)
FTABLE Definition

HSPF Reach	FTABLE Origin	Stream System	Downstream Extent	Upstream Extent
510	Mannings	Drainage System	234th Street SW	234th Street SW
520	Mannings	Drainage System	700 feet north of 234th Street W	230th Street SW
600	Mannings	Drainage System	88th Avenue W	900 feet east of 88th Avenue W
610	Mannings	Drainage System	900 feet east of 88th Avenue W	84th Avenue W
700	Mannings	Drainage System	100 feet west of 88th Avenue W	88th Avenue W
710	Mannings	Drainage System	88th Avenue W	500 feet east of 88th Avenue W
720	Mannings	Drainage System	500 feet east of 88th Avenue W	228th Street SW
509	N/A	Combined outflow for the R-600 and R-700 Series	n/a	n/a
109	N/A	Combined outflow for the R-100 and R-400 Series	n/a	n/a

Mannings = simple mannings equations for Storage and Flow relationship.

Also, some siltation of the Chase Lake detention facility has occurred according to County staff in the drainage facilities group. However, no measurements have been taken to determine how much the detention volumes are affected by the sedimentation. The County recommended that the Chase Lake detention facility design volume be reduced by 10 percent to account for the observed silt levels. Consequently, the 10 percent reduction of the Chase Lake detention facility was taken into account in calculating the pond volume.

The outlet of the Chase Lake detention facility is a weir constructed by steel sheet piles. The outflow stage and discharge relationship was first determined using the weir equation. However, the SWMM model set up by the hydraulic consultant generated stage and discharge information near the downstream end of the Chase Lake detention facility (outlet is the steel weir). An effort was made to adjust storage volumes to reflect the stage-discharge relationship of the downstream system, which creates a backwater effect during higher flows and, consequently, increases the storage volume of the Chase Lake facility during these flows. Please see Table A4-9 for FTABLE documentation.

A4.4.1.4 Model Parameter Estimation, Calibration, and Validation

The Chase Lake Subbasin is in the vicinity of and exhibits characteristics very similar to those of the Swamp Creek Basin. Therefore, the parameter set developed for Swamp Creek (as presented in the Hydrologic Modeling Protocol) was used in the Chase Lake Subbasin model.

A4.4.2 Future Conditions Model Configuration

The future conditions HSPF model is the same as the current conditions model, with exceptions as noted below.

A4.4.2.1 Incorporation of Land Use Changes

The Hydrologic Modeling Protocols define how future land use changes are to be incorporated into each model. Chase Lake future land use was developed using these protocols.

A4.4.2.2 Onsite Detention

Onsite detention is included in the HSPF model for all land to be converted to development in the future. This was done to be consistent with the current County requirements that detention be provided for future development, in accordance with the County's Title 24 standards. Each subbasin, which meets the minimum EIA requirement, was assumed to have a single pond that represents a detention facility or facilities that would be constructed in the future.

The PONDCN80 and POND7 computer programs were used to size each pond and compute the corresponding pond FTABLE. POND7 is based on the standards set forth in the Washington State Department of Ecology's 1992 *Stormwater Management Manual for the Puget Sound Basin*, as well as Snohomish County's Title 24 standards. The program uses Santa Barbara Urban Hydrograph (SBUH) computational procedures and 2-year, 10-year, and 100-year design storms. The user inputs the land use areas, time of concentration, and SCS curve numbers generated by PONDCN80, and a pond volume safety factor. For this analysis the pond volume safety factor was set to 1.30.

The HSPF model was constructed such that only surface runoff and interflow from the converted land use was directed to the ponds. Groundwater drained directly to the appropriate reach. It was also assumed that only 80 percent of the converted land use drains to the detention ponds. The remaining 20 percent was assumed to bypass the pond and drain according to the current conditions model. Table A4-10 shows the onsite detention volume assumed in each subbasin.

A4.4.2.3 Future Conditions Model Schematic

Figure A4-5 shows the future conditions schematic. The future conditions model is set up very much like the existing condition model, with the exception that detention ponds have been added to represent future detention requirements.

A4.5 Simulation Results

A4.5.1 Definition of Model Scenarios and Modeling Approach

HSPF modeling was performed for four scenarios: existing conditions (existing land use conditions and existing drainage system), future conditions (future land use conditions and existing drainage system plus subbasin detention ponds for new development), CIP Alternative 1 (future land use conditions, existing drainage systems, ponds for new development, plus conveyance improvements), and CIP Alternative 2 (future land use conditions, existing drainage systems, ponds for new development, plus conveyance and storage improvements). The results of each are described below.

A4.5.2 Existing Land Use Results

Results of the HSPF analysis for Chase Lake existing land use are discussed in the following two subsections.

A4.5.2.1 Flood Frequency Results

Flood frequency analysis was performed on the annual maximum series of flows for each simulated reach for the 52-year simulation period. Flood frequencies were computed using the standard LP3 (LP3) distribution as described in the Hydrologic Modeling Protocols. Where the LP3 did not produce a good fit based on visual assessment, the data were fit by hand through the plotted peak flows. Flows were then picked off the hand drawn curve at the frequency desired.

Table A4-11 shows the results of the flood frequency analysis for all 35 stream reaches represented in the Chase Lake model.

A4.5.2.2 Flow Duration Analysis

No flow duration analysis was performed for Chase Lake due to the lack of need for such input to habitat assessment.

A4.5.2.3 Runoff Volume Analysis

No runoff volume analysis was performed for Chase Lake Subbasin due to the lack of need for such input to habitat assessment.

Table A4-10
Onsite Detention Volumes and Acres of Developed Land for Future Land Use Conditions

HSPF Reach	Volume[a] (ac-ft)	% EIA[b]	Development[c] (ac)
100	No Pond	0.00	0.00
110	No Pond	0.00	0.00
115	No Pond	0.00	0.00
200	No Pond	0.00	0.00
205	No Pond	0.00	0.00
210	No Pond	0.00	0.00
220	No Pond	0.00	0.00
230	0.12	6.33	1.12
240	No Pond	0.00	0.00
250	0.62	17.40	5.89
300	No Pond	0.00	0.00
310	0.14	2.38	1.33
320	No Pond	3.07	0.56
330	0.00	11.72	0.75
335	No Pond	9.46	0.13
340	No Pond	2.00	0.63
350	0.11	1.25	1.02
360	No Pond	2.32	0.46
370	0.17	4.47	1.69
380	No Pond	6.28	0.25
390	0.11	1.78	1.27
400	0.11	1.73	1.04
420	No Pond	8.03	0.33
430	No Pond	0.95	0.02
440	No Pond	0.00	0.00
450	No Pond	0.00	0.00
460	0.27	4.02	2.62
500	No Pond	4.62	0.54
510	No Pond	0.00	0.00
520	No Pond	0.00	0.00
600	0.22	18.60	2.08
610	0.08	8.97	0.77
700	No Pond	0.97	0.06
710	0.23	9.79	2.08
720	0.34	9.89	3.13

[a] Detention was not considered for areas less than 0.75 acres

[b] %EIA refers to the impervious area of the newly developed land only

[c] Development is calculated as the sum of all existing to future land use changes for each subbasin, based on GIS analysis.

Figure A4-5a
Chase Lake HSPF Schematic for Future Conditions of North Chase Lake Drainage

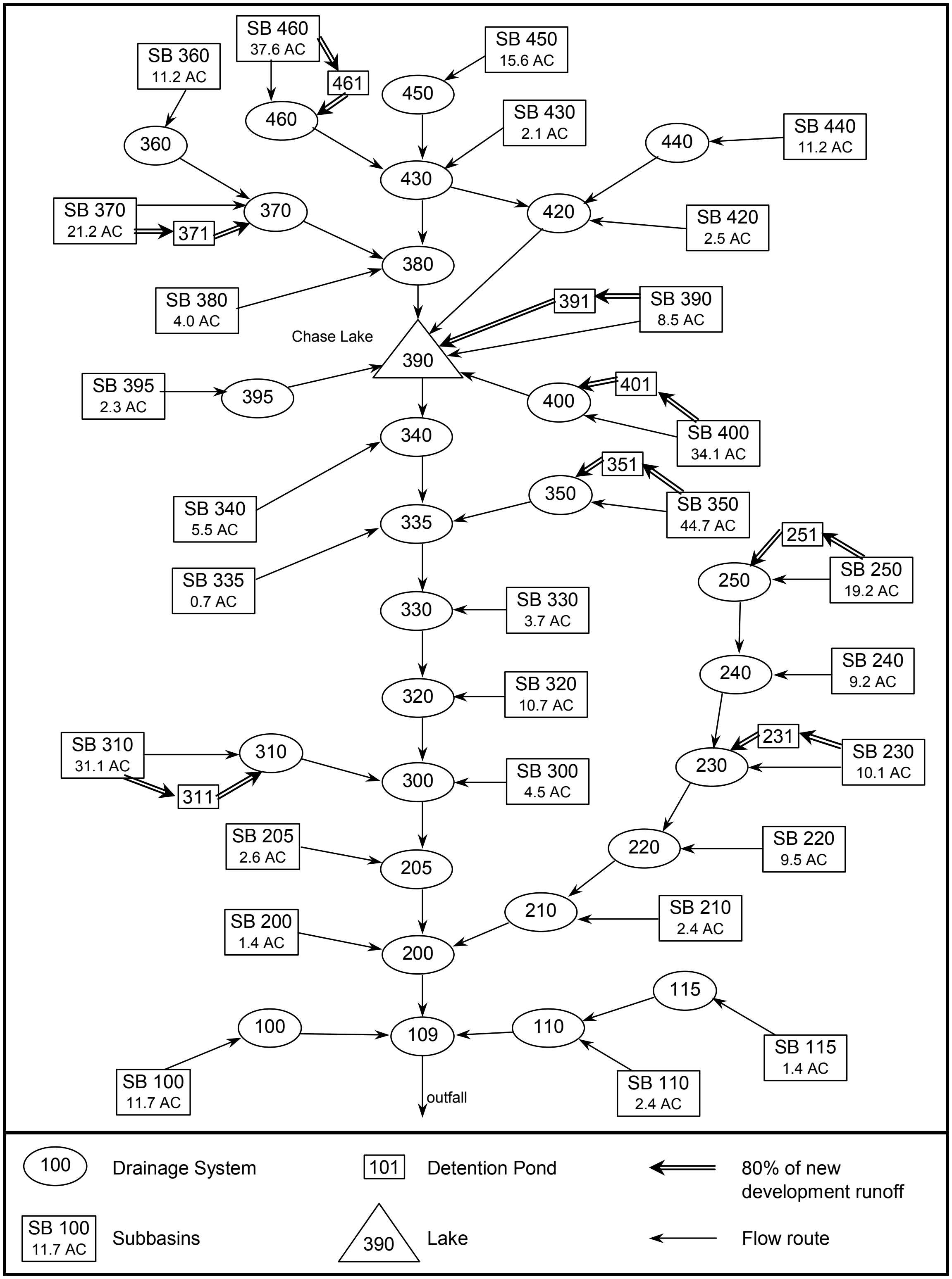


Figure A4-5b
Chase Lake HSPF Schematic for Future Conditions of Southwest Chase Lake Drainage

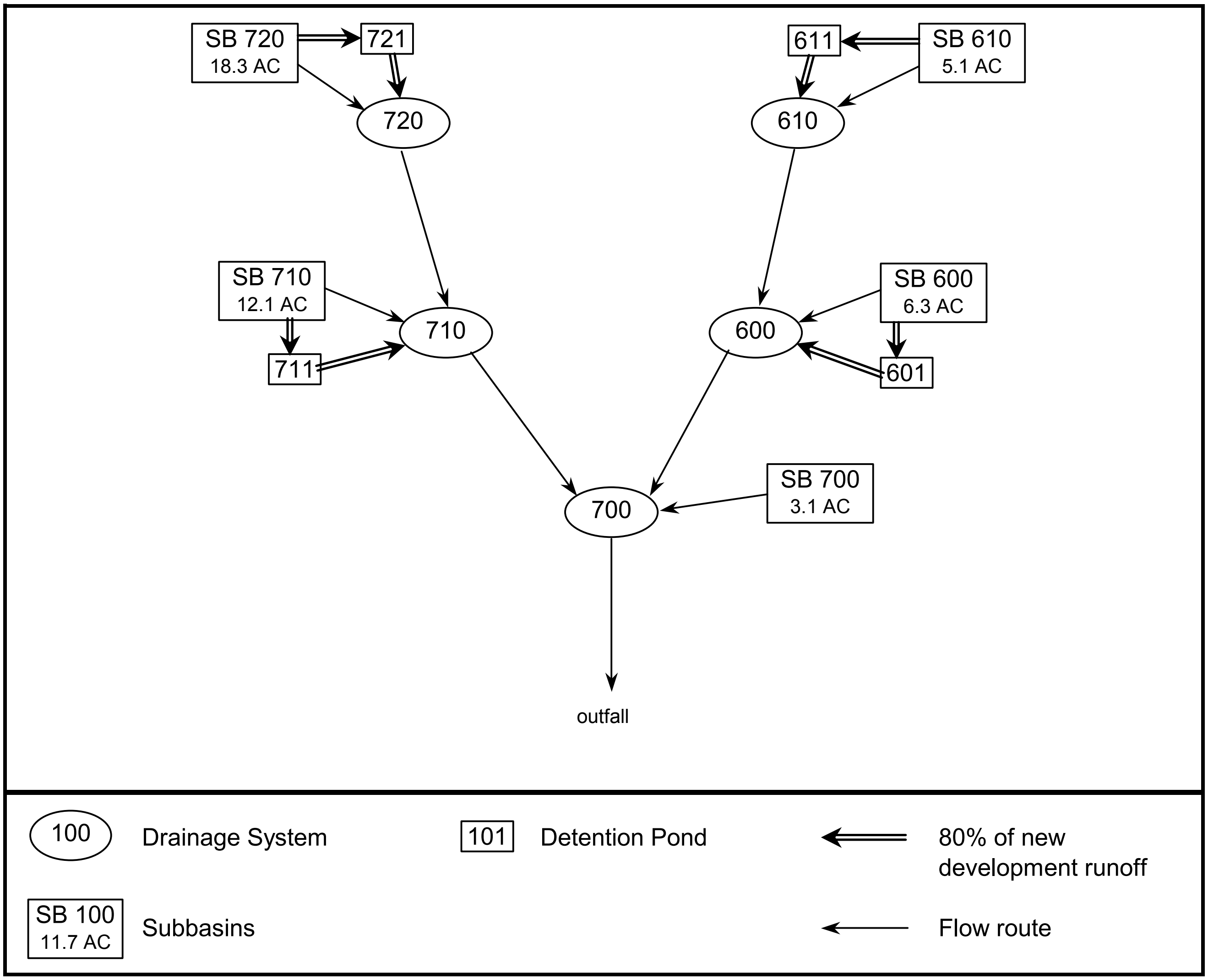


Figure A4-5c
Chase Lake HSPF Schematic for Future Conditions of Southeast Chase Lake Drainage

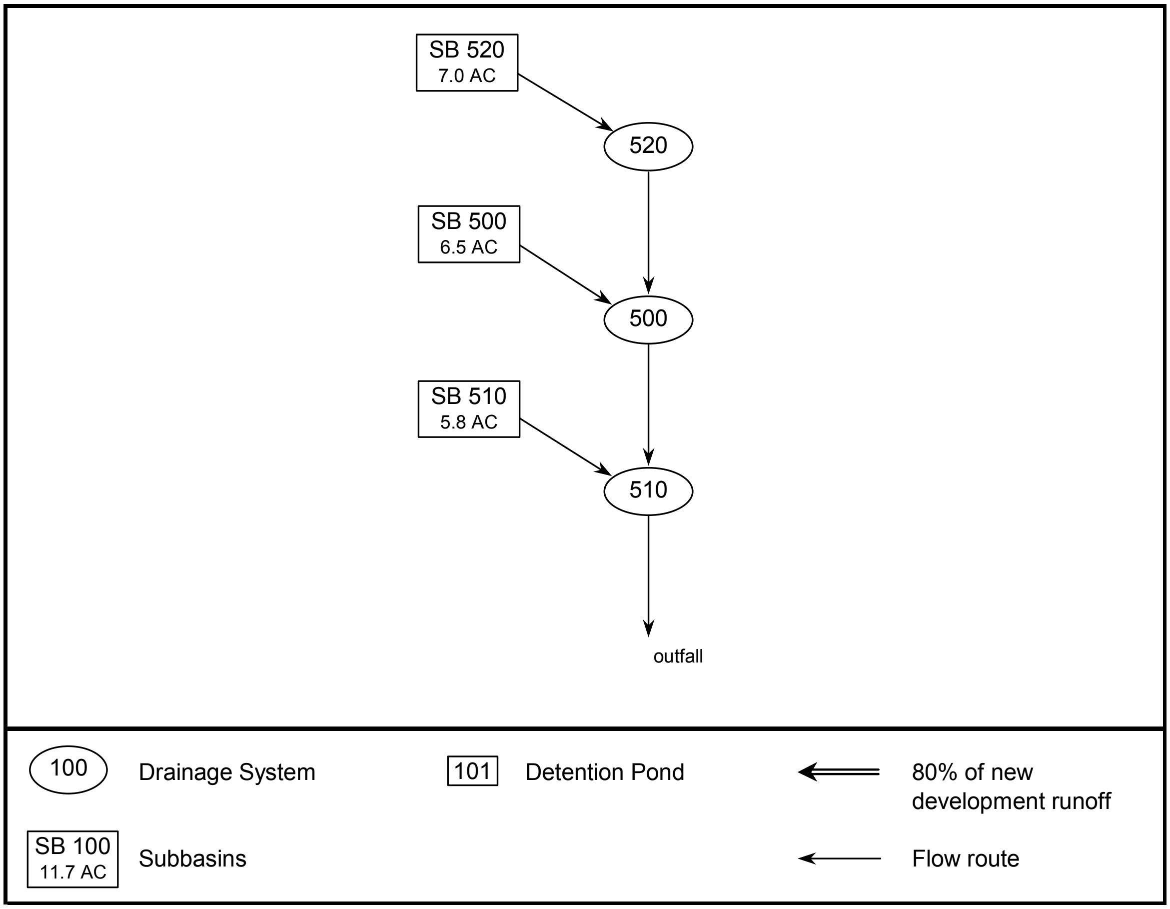


Table A4-11
Existing and Future Flood Frequencies for the Chase Lake Subbasin

HSPF Reach	Subbasin Area (ac)	Location	2-Year Peak Flow (cfs)			10-Year Peak Flow (cfs)			25-Year Peak Flow (cfs)			100-Year Peak Flow (cfs)		
			Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference
100	11.7	East of 84th Avenue W on 227th Place SW	2.9	2.9	0.0	4.6	4.6	0.0	5.6	5.6	0.0	7.1	7.1	0.0
110	2.4	upstream from 300 feet South of 224th Street SW	0.5	0.5	0.0	1.2	1.2	0.0	1.6	1.6	0.0	2.5	2.5	0.0
115	1.4	directly upstream from 224th Street SW	0.3	0.3	0.0	0.5	0.5	0.0	0.6	0.6	0.0	0.7	0.7	0.0
200	1.4	upstream from 250 feet South of 244th Street SW	24.1	24.8	0.7	37.3	38.0	0.7	44.0	44.6	0.6	54.1	54.4	0.3
205	2.6	upstream from 150 feet East of 78th Avenue W	16.9	17.4	0.5	25.7	26.4	0.7	30.3	31.1	0.8	37.5	38.3	0.8
210	2.4	directly upstream from 224th Street SW	8.3	8.4	0.1	13.3	13.4	0.1	15.9	15.9	0.0	19.9	19.7	-0.2
220	9.5	upstream from 200 feet North of 224th Street SW	7.3	7.5	0.2	12.0	11.9	-0.1	14.4	14.3	-0.1	18.2	17.8	-0.4
230	10.1	directly upstream from 222th Street SW	5.9	6.0	0.1	9.8	9.8	0.0	11.9	11.7	-0.2	15.3	14.7	-0.6
240	9.2	upstream from 300 feet South of 220th Street SW	4.6	4.7	0.1	7.6	7.6	0.0	9.2	9.1	-0.1	11.7	11.3	-0.4
250	19.2	directly upstream from 220th Street SW	2.9	3.1	0.2	4.8	4.9	0.1	5.8	5.8	0.0	7.4	7.2	-0.2
300	4.5	upstream from 300 feet East of 80th Avenue W	16.7	17.3	0.6	26.2	26.9	0.7	31.1	32.0	0.9	38.9	39.8	0.9
310	31.1	on 84th Street W from 228th St SW to 224th St SW	4.6	4.6	0.0	7.9	7.9	0.0	9.7	9.7	0.0	12.8	12.7	-0.1
320	10.7	directly upstream from 80th Avenue W	12.4	12.9	0.5	18.9	19.7	0.8	22.3	23.2	0.9	27.6	28.6	1.0
330	3.7	upstream from West of 80th Ave W to 82nd Pl W	10.9	11.2	0.3	16.2	16.8	0.6	19.1	19.7	0.6	23.5	24.3	0.8
335	0.7	upstream from 300 feet West of 80th Avenue W	10.1	10.3	0.2	15.2	15.5	0.3	17.9	18.2	0.3	22.1	22.4	0.3
340	5.5	upstream from 150 feet East of 82nd Avenue W	3.9	4.0	0.1	6.3	6.4	0.1	7.5	7.7	0.2	9.5	9.8	0.3
350	44.7	on 84th Street W from approx. 231st St SW to 228th St SW	10.1	10.1	0.0	15.9	16.0	0.1	19.0	19.0	0.0	23.6	23.6	0.0
360	11.2	directly upstream from 222nd Street SW	2.1	2.2	0.1	3.4	3.5	0.1	4.1	4.1	0.0	5.2	5.1	-0.1
370	21.2	directly upstream from 224th Street SW	5.1	5.2	0.1	8.6	8.7	0.1	10.6	10.5	-0.1	13.7	13.2	-0.5
380	2.2	upstream from 300 feet East of 84th Avenue W	6.9	7.2	0.3	12.9	13.2	0.3	16.8	17.2	0.4	23.9	24.3	0.4
390	3.4	upstream from 300 feet East of 84th Avenue W	3.9	3.9	0.0	6.0	6.1	0.1	7.2	7.3	0.1	9.0	9.1	0.1
400	34.1	upstream from 600 feet South of 220th Street SW	7.5	7.5	0.0	11.9	12.0	0.1	14.3	14.4	0.1	18.0	18.1	0.1
420	2.5	directly upstream from 84th Avenue W	7.3	7.4	0.1	11.5	11.6	0.1	13.5	13.6	0.1	16.4	16.5	0.1

Table A4-11 (continued)
Existing and Future Flood Frequencies for the Chase Lake Subbasin

HSPF Reach	Subbasin Area (ac)	Location	2-Year Peak Flow (cfs)			10-Year Peak Flow (cfs)			25-Year Peak Flow (cfs)			100-Year Peak Flow (cfs)		
			Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference	Existing	Future	Difference
430	2.1	directly upstream from 84th Avenue W	1.9	1.9	0.0	4.3	4.4	0.1	6.6	6.6	0.0	11.9	12.0	0.1
440	11.2	directly upstream from 224th Street SW	2.2	2.2	0.0	3.6	3.6	0.0	4.4	4.4	0.0	5.5	5.5	0.0
450	15.6	on 224th Street SW, 222nd St. SW, 86th Pl. W	2.6	2.6	0.0	4.5	4.5	0.0	5.5	5.5	0.0	7.2	7.2	0.0
460	37.6	directly upstream from 224th Street SW	6.6	6.6	0.0	10.2	10.2	0.0	12.0	12.0	0.0	14.6	14.6	0.0
500	6.5	directly upstream from 234th Street SW	2.1	2.3	0.2	3.7	3.9	0.2	4.5	4.7	0.2	5.9	6.1	0.2
510	5.8	directly upstream from 234th Street SW	3.1	3.3	0.2	5.3	5.5	0.2	6.6	6.8	0.2	8.5	8.7	0.2
520	7	upstream from 700 feet North of 234th Street SW	1.2	1.2	0.0	2.1	2.1	0.0	2.5	2.5	0.0	3.2	3.2	0.0
600	6.3	directly upstream of 88th Avenue W	1.7	1.8	0.1	2.9	2.9	0.0	3.5	3.5	0.0	4.5	4.4	-0.1
610	5.1	upstream from 900 feet East of 88th Avenue W	0.9	0.9	0.0	1.5	1.5	0.0	1.8	1.8	0.0	2.2	2.3	0.1
700	3.1	upstream from 100 feet West of 88th Avenue W	4.8	5.0	0.2	8.3	8.2	-0.1	10.1	9.9	-0.2	13.0	12.5	-0.5
710	12.1	directly upstream of 88th Avenue W	4.3	4.3	0.0	7.3	7.2	-0.1	9.0	8.7	-0.3	11.6	11.1	-0.5
720	18.3	upstream from 500 feet East of 88th Avenue W	2.5	2.6	0.1	4.3	4.2	-0.1	5.3	5.1	-0.2	6.8	6.5	-0.3
509	n/a	Combined overflow for the R-600 and R-700 series	5.8	6.1	0.3	10.0	10.0	0.0	12.3	12.0	-0.3	15.9	15.2	-0.7
109	n/a	Combined overflow for the R-100 and R-400 series	25.7	26.4	0.7	39.9	40.7	0.8	47.3	47.9	0.6	58.3	58.6	0.3

cfs = cubic feet per second

A4.5.3 Future Land Use Results

Results of the HSPF analysis for Chase Lake future land use are discussed in the following two subsections.

A4.5.3.1 Flood Frequency Results

Table A4-11 shows the results of the flood frequency analysis for all 35 stream reaches represented in the Chase Lake model. Flood frequency was computed using the standard LP3 distribution as outlined in Section 10 of the Hydrologic Modeling Protocols. The results indicate mostly minor flow increases, but also indicate some slight decreases in the Chase Lake Subbasin for the future land use conditions as shown in Table A4-11. Several factors support the results.

First, Chase Lake is an urbanized subbasin such that future development is very limited. Therefore, compared to other less urbanized basins, land use changes are less dramatic and, consequently, there is less dramatic change in surface flows as well.

Second, future developments are assumed to provide adequate detention to comply with current County surface water control standards (Title 24). Therefore, detention ponds were accounted for in the HSPF modeling run for the future developments or redevelopments in accordance with these standards. In some cases, the future flows can be slightly lower than the existing flows, due to the fact that future detention flows are required to match the forested condition that yields more conservative flows than flows generated by the actual existing land type.

Finally, a hand-fitted curve method was used in the LP3 statistical analysis of flood frequency. Since the HSPF program uses only approximately 50 years of historical rainfall data, the statistical analysis at the higher frequencies is often less reliable and skewed. Therefore, curves need to be hand-fitted using the professional judgment of the modeler to better estimate the flow frequencies.

However, fitting curves by hand can also introduce some uncertainties to the results. In a highly urbanized and relatively small subbasin such as Chase Lake, flow analysis accuracy is sensitive to the hand-fitting curve method. Please note that the small difference in the flow changes can be considered within the accepted accuracy tolerance.

A4.5.3.2 Flow Duration Analysis

No flow duration analysis was performed for Chase Lake Subbasin due to the lack of need for this input to habitat assessment.

A4.5.3.3 Runoff Volume Analysis

No runoff volume analysis was performed for Chase Lake Subbasin due to the lack of need for this input to habitat assessment.

A4.5.4 Selection of Design Events for CIP Analysis and Design

The Hydrologic Modeling Protocols call for selection of hydrographs with a peak flow at or near the 2-year, 10-year, and 25-year return peaks for SWMM modeling. However, the SWMM analysis performed for Chase Lake Subbasin is a steady-flow analysis that requires peak-flow values instead of hydrographs. The maximum annual flows provided by HSPF were analyzed using the LP3 method to determine the peak for the 2-year, 10-year, 25-year, and the 100-year events. The results of the frequency analysis were tabulated and entered into the SWMM model for flooding analysis.

A4.5.5 CIP Alternative 1

CIP Modeling Alternative 1 was designed to alleviate flooding problems along Chase Lake system. This was accomplished by installing larger culverts at selected locations to increase the capacity of the existing conveyance system. This alternative includes upgrading the pipe system from the outfall of Chase Lake to the city boundary of Edmonds to solve identified flooding. This upgraded pipe system was modeled using SWMM for the hydraulic evaluation. Then, new FTABLEs were generated to update the 12 FTABLEs in the Chase Lake subbasin using the methodology described earlier in this section and in Appendix B6.

A4.5.5.1 HSPF Model Modifications

The HSPF model schematic for CIP Modeling Alternative 1 is the same as for the future model schematic shown in Figure A4-5. The only changes made to the HSPF model for this Alternative were to update the FTABLEs. The following FTABLEs were modified for Alternative 1:

110	200	205	210	220	230
240	300	320	330	335	340

A4.5.5.2 Flood Frequency Results

Table A4-12 shows the results of the flood frequency analysis for the 35 reaches between the outfall to the City of Edmonds and the contributing systems above Chase Lake as represented in the Chase Lake Alternative 1 model. Flood frequency was computed using the LP3 Bulletin 17B procedures, as outlined in Section 10 of the Hydrologic Modeling Protocols. The frequency curves were hand-fit through the plotted peak flows where necessary. Flows were then picked off the hand drawn curve at the frequency desired.

In general, Alternative 1 increased future conditions flows in the lower pipe system below Chase Lake. For example, 2-year peak flows at stream reach 200 (upstream of high flow bypass) increased by 4.1 cfs (16.5 percent), while 2-year peak flows at reach 390 (outlet of Chase Lake) increased by 1.0 cfs (25.3 percent).

A4.5.6 CIP Alternative 2

CIP Modeling Alternative 2 for the Chase Lake subbasin generally addresses problems within the subbasin by providing a detention facility upgrade to reduce peak flows as well as installing larger pipe systems to address the flooding problems. The effect of implementing the detention facility upgrade is to reduce peak flows and is intended to mitigate for increased peak flows resulting from future development as well as increased downstream flows resulting from the upgraded pipe system. The detention facility upgrade will also provide improved water quality treatment. The detention facility upgrade included in this alternative is located near the intersection of 84th Avenue W and 221st Place SW as shown in Figure 9-1f. This site was identified during the CIP Alternatives Solutions Identification meeting on May 10, 2002. The selected site is currently a biofiltration swale and has adequate open space to accommodate the proposed upgrade.

Table A4-12
Modeled Flow Results for CIP Modeling Alternatives 1 and 2 for Chase Lake Subbasin

HSPF Reach	Location	2-Year Peak Flow							10-Year Peak Flow							25-Year Peak Flow							100-Year Return Interval						
		Peak Flow (cfs)				Percent Increase			Peak Flow (cfs)				Percent Increase			Peak Flow (cfs)				Percent Increase			Peak Flow (cfs)				Percent Increase (%)		
		Exist.	Fut.	Alt 1	Alt 2	Exist. to Fut.	Fut. to Alt 1	Fut. to Alt 2	Exist.	Fut.	Alt 1	Alt 2	Exist. to Fut.	Fut. to Alt 1	Fut. to Alt 2	Exist.	Fut.	Alt 1	Alt 2	Exist. to Fut.	Fut. to Alt 1	Fut. to Alt 2	Exist.	Fut.	Alt 1	Alt 2	Exist. to Fut.	Fut. to Alt 1	Fut. to Alt 2
100	Drainage System east of 84th Ave. W on 227th PL SW	2.9	2.9	2.9	2.9	0.0	0.0	0.0	4.6	4.6	4.6	4.6	0.0	0.0	0.0	5.6	5.6	5.6	5.6	0.0	0.0	0.0	7.1	7.1	7.1	7.1	0.0	0.0	0.0
110	Drainage System u/s from 300 feet south of 224th Street SW	0.5	0.5	0.8	0.8	0.0	40.7	40.7	1.2	1.2	1.2	1.2	0.0	4.3	4.3	1.6	1.6	1.4	1.4	0.0	-10.6	-10.6	2.5	2.5	1.5	1.8	0.0	-39.0	-27.6
115	Drainage System directly u/s from 224th Street SW	0.3	0.3	0.3	0.3	0.0	0.0	0.0	0.5	0.5	0.5	0.5	0.0	0.0	0.0	0.6	0.6	0.6	0.6	0.0	0.0	0.0	0.7	0.7	0.7	0.7	0.0	0.0	0.0
200	Drainage System u/s from 250 feet south of 244th Street SW	24.1	24.8	28.9	27.0	3.1	16.5	8.7	37.3	38.0	47.0	40.1	2.0	23.6	5.5	44.0	44.6	51.2	46.3	1.4	14.9	3.8	54.1	54.4	60.1	45.0	0.4	10.5	-17.2
205	Drainage System u/s from 150 feet east of 78th Avenue W	16.9	17.4	21.5	19.4	3.1	23.7	11.3	25.7	26.4	35.7	27.6	2.8	34.9	4.6	30.4	31.1	31.4	38.5	2.5	0.8	23.6	37.5	38.3	50.0	32.5	2.2	30.4	-15.2
210	Drainage System directly u/s from 224th Street SW	8.3	8.4	8.5	8.6	1.9	0.9	1.3	13.3	13.4	13.5	13.5	0.5	0.9	0.8	15.9	15.9	16.0	16.0	-0.2	0.9	0.7	19.9	19.7	17.0	19.8	-1.0	-13.6	0.5
220	Drainage System u/s from 200 feet north of 224th Street SW	7.3	7.5	7.5	7.6	2.1	1.1	1.5	12.0	12.0	12.1	12.1	-0.1	1.2	0.8	14.4	14.3	14.4	14.3	-1.0	1.3	0.6	18.2	17.8	15.0	17.8	-2.2	-15.5	0.3
230	Drainage System directly u/s from 222nd Street SW	5.9	6.0	6.1	6.2	2.7	1.3	2.0	9.8	9.8	9.7	9.7	-0.4	-0.4	-1.0	11.9	11.7	11.6	11.4	-1.7	-1.2	-2.4	15.3	14.7	12.0	14.1	-3.5	-18.6	-4.1
240	Drainage System u/s from 300 feet south of 220th Street SW	4.6	4.8	4.8	4.8	3.5	0.8	0.8	7.6	7.6	7.7	7.7	0.0	1.2	1.2	9.2	9.1	9.2	9.2	-1.3	1.3	1.4	11.7	11.3	11.5	11.5	-3.2	1.8	1.9
250	Drainage System directly u/s from 220th Street SW	2.9	3.1	3.1	3.1	5.4	0.0	0.0	4.8	4.9	4.9	4.9	1.0	0.0	0.0	5.8	5.8	5.8	5.8	-0.5	0.0	0.0	7.4	7.2	7.2	7.2	-2.8	0.0	0.0
300	Drainage System u/s from 300 feet east of 80th Avenue W	16.8	17.3	20.8	18.7	3.3	20.1	8.2	26.2	26.9	34.9	26.7	2.9	29.6	-0.9	31.1	32.0	42.9	30.3	2.7	34.1	-5.3	38.9	39.8	50.0	35.3	2.3	25.8	-11.3
310	Drainage System on 84th Street W from 228th St SW to 224th St SW	4.6	4.6	4.6	4.6	0.4	0.0	0.0	7.9	7.9	7.9	7.9	0.1	0.0	0.0	9.7	9.7	9.7	9.7	-0.1	0.0	0.0	12.8	12.7	12.7	12.7	-0.5	0.0	0.0
320	Drainage System directly u/s from 80th Avenue W	12.4	12.9	16.1	13.8	4.2	24.2	7.0	18.9	19.7	27.6	18.8	4.1	40.3	-4.5	22.3	23.2	34.6	20.9	3.9	49.6	-9.7	27.6	28.6	46.9	23.8	3.6	64.3	-16.8
330	Drainage System u/s from west of 80th Avenue W to 82nd PL W	10.9	11.2	14.4	12.1	3.3	28.3	7.6	16.3	16.8	25.1	16.4	3.4	49.2	-2.6	19.1	19.7	31.9	18.3	3.4	61.6	-7.2	23.5	24.3	44.1	21.0	3.2	81.7	-13.5
335	Drainage System u/s from 300 feet west of 80th Avenue W	10.1	10.3	13.3	10.9	2.3	29.0	5.8	15.2	15.5	23.7	15.2	2.0	53.1	-1.9	17.9	18.2	30.6	17.3	1.8	67.9	-5.1	22.1	22.4	43.1	20.4	1.5	92.2	-9.2
340	Drainage System u/s from 150 feet east of 82nd Avenue W	3.9	4.0	5.0	3.6	2.0	25.4	-10.7	6.3	6.4	16.0	10.4	2.2	149.6	62.4	7.5	7.7	25.0	15.9	2.4	224.3	105.8	9.5	9.8	30.0	26.3	2.7	207.1	168.8
350	Drainage System on 84th Ave. W. from 231st St SW to 228th St. SW	10.1	10.1	10.1	10.1	0.2	0.0	0.0	15.9	16.0	16.0	16.0	0.1	0.0	0.0	19.0	19.0	19.0	19.0	0.1	0.0	0.0	23.6	23.6	23.6	23.6	0.0	0.0	0.0
360	Drainage System directly u/s from 222nd Street SW	2.1	2.2	2.2	2.2	6.3	0.0	0.0	3.4	3.5	3.6	3.6	2.6	2.6	2.6	4.1	4.2	4.3	4.3	1.5	3.9	3.9	5.2	5.1	5.4	5.4	-0.8	5.7	5.7
370	Drainage System directly u/s from 224th Street SW	5.1	5.2	5.2	5.2	3.4	0.0	0.0	8.7	8.7	8.9	8.9	0.2	2.1	2.1	10.6	10.5	10.8	10.8	-1.1	3.1	3.1	13.7	13.3	13.9	13.9	-3.0	4.5	4.5
380	Drainage System u/s from 300 feet east of 84th Avenue W	6.9	7.2	7.2	7.2	3.6	0.0	0.0	12.9	13.2	13.2	13.2	2.7	0.0	0.0	16.8	17.2	17.2	17.2	2.4	0.0	0.0	23.9	24.3	24.3	24.3	1.8	0.0	0.0
390	Chase Lake	3.9	3.9	4.9	3.3	1.3	25.3	-15.8	6.1	6.1	12.3	10.5	1.3	101.3	70.5	7.2	7.3	23.7	16.1	1.7	224.2	120.8	9.0	9.2	34.0	20.0	2.0	271.6	118.6
400	Drainage System u/s from 600 feet south of 220th Street SW	7.5	7.5	7.5	7.5	0.4	0.0	0.0	11.9	12.0	12.0	12.0	0.3	0.0	0.0	14.3	14.4	14.4	14.4	0.3	0.0	0.0	18.0	18.1	18.1	18.1	0.3	0.0	0.0
420	Drainage System directly u/s from 84th Avenue W (Swale to Chase Lake)	7.3	7.5	7.5	-	2.3	0.0	-	11.5	11.6	11.6	-	1.4	0.0	-	13.5	13.6	12.3	-	0.9	-9.8	-	16.4	16.5	16.5	-	0.3	0.0	-
430	Drainage System directly u/s from 84th Avenue W	1.9	1.9	1.9	1.9	1.6	0.0	0.0	4.3	4.4	4.4	4.4	1.4	0.0	0.0	6.6	6.6	6.6	6.6	1.2	0.0	0.0	11.9	12.0	12.0	12.0	0.4	0.0	0.0
440	Drainage System directly u/s from 224th Street SW	2.2	2.2	2.2	2.2	0.0	0.0	0.0	3.6	3.6	3.6	3.6	0.0	0.0	0.0	4.4	4.4	4.4	4.4	0.0	0.0	0.0	5.5	5.5	5.5	5.5	0.0	0.0	0.0
450	Drainage Systemon 224th Street SW, 222nd St. SW, 86th PL. W	2.6	2.6	2.6	2.6	0.0	0.0	0.0	4.5	4.5	4.5	4.5	0.0	0.0	0.0	5.5	5.5	5.5	5.5	0.0	0.0	0.0	7.2	7.2	7.2	7.2	0.0	0.0	0.0
460	Drainage System directly u/s from 224th Street SW	6.6	6.6	6.6	6.6	0.0	0.0	0.0	10.2	10.2	10.2	10.2	0.0	0.0	0.0	12.0	12.0	12.0	12.0	0.0	0.0	0.0	14.7	14.7	14.7	14.7	0.0	0.0	0.0
500	Drainage System directly u/s from 234th Street SW	2.2	2.3	2.3	2.3	7.0	0.0	0.0	3.7	3.9	3.9	3.9	5.1	0.0	0.0	4.5	4.7	4.7	4.7	4.4	0.0	0.0	5.9	6.1	6.1	6.1	3.2	0.0	0.0
510	Drainage System directly u/s from 234th Street SW	3.1	3.3	3.3	3.3	5.2	0.0	0.0	5.4	5.5	5.5	5.5	3.6	0.0	0.0	6.6	6.8	6.8	6.8	2.9	0.0	0.0	8.5	8.7	8.7	8.7	2.2	0.0	0.0
520	Drainage System u/s from 700 feet north of 234th Street SW	1.2	1.2	1.2	1.2	0.0	0.0	0.0	2.1	2.1	2.1	2.1	0.0	0.0	0.0	2.5	2.5	2.5	2.5	0.0	0.0	0.0	3.2	3.2	3.2	3.2	0.0	0.0	0.0
600	Drainage System directly u/s of 88th Avenue W	1.7	1.8	1.8	1.8	5.2	0.0	0.0	2.9	2.9	2.9	2.9	1.0	0.0	0.0	3.5	3.5	3.5	3.5	0.0	0.0	0.0	4.5	4.4	4.4	4.4	-1.6	0.0	0.0
610	Drainage System u/s from 900 feet east of 88th Avenue W	0.9	1.0	1.0	1.0	4.4	0.0	0.0	1.5	1.5	1.5	1.5	2.0	0.0	0.0	1.8	1.8	1.8	1.8	1.7	0.0	0.0	2.2	2.3	2.3	2.3	0.9	0.0	0.0
700	Drainage System u/s from 100 feet west of 88th Avenue W	4.8	5.0	5.0	5.0	2.5	0.0	0.0	8.3	8.2	8.2	8.2	-1.0	0.0	0.0	10.1	9.9	9.9	9.9	-2.3	0.0	0.0	13.0	12.5	12.5	12.5	-3.8	0.0	0.0
710	Drainage System directly u/s of 88th Avenue W	4.3	4.4	4.4	4.4	2.4	0.0	0.0	7.3	7.2	7.2	7.2	-1.4	0.0	0.0	9.0	8.7	8.7	8.7	-2.9	0.0	0.0	11.6	11.1	11.1	11.1	-4.6	0.0	0.0
720	Drainage System u/s from 500 feet east of 88th Avenue W	2.5	2.6	2.6	2.6	3.2	0.0	0.0	4.3	4.3	4.3	4.3	-0.9	0.0	0.0	5.3	5.1	5.1	5.1	-2.7	0.0	0.0	6.9	6.5	6.5	6.5	-4.7	0.0	0.0
509	Outfall for the Southwest Chase Lake System	5.9	6.1	6.1	6.1	3.8	0.0	0.0	10.0	10.0	10.0	10.0	-0.3	0.0	0.0	12.3	12.0	12.0	12.0	-2.3	0.0	0.0	15.9	15.2	15.2	15.2	-4.8	0.0	0.0
109	Outfall for the North Chase Lake System	25.7	26.4	30.3	28.6	2.8	14.8	8.3	40.0	40.7	49.0	42.8	1.9	20.4	5.0	47.3	47.9	58.0	49.5	1.3	21.1	3.4	58.3	58.6	65.0	59.3	0.5	10.9	1.2

cfs = cubic feet per second
u/s = upstream
HSPF Reach 420 was combined with HSPF Reach 390 for Alternative 2

The same pipe system upgrade for Alternative 1 is included in this alternative. The upgraded pipe system was modeled using SWMM for the hydraulic evaluation. Then, new FTABLEs were generated to update the 12 FTABLEs in the Chase Lake subbasin using the methodology described earlier in this section and in Appendix B6.

A4.5.6.1 HSPF Model Modifications

The HSPF model schematic for CIP Alternative 2 is shown the same as in Figure A4-6. The FTABLEs were updated using the SWMM model as described previously. In addition, the following changes were made to the HSPF model to include the detention facility upgrade.

The detention facility was roughly sized in HSPF such that the current 25-year water surface elevation with future land use matched the 25-year water surface elevation for this alternative. The Chase Lake Detention Facility was expanded to incorporate the water quality swale south of Chase Lake. By removing the swale, the storage of the facility was increased by 10.3 ac-ft (39.1 percent).

The following FTABLEs were modified for Alternative 2:

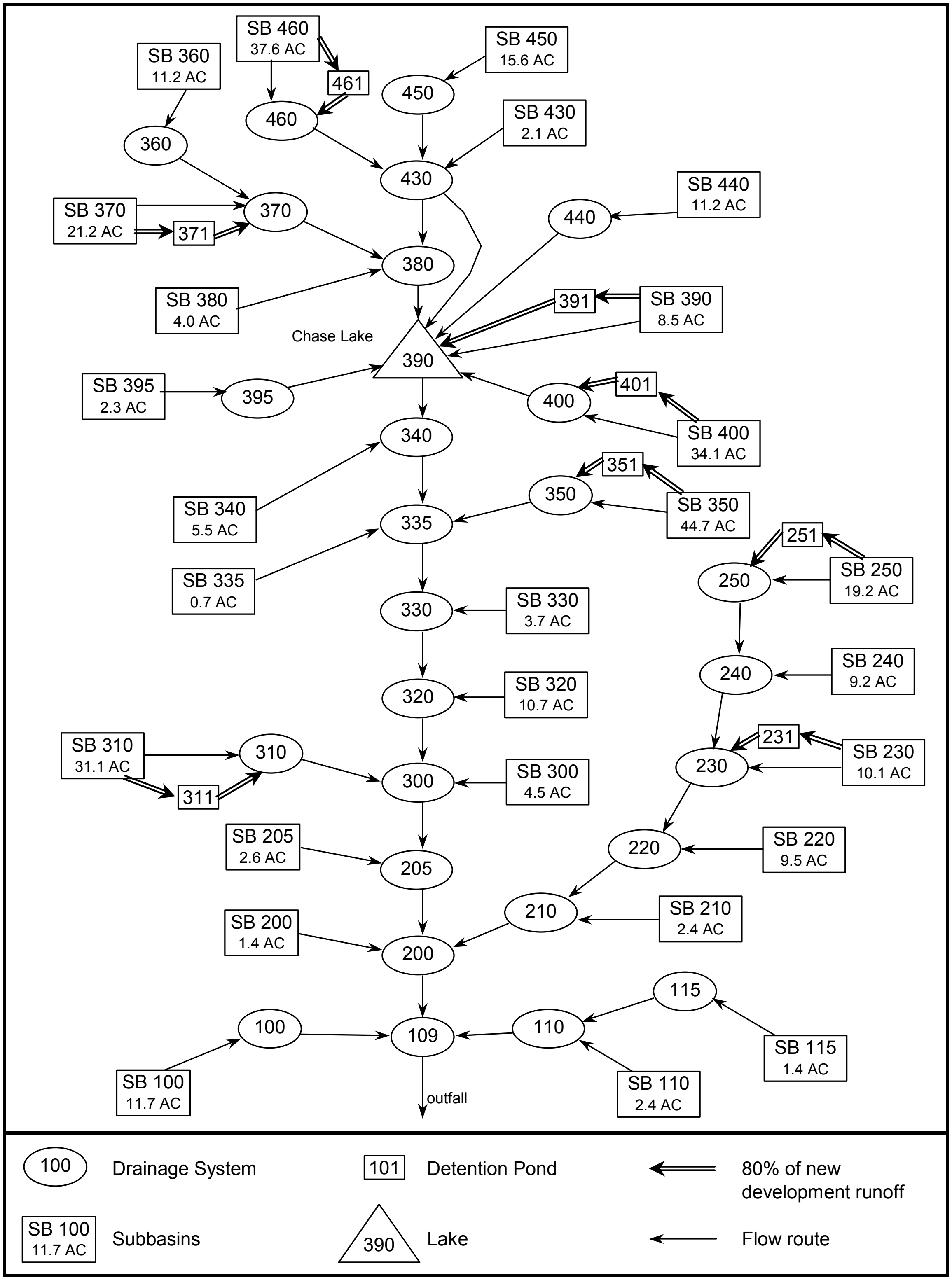
110	200	205	210	220	230
240	300	320	330	335	340
390	420 (combined with 390)				

A4.5.6.2 Flood Frequency Results

Table A4-12 shows the results of the flood frequency analysis for the 35 reaches between the outfall to the City of Edmonds and the contributing systems above Chase Lake as represented in the Chase Lake Alternative 2 model. Flood frequency was computed using the LP3 Bulletin 17B procedures, as outlined in Section 10 of the Hydrologic Modeling Protocols. Where necessary, the frequency curves were fit by hand through the plotted peak flows. Flows were then picked off the hand drawn curve at the frequency desired.

In general, Alternative 2 increased future conditions flows in the lower pipe system below Chase Lake. For example, 2-year peak flows at stream reach 200 (upstream of high flow bypass) increased by 2.2 cfs (8.7 percent). The Chase Lake improvements reduced the 2-year peak flow at reach 390 (outfall of Chase Lake) by 0.6 cfs (-15.8 percent). It is possible that a more refined design of this facility could reduce peak flood flows even more.

Figure A4-6
Chase Lake HSPF Schematic for Future Conditions (CIP Alternative 2) of North Chase Lake Drainage



A4.6 Archiving of Model and Model Results

A4.6.1 Listing and Disposition of Digital Files

Table A4-13 lists input files used in the Swamp Creek HSPF modeling effort. These files have been provided to the County on CD-ROM.

- Swa4ec.inp (existing system with existing land use conditions)
- Swa4fc.inp (existing system with future land use conditions)
- Swa4fa1.inp (CIP Modeling Alternative 1 with future land use conditions)
- Swa4fa2.inp (CIP Modeling Alternative 2 with future land use conditions)

A4.6.2 WDM Contents

Table A4-14 contains a list of all WDM datasets in the Swamp Creek WDM file.

A4.7 References

Chesterfield, Blaine A. Snohomish County Public Works. Telephone and email communications with Wan-Yee Kuo, Entranco. 2001.

Snohomish County. 1985. Chase Lake Drainage Improvements Phase II, stormwater filtration plan. Snohomish County Public Works.

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Snohomish County. 1985. Chase Lake Drainage Improvements Phase II, system profiles. Snohomish County Public Works.

Snohomish County. 1989. Chase Lake Regional Detention Facility, control structure plan. Snohomish County road project no. 88-604.

Snohomish County. 1989. Chase Lake Regional Detention Facility, site grading and facility layout plan. Snohomish County road project no. 88-604.

Snohomish County. 1989. Chase Lake Regional Detention Facility, profiles. Snohomish County road project no. 88-604.

Table A4-13
HSPF Input Files for Chase Lake

FILE NAME	EXTENSION	BRIEF DESCRIPTION
Swa4ec	.INP	input file for simulating existing routed flows
Swa4fc	.INP	input file for simulating future routed flows
Swa4fa1	.INP	input file for future CIP Alt 1 condition
Swa4fa2	.INP	input file for future CIP Alt 2 condition
Swa4edf	.INP	input file for preliminary design flows
SWUGA	.WDM	WDM file

Table A4-14
WDM Data Set Numbering Protocols

HSPF Reach	HSPF Target Name	WDM Data Set Number			
		Existing	Future	CIP Alternative 1	CIP Alternative 2
100	RCHRES	1100	3100	5100	7100
110	RCHRES	1110	3110	5110	7110
115	RCHRES	1115	3115	5115	7115
200	RCHRES	1200	3200	5200	7200
205	RCHRES	1205	3205	5205	7205
210	RCHRES	1210	3210	5210	7210
220	RCHRES	1220	3220	5220	7220
230	RCHRES	1230	3230	5230	7230
240	RCHRES	1240	3240	5240	7240
250	RCHRES	1250	3250	5250	7250
300	RCHRES	1300	3300	5300	7300
310	RCHRES	1310	3310	5310	7310
320	RCHRES	1320	3320	5320	7320
330	RCHRES	1330	3330	5330	7330
335	RCHRES	1335	3335	5335	7335
340	RCHRES	1340	3340	5340	7340
350	RCHRES	1350	3350	5350	7350
360	RCHRES	1360	3360	5360	7360
370	RCHRES	1370	3370	5370	7370
380	RCHRES	1380	3380	5380	7380
390	RCHRES	1390	3390	5390	7390
390	RCHRES	2390 (stage)	4390 (stage)	6390 (stage)	8390 (stage)
400	RCHRES	1400	3400	5400	7400
420	RCHRES	1420	3420	5420	7420
430	RCHRES	1430	3430	5430	7430
440	RCHRES	1440	3440	5440	7440
450	RCHRES	1450	3450	5450	7450
460	RCHRES	1460	3460	5460	7460
500	RCHRES	1500	3500	5500	7500
510	RCHRES	1510	3510	5510	7510
520	RCHRES	1520	3520	5520	7520
600	RCHRES	1600	3600	5600	7600
610	RCHRES	1610	3610	5610	7610
700	RCHRES	1700	3700	5700	7700
710	RCHRES	1710	3710	5710	7710
720	RCHRES	1720	3720	5720	7720
509	COPY	1509	3509	5509	7509
109	COPY	1109	3109	5109	7109