Appendix B
Technical Memorandum
City-wide Hydraulic Analysis
Otak, Inc.
June 9, 2010

Technical Memorandum

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Date:	June 9, 2010
Subject:	City-wide Hydraulic Analysis
Project No.:	31324

Introduction

This memo describes the city-wide hydraulic analysis completed as one element of the Stormwater Comprehensive Plan project for the City of Woodinville (City). The purpose of the analysis is to better identify portions of the City's storm drainage conveyances that may not have adequate capacity to accommodate potential development within Woodinville.

The City inventoried approximately 4,700 stormwater pipes as part of a geographic information system (GIS) database. This GIS database of stormwater pipes was used for pipe size, type, and system connectivity. The stormwater database was significantly updated during the time of the city-wide hydraulic analysis. The City will continue to update the GIS database as new development and re-development occurs and additional survey information is acquired.

The city-wide hydraulic analysis focused on the larger pipes located lower in the various drainage basins. This analysis did not include an evaluation of existing culverts or ditches. The capacity of the culverts that convey Little Bear Creek were analyzed in a technical memorandum by Otak, Inc. (Otak) dated July 11, 2008 (see Appendix A).

Hydrologic and hydraulic methodology is described in the following sections. All supporting calculations for this analysis are included in Appendix B.

Hydrology

The peak discharge from the various subbasins tributary to the City's storm drainage system was analyzed using the Santa Barbara Urban Hydrograph (SBUH) methodology. The SBUH method was selected for the hydrologic model because it is widely used; it is an accepted method for conveyance sizing in the King County 2009 Surface Water Design Manual, which is the City's standard for

stormwater management; and it does not require a specialized computer program for updates. SBUH is a single event hydrologic model that computes peak discharge based on 24-hour storm events. Input for the SBUH method is based on the following:

- Precipitation
- Drainage Basin Area
- Curve Number
- Time of Concentration

Precipitation

Precipitation maps for Washington State were updated for the Department of Ecology and Washington State Department of Transportation by MGS Engineering Consultants and Oregon Climate Service in January 2006. Table 1 presents the minimum, maximum, and average 24-hour precipitation depths throughout the City of Woodinville. Average precipitation depths were used for the city-wide hydraulic analysis.

Table 1
24-Hour Precipitation Depths

Recurrence Interval	24-hr Precipitation Depths within the City Limits of Woodinville (in)		
	Minimum	Maximum	Average
6-month	1.41	1.56	1.5
2-year	2.0	2.2	2.1
10- year	2.7	2.9	2.8
25- year	3.2	3.4	3.3
100- year	3.9	4.1	4.0

Drainage Basin Delineation

The City of Woodinville had divided the city into seven major basins including: Little Bear Creek, Sammamish River, Juanita Creek, Woodin Creek, Lake Leota, School, and Daniels Creek Basins. Based on the areas of interest to this city-wide hydraulic analysis, Otak split three of these basins (Little Bear into East and West; Sammamish River into North, West, and East; and School into North and South). These major basins were then subdivided into a total of 99 subbasins to calculate peak flows at critical points of interest.

Subbasin delineation was completed by use of aerial photos, the City's topographic map, King County LIDAR data, the City's stormwater pipe and open channel GIS mapping, and field reconnaissance at locations of apparent mapping conflicts. Data collected during site visits was updated into the City's stormwater GIS database.

In areas without complete storm drainage mapping (i.e., outside the City limits), basin boundaries were delineated using only available topographic information. The GIS drainage data available for areas outside of the City limits was not used because it was not consistent with field observations by Otak and City staff. The basin boundaries may change if new information about the underground storm drainage system is acquired.

Curve Number

The major components that determine a curve number are the land use and cover, the underlying soil and its hydrologic condition, and antecedent moisture condition. Composite curve numbers were estimated for each subbasin according to a combination of land cover and hydrologic soil group.

Land Use

Land cover was indirectly estimated by use of present land use data for existing conditions and zoning data for future conditions. For existing conditions, the present land use data was obtained from three separate sources:

- City of Woodinville Transportation Analysis Zones (TAZ) data (2009)
- King County Tax Assessor Data by Aerial Express (May 2006)
- Snohomish Tax Assessor Data by Aerial Express (May 2006)

For future conditions, zoning data was obtained from three separate sources:

- City of Woodinville Zoning (September 9, 2009)
- King County Tax Assessor Data by Aerial Express (May 2006)
- Snohomish Tax Assessor Data by Aerial Express (May 2006)

The land uses for both present and future scenarios were consolidated into 13 categories including:

- Open space
- Agriculture
- Park/recreation
- Public institution
- Greenhouse
- Single family residential (SFR) rural (parcel size >2 acres)
- SFR low (parcel size 0.5 to 2 acres)
- SFR med (parcel size 7,500 square feet to 0.5 acres)
- SFR high (parcel size <7,500 square feet)
- Multi-family
- Commercial
- Industrial
- Right-of-way (ROW)

After these consolidated land uses were assigned, they were mapped and compared to the 2007 aerial photography. The land uses initially assigned to several locations were modified to reflect the land uses visible in the aerial photograph. Figures 1 and 2 present the assigned existing and future land uses.

The land uses assigned to some areas within the City were adjusted to account for the runoff control facilities within those areas. The city-wide hydraulic analysis did not attempt to model individual retention and detention facilities, because the City did not consider the effort required to obtain data on each of these facilities and the effort to model each of these facilities compatible with the objectives of the city-wide analysis. A technical memorandum by Otak dated November 12, 2009 provided a method for approximating the attenuation effects of detention ponds associated with newer developments. It showed that curve numbers can be adjusted to near pre-developed values in order to cost effectively estimate detention. For this city-wide hydraulic analysis, land use was adjusted based upon the date of development. New developments between 1990 and 1998 and new development after 1998 were considered separately because of the drainage standards in effect during those periods, and land uses assigned to these areas were adjusted accordingly. These newer developments were identified using aerial photographs including:

- 1990 USGS Orthoquad Imagery
- 2007 City of Woodinville aerial photograph
- 2005 images from Aerial Express for drainage basins outside the City of Woodinville

Figure 3 shows the areas considered as new development between 1990 and 1998 and new development after 1998.

Future land use was not further analyzed for peak discharge or pipe capacity. It is assumed that any future development will provide the detention required to maintain existing discharge conditions from the developed site and not result in significant changes in peak discharge downstream.

Land Cover Conversions

Land uses for the existing conditions were then converted to land cover based on the assumptions presented in Table 2.

Table 2
Land Use Conversions to Land Cover

Land Use	Land Cover							
	Effective Impervious percent	Forest percent	Grass percent	Bare ground percent	1990 Develop-ment	1998 Develop-ment	Total	Notes
Open Space	0%	80%	20%	0%	0%	0%	100%	2
Agriculture	0%	0%	50%	50%	0%	0%	100%	2
SFR Rural	1.0%	49.5%	49.5%	0%	0%	0%	100%	1

Table 2 (cont.) Land Use Conversions to Land Cover								
Land Use	Land Cover							
	Effective Impervious percent	Forest percent	Grass percent	Bare ground percent	1990 Develop-ment	1998 Develop-ment	Total	Notes
SFR Low	3%	30%	67%	0%	0%	0%	100%	2
Park/Recreation	15%	10%	60%	15%	0%	0%	100%	2
SFR Med	18%	0%	82%	0%	0%	0%	100%	1
Public Institution	20%	0%	60%	20%	0%	0%	100%	2
Greenhouse	25%	0%	40%	35%	0%	0%	100%	2
SFR High	41%	0%	59%	0%	0%	0%	100%	1
Multi-family	67%	0%	33%	0%	0%	0%	100%	1
ROW	86%	0%	14%	0%	0%	0%	100%	1
Commercial	86%	0%	14%	0%	0%	0%	100%	1
Industrial	86%	0%	14%	0%	0%	0%	100%	1
1990 Development	0%	0%	0%	0%	100%	0%	100%	3
1998 Development	0%	0%	0%	0%	0%	100%	100%	3

1. Land cover from Snohomish County. 2002. Hydrologic Modeling Protocols, Ver. 1.4.
2. Otak assumed land covers based on aerial photography observations.
3. See Otak Memo dated Nov. 12, 2009 for development later than 1990 and development later than 1998.

Soils

Soils were assigned to the subbasins based on the Natural Resources Conservation Service (NRCS) Soil Survey. This NRCS Soil Survey was downloaded directly from the NRCS web site in GIS format.

Each soil type was assigned a hydrologic soil group. The hydrologic soil group is based on a soil's ability to infiltrate after prolonged wetting. Hydrologic soil group A is the most infiltrative soil and D is the least. Table 3 presents the soils found with the City of Woodinville. Figure 4 shows the aerial extents of each of the soils.

Table 3 Soils Types		
Soil Name	Soil Abbreviation	Hydrologic Soil Group[1]
Alderwood	Ag	C
Arents, Alderwood	Am	B
Arents, Everett	An	B

Table 3 (cont.) Soils Types		
Soil Name	Soil Abbreviation	Hydrologic Soil Group[1]
Briscot	Br	D
Earlmont	Ea	C
Everett	Ev	A
Gravel Pit	PITS	A
Indianola	In	A
Kitsap	Kp	C
McKenna	Mc	D
Norma	No	D
Seattle	Sk	D
Snohomish	Sr	D
Tukwila	Tu	D
Urban	Ur	D

1. Hydrologic soil group based on Department of Ecology 2005 Stormwater Management Manual for Western Washington.

Composite Curve Number Calculation

Curve numbers are based upon the land cover and the soil type. Area-weighted composite curve numbers were calculated for each subbasin based on the curve number assumptions presented in Table 4. Curve numbers for forest, grass, and bare ground are from the NRCS Urban Hydrology for Small Watersheds, TR-55 (1986). Curve numbers for 1990 and 1998 Development are based on Otak's November 12, 2009 analysis.

Table 4 Curve Numbers						
Hydrologic Soil Group	Impervious CN	Forest CN	Grass CN	Bare ground CN	1990 Develop-ment	1998 Develop-ment
A	98	30	49	72	60	60
B	98	55	69	82	65	60
C	98	70	79	87	70	60
D	98	77	84	89	80	60

Composite curve numbers represent only the pervious portion of the land. Impervious areas were not included in the composite curve numbers. The impervious areas were subtotaled separately by subbasin as typically required as input for the SBUH method. Appendix B shows the composite curve numbers used for each subbasin.

Table 5 presents the composite curve numbers for all 99 subbasins and how the curve numbers and flow rates have changed as development has occurred.

Appendix C provides a detailed description of the methodology that was developed in order to create a cost effective approach to estimate existing detention, match observed field conditions, and utilize the amount and type of data available from the City.

Time of Concentration

Time of concentration was estimated for each subbasin using drainage basin lengths measured in GIS. The time of concentration assumes an initial 30 minutes for sheet flow followed by concentrated flow at a velocity of 2.5 feet per second (fps) for the distance of the measured basin length.

Flow Routing

This analysis uses limited flow routing methods to evaluate runoff at different points in the drainage system. The analysis included combined subbasins, flow diversions, and limited use of level pool routing.

Combined Subbasins

In order to efficiently simulate the City's drainage network, the city-wide hydraulic analysis did not attempt to model the individual branches of the City's storm drainage system and combine these branches within a composite model. Rather, for this city-wide analysis, each point of interest was described by combining all of the subbasins contributing to the drainage at that point of interest, and computing a new composite curve number for the combined subbasin. Additionally, new time concentrations were estimated for each combined subbasin.

Flow Diversions

Two diversion structures within the City's stormwater system along 124th Avenue NE were included in this city-wide analysis. The diverted flows were accounted for by distributing the upstream subbasin areas to each of the downstream combined subbasins proportionally to the hydraulic capacity of the downstream conveyance systems.

Table 5
Change in CN Value and Flow Rates as a Result of Development

Combined Subbasin ID	Contributing Subbasins[1]	Total Area[2] (ac)	Forested Condition[2]			Pre 2002 Development Condition			Existing Condition (Development Post 2002)		
			Composite CN Value (100% Pervious)	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)
JC10+	JC10, JC11, JC12, JC13	118.32	61.3	3.96	6.13	73.6	31.5	41.4	73.6	31.5	41.4
JC11+	JC11, JC 12	39.37	67.9	2.00	3.52	77.4	9.4	12.8	77.4	9.4	12.8
JC11	JC11	14.38	69.8	0.91	1.59	80.8	4.0	5.4	80.8	4.0	5.4
JC12	JC12	24.99	66.8	1.18	2.13	75.2	6.4	8.7	75.2	6.4	8.7
JC13	JC13	73.22	57.5	1.93	3.11	70.6	21.6	27.9	70.6	21.6	27.9
SRW10+	SRW10, SRW11 (15%), SRW12 (15%), SRW13 (5%), SRW14 (5%), SRW15 (5%)	23.08	64.9	0.94	1.53	60.4	4.9	6.2	62.4	4.9	6.3
SRW11de	SRW11 (15%), SRW12 (15%), SRW13 (5%), SRW14 (5%), SRW15 (5%)	3.39	55.6	0.08	0.13	57.8	0.4	0.5	67.2	0.5	0.7
SRW11dw	SRW11 (85%), SRW12 (85%), SRW13 (95%), SRW14 (95%), SRW15 (95%)	40.13	59.1	1.17	1.85	67.8	6.8	9.4	72.4	7.9	10.8
SRW11+	SRW11, SRW12, SRW13 (40%), SRW14 (40%), SRW15 (40%)	24.71	56.2	0.59	0.97	59.4	3.4	4.5	68.0	4.1	5.7
SRW12+	SRW12, SRW13 (40%), SRW14 (40%), SRW15 (40%)	18.78	53.7	0.37	0.64	71.3	4.0	5.4	71.3	4.0	5.4
SRW13de	SRW13 (40%), SRW14 (40%), SRW15 (40%), SRW15 (40%)	17.27	64.4	0.69	1.14	76.6	4.0	5.5	76.6	4.0	5.5
SRW13dw	SRW13 (60%), SRW14 (60%), SRW15 (60%), SRW15 (60%)	25.90	64.4	1.03	1.71	76.6	6.0	8.2	76.6	6.0	8.2
SRW13+	SRW13, SRW14, SRW15	31.37	62.3	1.11	1.77	77.4	7.9	10.7	77.4	7.9	10.7
SRW14+	SRW14, SRW15	23.13	70.0	1.48	2.58	76.2	6.0	8.1	76.2	6.0	8.1
SRW15	SRW15	11.80	70.0	0.78	1.35	74.8	2.7	3.8	74.8	2.7	3.8
SRW20	SRW20	27.12	70.0	1.71	2.97	72.3	7.2	9.5	72.3	7.2	9.5
SRW30+	SRW30, SRW31, SRW32, SRW33	194.22	46.0	1.73	3.62	71.2	26.0	37.7	71.1	25.9	37.7
SRW31+	SRW31, SRW32, SRW33	188.15	45.2	1.49	3.25	71.0	26.1	37.8	71.0	26.0	37.7
SRW32	SRW32	144.00	38.8	0.08	1.03	71.9	18.8	28.0	71.9	18.7	27.9
SRW33	SRW33	28.31	66.8	1.33	2.38	72.3	5.1	7.3	72.3	5.1	7.3
SRW40+	SRW40, SRW41, SRW42, SRW43, SRW44, SRW45, SRW46, SRW47	262.26	63.6	9.92	15.60	68.5	24.3	37.5	68.1	23.7	36.7

Table 5 (cont.)
Change in CN Value and Flow Rates as a Result of Development

Combined Subbasin ID	Contributing Subbasins[1]	Total Area[2] (ac)	Forested Condition[2]			Pre 2002 Development Condition			Existing Condition (Development Post 2002)		
			Composite CN Value (100% Pervious)	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)
SRW41+	SRW41, SRW42, SRW43, SRW44, SRW45, SRW46, SRW47	242.19	63.2	8.98	14.06	68.3	23.3	35.8	67.9	22.7	35.0
SRW42+	SRW42, SRW43, SRW44, SRW45, SRW46, SRW47	89.67	60.8	2.90	4.52	72.4	9.8	15.6	72.4	9.8	15.6
SRW44+	SRW44, SRW45	35.80	70.0	2.30	4.00	71.7	4.4	7.1	71.7	4.4	7.1
SRW45	SRW45	16.10	70.0	1.05	1.82	68.0	1.6	2.7	68.0	1.6	2.7
SRW47	SRW47	12.20	66.4	0.56	1.02	74.6	1.6	2.6	74.6	1.6	2.6
SRW46	SRW46	85.53	62.5	3.05	4.70	68.9	6.0	10.1	67.8	5.5	9.4
SRW51+	SRW51, SRW52, SRW53	82.15	50.8	1.27	2.29	63.6	11.1	15.4	63.6	11.1	15.4
SRW52	SRW52	16.84	38.3	0.00	0.11	50.6	0.8	0.9	50.6	0.8	0.9
SRW53	SRW53	44.79	45.6	0.38	0.81	71.0	6.1	9.2	71.0	6.1	9.2
SRW60	SRW60	188.73	67.8	9.29	15.76	62.3	19.7	28.1	62.3	19.7	28.1
SRW70+	SRW70, SRW71, SRW72, SRW11 (85%), SRW12 (85%), SRW13 (95%), SRW14 (95%), SRW15 (95%)	79.07	59.6	2.38	3.75	70.7	13.7	19.1	73.0	14.9	20.5
SRW71+	SRW71	34.42	65.8	1.48	2.58	75.7	7.8	10.7	75.7	7.8	10.7
SRW72	SRW72	4.51	70.0	0.29	0.51	78.2	1.4	1.9	78.2	1.4	1.9
SRE40	SRE40	11.27	70.0	0.74	1.29	48.1	2.9	3.6	48.1	2.9	3.6
SRE50	SRE50	569.85	36.4	0.00	1.84	75.0	67.1	100.3	74.9	66.5	99.6
SRN20+	SRN20, SRN 10	98.48	62.0	3.42	5.35	59.4	16.0	20.8	59.4	16.0	20.8
SRN20	SRN20	84.09	60.6	2.70	4.21	58.9	10.3	13.7	58.9	10.4	13.7
SRN10	SRN10	14.39	69.7	0.85	1.46	72.9	5.5	6.9	72.9	5.5	6.9
SRN30	SRN30	24.08	32.5	0.00	0.00	75.8	6.3	8.6	75.8	6.3	8.6
WC10+	WC10, WC11, WC12, WC13, WC13.5, WC14, WC15, WC16, WC17, WC18, WC19.1, WC19.2	648.75	44.7	4.57	10.48	57.6	57.6	75.8	57.6	57.6	75.7
WC11	WC11	20.33	30.4	0.00	0.00	55.4	3.9	4.7	55.4	3.9	4.7

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			Composite CN Value (100% Pervious)	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)
WC12+	WC12, WC13, WC13.5, WC14	305.65	50.1	4.34	7.98	60.5	16.6	26.0	60.4	16.5	25.8
WC13	WC13	172.00	55.0	3.80	6.33	64.2	11.0	18.6	64.1	11.0	18.5
WC14+	WC14, WC13.5	89.16	50.5	1.34	2.43	59.1	4.4	7.1	58.8	4.4	7.0
WC13.5	WC13.5	57.93	58.6	1.64	2.61	66.7	5.6	8.8	66.2	5.4	8.6
WC15++	WC15, WC16, WC17, WC18, WC19.1, WC19.2	256.10	39.6	0.34	2.13	52.8	33.8	41.3	52.9	33.8	41.3
WC15+	WC15, WC16, WC17	156.40	41.7	0.59	1.81	54.7	15.6	19.2	54.7	15.6	19.2
WC15	WC15	103.64	44.5	0.74	1.67	56.0	9.8	12.4	56.0	9.8	12.4
WC16+	WC16, WC17	52.76	36.2	0.00	0.18	52.0	6.3	7.7	52.0	6.3	7.7
WC16	WC16	31.93	33.6	0.00	0.00	50.3	4.9	6.0	50.3	4.9	6.0
WC18+	WC18, WC19.1, WC19.2	99.70	36.3	0.00	0.32	49.0	17.1	20.9	49.2	17.1	20.9
WC19.1+	WC19.1, WC19.2	62.97	36.0	0.00	0.19	47.8	5.7	6.9	48.0	5.7	6.9
LBE05	LBE05	25.17	62.6	0.90	1.40	71.7	6.5	8.4	71.7	6.5	8.4
LBE11+	LBE11, LBE12, LBE13, LBE13.5, LBE14, LBE15	135.21	61.4	4.54	7.06	72.2	47.0	59.4	72.2	47.0	59.4
LBE15+	LBE15, LBE13, LBE13.5, LBE14, LBE12	113.37	63.0	4.18	6.74	72.7	38.2	48.5	72.7	38.2	48.5
LBE13+	LBE13, LBE13.5, LBE14, LBE12	100.26	62.1	3.51	5.55	72.4	32.6	41.6	72.4	32.6	41.6
LBE13.5	LBE13.5	8.56	70.0	0.53	0.92	72.0	1.1	1.7	72.0	1.1	1.7
LBE14+	LBE14, LBE12	59.33	61.3	1.98	3.08	72.5	18.1	23.4	72.5	18.1	23.4
LBE14	LBE14	34.57	66.5	1.60	2.86	73.6	8.8	11.9	73.6	8.8	11.9
LBE15	LBE15	13.10	70.0	0.84	1.45	79.0	5.8	7.2	79.0	5.8	7.2
LBE10+	LBE10, LBE16, LBE17, LBE18, LBE19, LBE20	244.23	67.6	11.43	18.89	71.4	40.6	55.3	71.7	40.9	55.7
LBE16	LBE16	8.48	70.0	0.54	0.95	78.1	3.7	4.6	78.1	3.7	4.6

Table 5 (cont.)
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			Composite CN Value (100% Pervious)	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)
SRW41+	SRW41, SRW42, SRW43, SRW44, SRW45, SRW46, SRW47	242.19	63.2	8.98	14.06	68.3	23.3	35.8	67.9	22.7	35.0
SRW42+	SRW42, SRW43, SRW44, SRW45, SRW46, SRW47	89.67	60.8	2.90	4.52	72.4	9.8	15.6	72.4	9.8	15.6
SRW44+	SRW44, SRW45	35.80	70.0	2.30	4.00	71.7	4.4	7.1	71.7	4.4	7.1
SRW45	SRW45	16.10	70.0	1.05	1.82	68.0	1.6	2.7	68.0	1.6	2.7
SRW47	SRW47	12.20	66.4	0.56	1.02	74.6	1.6	2.6	74.6	1.6	2.6
SRW46	SRW46	85.53	62.5	3.05	4.70	68.9	6.0	10.1	67.8	5.5	9.4
SRW51+	SRW51, SRW52, SRW53	82.15	50.8	1.27	2.29	63.6	11.1	15.4	63.6	11.1	15.4
SRW52	SRW52	16.84	38.3	0.00	0.11	50.6	0.8	0.9	50.6	0.8	0.9
SRW53	SRW53	44.79	45.6	0.38	0.81	71.0	6.1	9.2	71.0	6.1	9.2
SRW60	SRW60	188.73	67.8	9.29	15.76	62.3	19.7	28.1	62.3	19.7	28.1
SRW70+	SRW70, SRW71, SRW72, SRW11 (85%), SRW12 (85%), SRW13 (95%), SRW14 (95%), SRW15 (95%)	79.07	59.6	2.38	3.75	70.7	13.7	19.1	73.0	14.9	20.5
SRW71+	SRW71	34.42	65.8	1.48	2.58	75.7	7.8	10.7	75.7	7.8	10.7
SRW72	SRW72	4.51	70.0	0.29	0.51	78.2	1.4	1.9	78.2	1.4	1.9
SRE40	SRE40	11.27	70.0	0.74	1.29	48.1	2.9	3.6	48.1	2.9	3.6
SRE50	SRE50	569.85	36.4	0.00	1.84	75.0	67.1	100.3	74.9	66.5	99.6
SRN20+	SRN20, SRN 10	98.48	62.0	3.42	5.35	59.4	16.0	20.8	59.4	16.0	20.8
SRN20	SRN20	84.09	60.6	2.70	4.21	58.9	10.3	13.7	58.9	10.4	13.7
SRN10	SRN10	14.39	69.7	0.85	1.46	72.9	5.5	6.9	72.9	5.5	6.9
SRN30	SRN30	24.08	32.5	0.00	0.00	75.8	6.3	8.6	75.8	6.3	8.6
WC10+	WC10, WC11, WC12, WC13, WC13.5, WC14, WC15, WC16, WC17, WC18, WC19.1, WC19.2	648.75	44.7	4.57	10.48	57.6	57.6	75.8	57.6	57.6	75.7
WC11	WC11	20.33	30.4	0.00	0.00	55.4	3.9	4.7	55.4	3.9	4.7

Table 5 (cont.)
Change in CN Value and Flow Rates as a Result of Development

Combined Subbasin ID	Contributing Subbasins[1]	Total Area[2] (ac)	Forested Condition[2]			Pre 2002 Development Condition			Existing Condition (Development Post 2002)		
			Composite CN Value (100% Pervious)	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)
WC12+	WC12, WC13, WC13.5, WC14	305.65	50.1	4.34	7.98	60.5	16.6	26.0	60.4	16.5	25.8
WC13	WC13	172.00	55.0	3.80	6.33	64.2	11.0	18.6	64.1	11.0	18.5
WC14+	WC14, WC13.5	89.16	50.5	1.34	2.43	59.1	4.4	7.1	58.8	4.4	7.0
WC13.5	WC13.5	57.93	58.6	1.64	2.61	66.7	5.6	8.8	66.2	5.4	8.6
WC15++	WC15, WC16, WC17, WC18, WC19.1, WC19.2	256.10	39.6	0.34	2.13	52.8	33.8	41.3	52.9	33.8	41.3
WC15+	WC15, WC16, WC17	156.40	41.7	0.59	1.81	54.7	15.6	19.2	54.7	15.6	19.2
WC15	WC15	103.64	44.5	0.74	1.67	56.0	9.8	12.4	56.0	9.8	12.4
WC16+	WC16, WC17	52.76	36.2	0.00	0.18	52.0	6.3	7.7	52.0	6.3	7.7
WC16	WC16	31.93	33.6	0.00	0.00	50.3	4.9	6.0	50.3	4.9	6.0
WC18+	WC18, WC19.1, WC19.2	99.70	36.3	0.00	0.32	49.0	17.1	20.9	49.2	17.1	20.9
WC19.1+	WC19.1, WC19.2	62.97	36.0	0.00	0.19	47.8	5.7	6.9	48.0	5.7	6.9
LBE05	LBE05	25.17	62.6	0.90	1.40	71.7	6.5	8.4	71.7	6.5	8.4
LBE11+	LBE11, LBE12, LBE13, LBE13.5, LBE14, LBE15	135.21	61.4	4.54	7.06	72.2	47.0	59.4	72.2	47.0	59.4
LBE15+	LBE15, LBE13, LBE13.5, LBE14, LBE12	113.37	63.0	4.18	6.74	72.7	38.2	48.5	72.7	38.2	48.5
LBE13+	LBE13, LBE13.5, LBE14, LBE12	100.26	62.1	3.51	5.55	72.4	32.6	41.6	72.4	32.6	41.6
LBE13.5	LBE13.5	8.56	70.0	0.53	0.92	72.0	1.1	1.7	72.0	1.1	1.7
LBE14+	LBE14, LBE12	59.33	61.3	1.98	3.08	72.5	18.1	23.4	72.5	18.1	23.4
LBE14	LBE14	34.57	66.5	1.60	2.86	73.6	8.8	11.9	73.6	8.8	11.9
LBE15	LBE15	13.10	70.0	0.84	1.45	79.0	5.8	7.2	79.0	5.8	7.2
LBE10+	LBE10, LBE16, LBE17, LBE18, LBE19, LBE20	244.23	67.6	11.43	18.89	71.4	40.6	55.3	71.7	40.9	55.7
LBE16	LBE16	8.48	70.0	0.54	0.95	78.1	3.7	4.6	78.1	3.7	4.6

Table 5 (cont.)
Change in CN Value and Flow Rates as a Result of Development

Combined Subbasin ID	Contributing Subbasins[1]	Total Area[2] (ac)	Forested Condition[2]			Pre 2002 Development Condition			Existing Condition (Development Post 2002)		
			Composite CN Value (100% Pervious)	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)
LBE17+	LBE17, LBE18, LBE19, LBE20	191.36	66.7	8.54	13.91	71.3	29.1	40.4	71.7	29.5	40.9
LBE17++	LBE17, LBE18	86.08	70.0	4.85	7.93	74.2	17.9	23.7	74.2	17.9	23.7
LBE18	LBE18	32.52	70.0	2.04	3.54	73.8	7.0	9.7	73.8	7.0	9.7
LBE30	LBE30	15.51	70.5	1.04	1.79	77.9	6.7	8.3	77.9	6.7	8.3
LBE40+	LBE40, LBE41, LBE42, LBE43, LBE44, LBE45, LBE47, LBE48	115.19	53.7	2.29	3.91	56.5	24.9	30.7	60.4	25.1	32.0
LBE41+	LBE41, LBE42, LBE43, LBE44, LBE45	75.13	48.4	0.91	1.75	55.2	13.1	16.1	58.7	13.1	16.9
LBE42+	LBE42, LBE44	47.30	52.4	0.85	1.48	56.6	4.4	5.6	59.1	4.4	6.2
LBE44	LBE44	8.47	30.8	0.00	0.00	47.3	1.7	2.0	47.3	1.7	2.0
LBE45+	LBE45, LBE43	23.34	43.7	0.15	0.35	57.5	7.3	9.0	57.6	7.3	9.0
LBE43	LBE43	8.57	39.0	0.01	0.06	52.2	2.3	2.8	52.2	2.3	2.8
LBE47	LBE47	25.05	63.2	0.93	1.51	57.8	8.6	10.5	66.8	8.8	11.0
LBE48	LBE48	10.11	70.0	0.64	1.12	75.1	3.9	5.0	75.1	3.9	5.0
LBW15+	LBW15, LBW16	29.90	54.0	0.61	1.04	57.1	2.4	3.2	65.1	3.1	4.9
LBW15	LBW15	15.60	67.8	0.81	1.46	75.1	3.7	5.1	75.7	3.8	5.2
LBW16	LBW16	14.30	39.0	0.01	0.11	42.9	0.2	0.2	56.7	0.4	0.6
LBW21	LBW21	7.30	30.0	0.00	0.00	34.5	0.0	0.0	43.4	0.0	0.1
LBW30	LBW30	36.42	43.5	0.22	0.53	50.7	2.1	2.5	59.4	2.1	3.3
LBW40+	LBW40, LBW45	134.42	55.4	3.06	5.06	66.5	15.2	23.0	64.9	14.0	21.3
LBW45	LBW45	69.34	70.0	4.21	7.23	73.9	10.7	15.7	70.9	9.0	13.6
LBW50+	LBW50, LBW55	27.41	49.4	0.37	0.69	60.0	2.7	3.9	60.0	2.7	3.9
LBW55	LBW55	14.39	56.7	0.36	0.58	69.1	2.8	3.9	69.1	2.8	3.9

Table 5 (cont.)
Change in CN Value and Flow Rates as a Result of Development

Combined Subbasin ID	Contributing Subbasins[1]	Total Area[2] (ac)	Forested Condition[2]			Pre 2002 Development Condition			Existing Condition (Development Post 2002)		
			Composite CN Value (100% Pervious)	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)	Pervious CN Value[3]	25-year Flow Rate (cfs)	100-year Flow Rate (cfs)
LBW60+	LBW60, LBW65	135.69	58.9	3.91	6.20	67.7	23.3	31.8	67.6	23.2	31.7
LBW65	LBW65	83.03	68.8	4.67	8.27	77.7	24.0	31.7	77.3	23.8	31.5
LBW70	LBW70	36.63	33.4	0.00	0.00	54.9	5.4	6.7	54.9	5.4	6.7
SN20	SN20	62.49	70.0	3.98	6.91	74.6	8.8	13.7	74.6	8.8	13.7
SS10+	SS10, SS20	220.69	70.4	13.27	22.24	75.9	31.5	46.5	75.5	30.8	45.6
LL10+	LL10, LL20, LL30, LL40, LL50, LL60, LL70, LL80	474.90	65.5	19.82	31.43	72.2	50.3	75.5	72.2	50.3	75.4
LL20	LL20	57.54	60.0	1.78	2.79	67.3	5.2	8.7	67.3	5.2	8.7
LL30+	LL30, LL40, LL50, LL60, LL70	300.78	63.9	11.57	18.35	71.2	34.3	51.8	71.1	34.3	51.7
LL40+	LL40, LL50, LL60, LL70	236.69	67.3	11.20	18.93	74.1	32.1	47.5	74.1	32.0	47.4
LL50	LL50	13.35	51.6	0.22	0.40	68.9	4.7	6.0	69.0	4.7	6.0
LL60	LL60	140.79	68.5	7.63	13.50	74.4	21.2	31.9	74.2	20.9	31.6
LL70	LL70	35.24	70.0	2.14	3.69	75.9	6.3	9.0	75.9	6.3	9.0
LL80	LL80	53.45	70.0	3.33	5.77	74.4	7.7	11.7	74.4	7.7	11.7

1. Percent indicating only portion of basin in case of diversion.
2. Assume that the basin boundaries are the same in all conditions and are delineated based on existing information.
3. Impervious CN Values are assumed to be 98 for HGS A, B, C, D and 100 for water cover.

Level Pool Routing

Level pool routing was applied to three areas that had significant storage areas that provide flow attenuation within the City's drainage system. These three areas are Lake Leota, a wetland/pond in subbasin LBW50, and a backwater condition upstream of subbasin LBE11. Level pool routing provides more realistic peak discharge results to the downstream pipes in these cases. Storage volumes were estimated using measurements in GIS. Discharge was approximated by the capacity of the outlet structure or natural channel.

Hydraulics

The stormwater pipe GIS database is a collection of several sources of data including: survey grade mapping by Otak, global positioning system (GPS) mapping by the City, visual inspections, and other sources. For most of the stormwater pipes, elevations and pipe depths were not available. Because of the lack of pipe depth and elevation data, a simplified hydraulic analysis was completed. The capacity of each pipe was analyzed using the methodology as presented in the Federal Highway Administration's (FHWA) HDS-5 (2005) publication. Assumptions include:

- Pipe length was set at 300 feet because accurate pipe lengths were unknown.
- Headwater depth allowed to reach three feet above the pipe crown (assumes three feet of cover).
- Tailwater set equal to the mid-point of the outlet of the pipe.
- The slope was set at 2% for pipes 24 inches and less, 1% for pipes between 24 and 48 inches, and 0.5% for pipes 48 inches and greater. Typically, these values forced a solution to inlet control.

The hydraulic capacities of pipes under these hydraulic assumptions were estimated and presented in Table 6.

Table 6
Typical Pipe Capacities

Pipe Size (in)	Capacity for smooth pipe (cfs)	Capacity for corrugated pipe (cfs)
12	5.8	3.3
15	10.2	5.9
18	16.2	9.5
24	30.2	20.3
30	47.3	30.0
36	70.9	48.0
42	98.5	71.7

Table 6 (cont.) Typical Pipe Capacities		
Pipe Size (in)	Capacity for smooth pipe (cfs)	Capacity for corrugated pipe (cfs)
48	128.5	89.3
54	169.0	120.7
60	212.5	158.3
72	316.7	251.7
84	445.3	371.1

Results

The city-wide hydraulic analysis compared the estimated pipe capacity and the calculated peak discharge for approximately 300 pipe locations within the City's drainage system. The analysis looks at both the 25-year and 100-year, 24-hour storm events.

The city-wide hydraulic analysis shows that approximately 25% of the analyzed pipes do not have sufficient capacity for the 24-hour, 25-year rainfall event. Approximately 27% of the analyzed pipes do not have sufficient capacity for the 24-hour, 25-year rainfall event and 37% in the 24-hour, 100-year rainfall event. The results of this analysis are presented in Appendix B and Figures 5 through 11. The discharges and capacities of the culverts along Little Bear Creek (presented in the technical memorandum by Otak dated July 11, 2008) have also been included in both the tabular and graphical results.

The areas of insufficient capacity are located throughout the City. However, some of the larger problem areas are in the Little Bear Creek culvert crossings, Woodin Creek basin, and upstream of Lake Leota.

While several of the capacity problems are associated with drainage complaints received from the public or City staff, the majority of the undersized pipes do not correlate to reported problem areas. Probable explanations may include:

- The design storm has a short duration and high intensity rainfall, so the pipe may be undersized for less than an hour during a 25-year event. This level of overflow may not be noticed by the public.
- The overflow may cause minor standing water that does not impede the traveled roadways or impact private property.
- Overflow routes may allow flood waters to spread out or flow harmlessly downstream, so they do not cause damage or other problems.

Recommendations

The results of the city-wide hydraulic analysis identify portions of the City's storm drainage pipes that appear to have inadequate conveyance capacity. Because the city-wide hydraulic analysis is an estimation of the conveyance capacity, we caution anyone from interpreting the results without appreciating the assumptions and methods used in the analysis.

- Do not include all undersized pipes on the CIP list. Be selective by choosing systems that:
  - Coincide with drainage complaints/City maintenance concerns.
  - Have a higher potential for damage when overtopping occurs.
  - Use rating/ranking system.
  - Current method is to list pipes that are >150% over capacity.
- When new developments connect to storm pipes that are already shown to be under capacity, require a downstream analysis to include refined analysis, such as survey of system.
- Continue to update City GIS database.
- For streets that will be reconstructed, upgrade culverts when shown as undersized.

These results are based on the GIS information available at the time of the analysis. Pipes showing inadequate conveyance capacity in this analysis should be evaluated using more detailed pipe information, such as pipe length and slope, invert elevations, depth of cover, backwater influences, and the interconnectivity of the surrounding drainage systems. In most cases, a detailed pipe network model should be developed as part of the engineering analysis associated with a capital project or system upgrade.

References

Department of Ecology (2001). Stormwater Management Manual for Western Washington.

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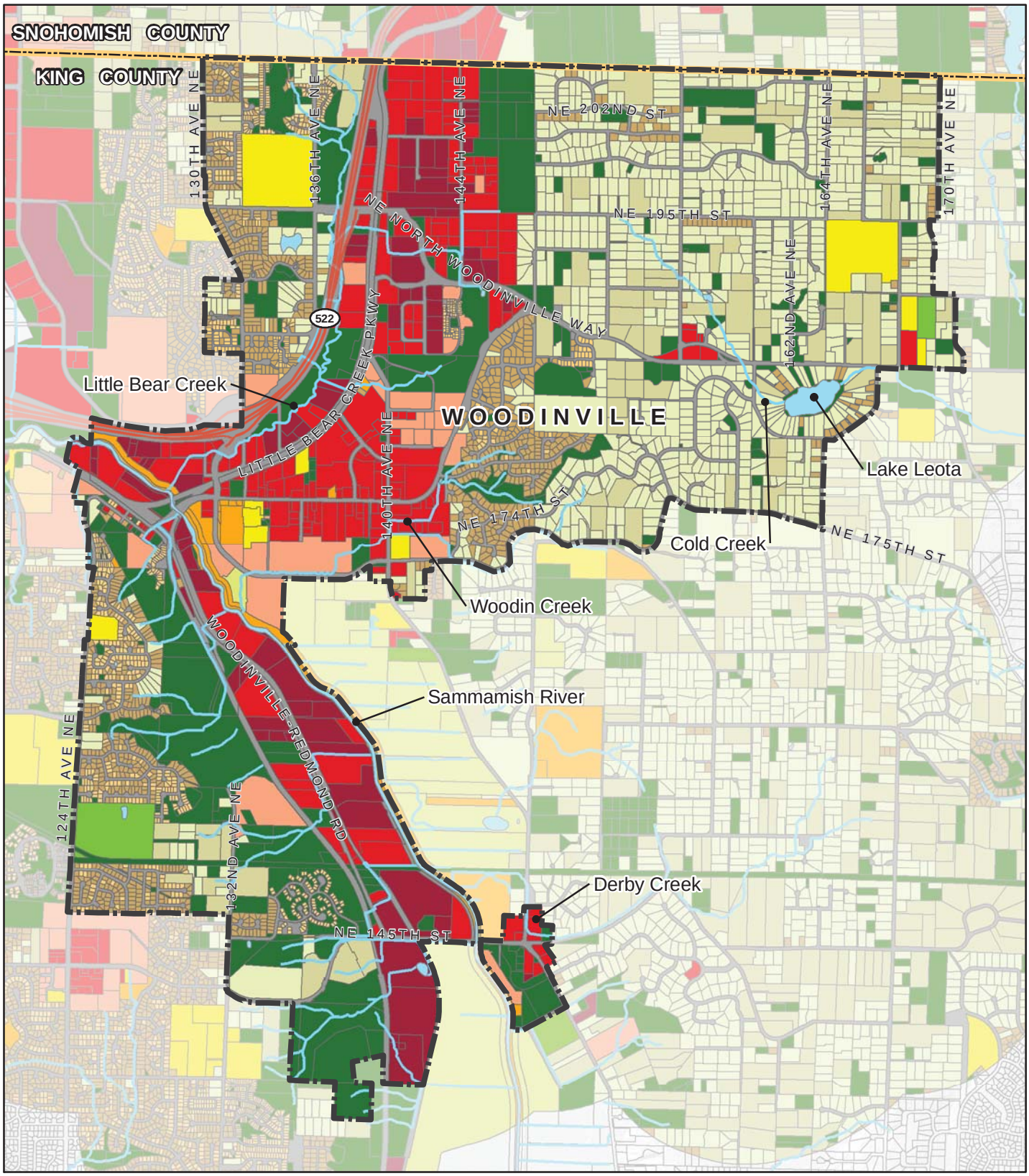
Figures



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LEGEND

- Streams
- Lake
- City Limits
- Parcel Boundary
- County Boundary

LAND USE

- Agriculture
- Commercial
- Greenhouse
- Industrial
- Multi Family
- Open Space
- Park/Recreation
- Public Institution
- ROW
- Single Family Residence (SFR) High
- SFR Low
- SFR Med
- SFR Rural

N

0 0.25 0.5 Miles

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc., from the City of Woodinville, King County GIS and from Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

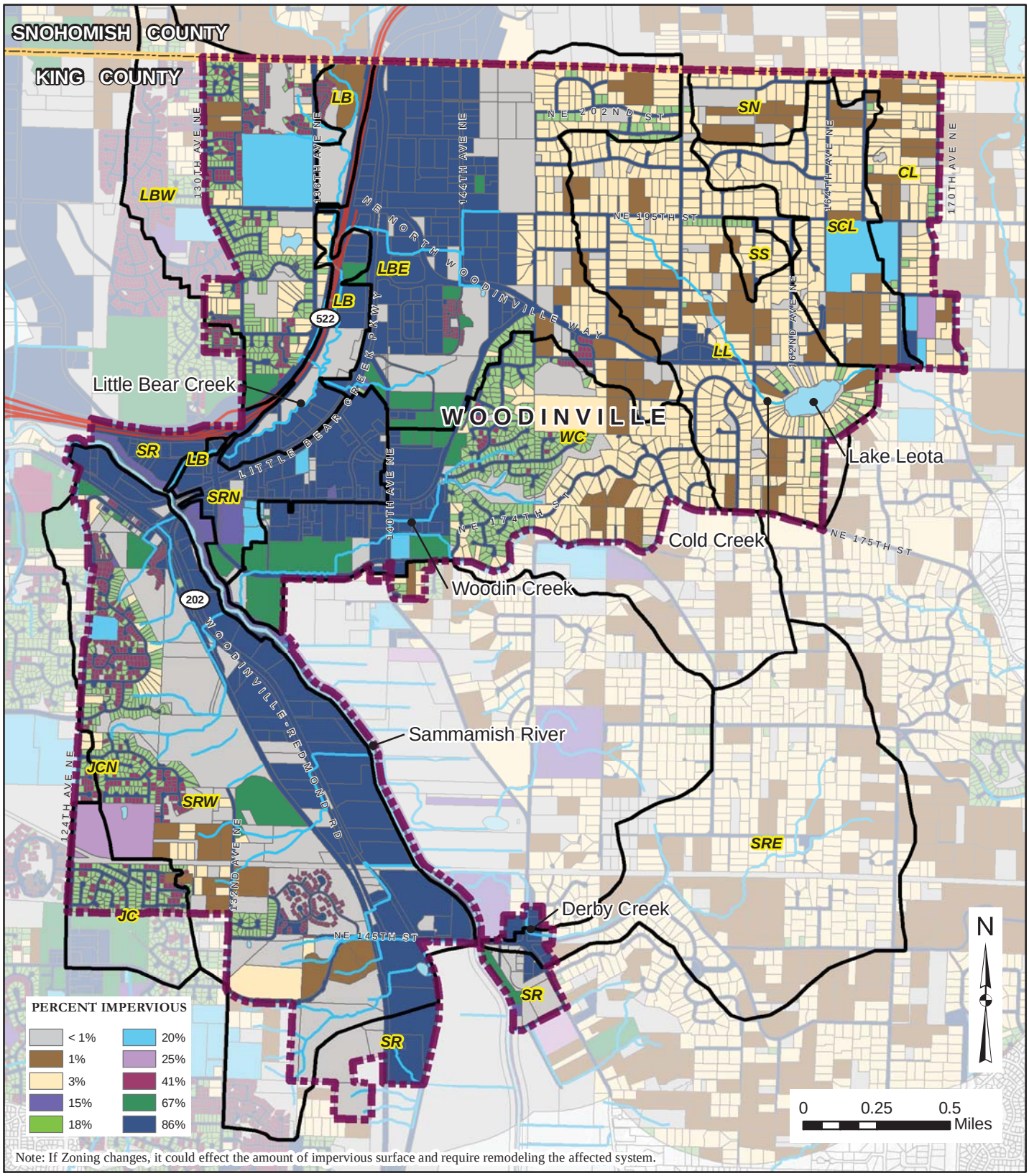
STORMWATER MANAGEMENT PLAN

FIGURE 1

EXISTING IMPERVIOUS SURFACE LAND DESIGNATION

CITY OF WOODINVILLE

MARCH 2010



Note: If Zoning changes, it could effect the amount of impervious surface and require remodeling the affected system.

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LEGEND

- City Limits
- County Boundary
- SR Subbasin Boundary
- Parcel Boundary
- Lake
- Streams

Basin Name and Abbreviation

Cottage Lake (CL)	School North (SN)
Juanita Creek (JC)	School South (SS)
Juanita Creek (JC)	Sammamish River (SR)
Little Bear (LB)	Sammamish River East (SRE)
Little Bear East (LBE)	Sammamish River North (SRN)
Little Bear West (LBW)	Sammamish River West (SRW)
Lake Leota (LL)	Woodin Creek (WC)

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc.(basin boundaries, future land use impervious area), from the City of Woodinville (city limits, hydrology,parcel boundaries,streets), King County GIS (county boundary,water bodies).
This data is not to survey accuracy and is meant for planning purposes only.

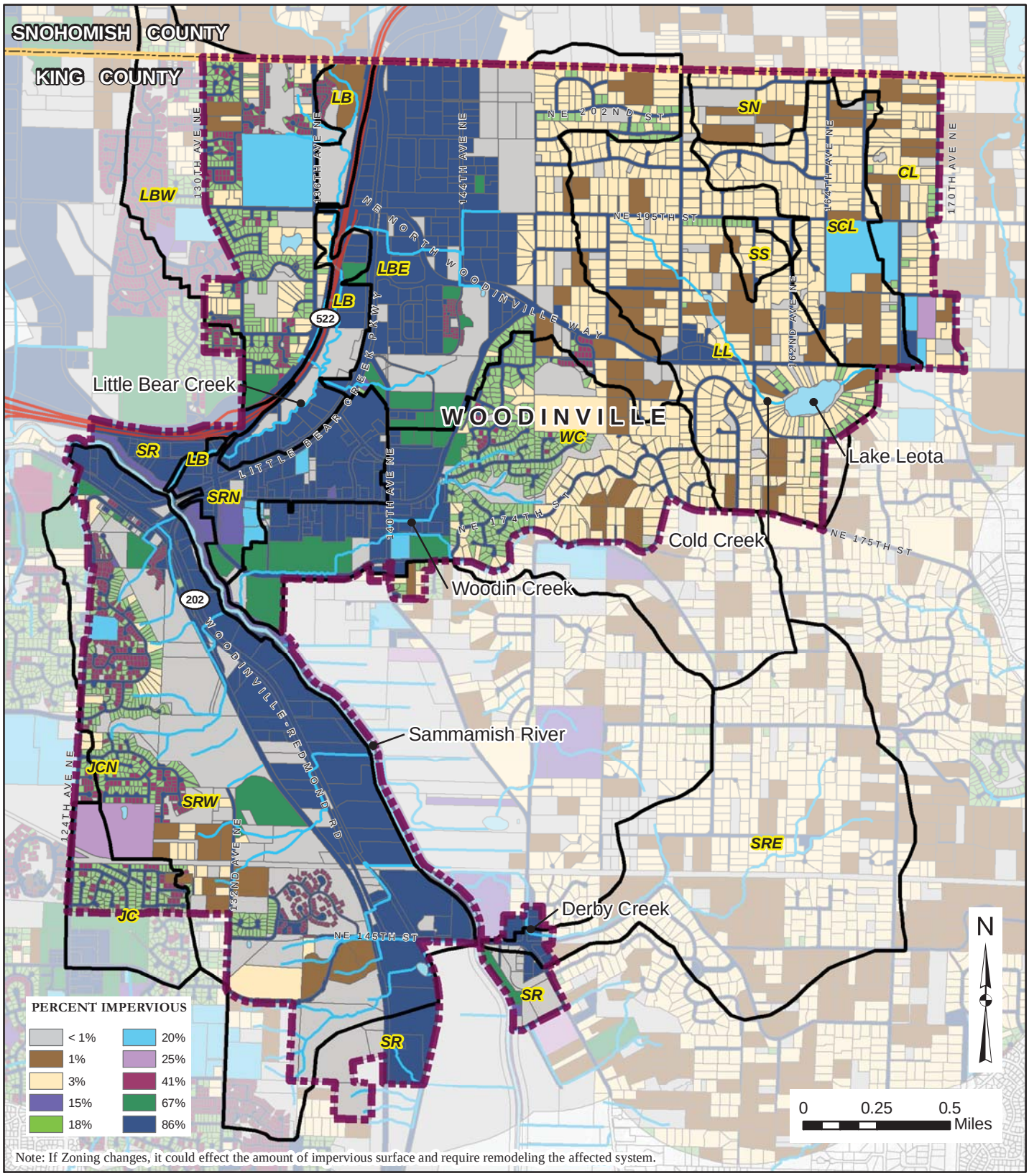
STORMWATER MANAGEMENT PLAN

FIGURE 2

FUTURE IMPERVIOUS PERCENT AREA

CITY OF WOODINVILLE

OCTOBER 2010



Note: If Zoning changes, it could effect the amount of impervious surface and require remodeling the affected system.

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LEGEND

- City Limits
- County Boundary
- SR Subbasin Boundary
- Parcel Boundary
- Lake
- Streams

Basin Name and Abbreviation

Cottage Lake (CL)	School North (SN)
Juanita Creek (JC)	School South (SS)
Juanita Creek (JC)	Sammamish River (SR)
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Little Bear East (LBE)	Sammamish River North (SRN)
Little Bear West (LBW)	Sammamish River West (SRW)
Lake Leota (LL)	Woodin Creek (WC)

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc.(basin boundaries, future land use impervious area), from the City of Woodinville (city limits, hydrology,parcel boundaries,streets), King County GIS (county boundary,water bodies).
This data is not to survey accuracy and is meant for planning purposes only.

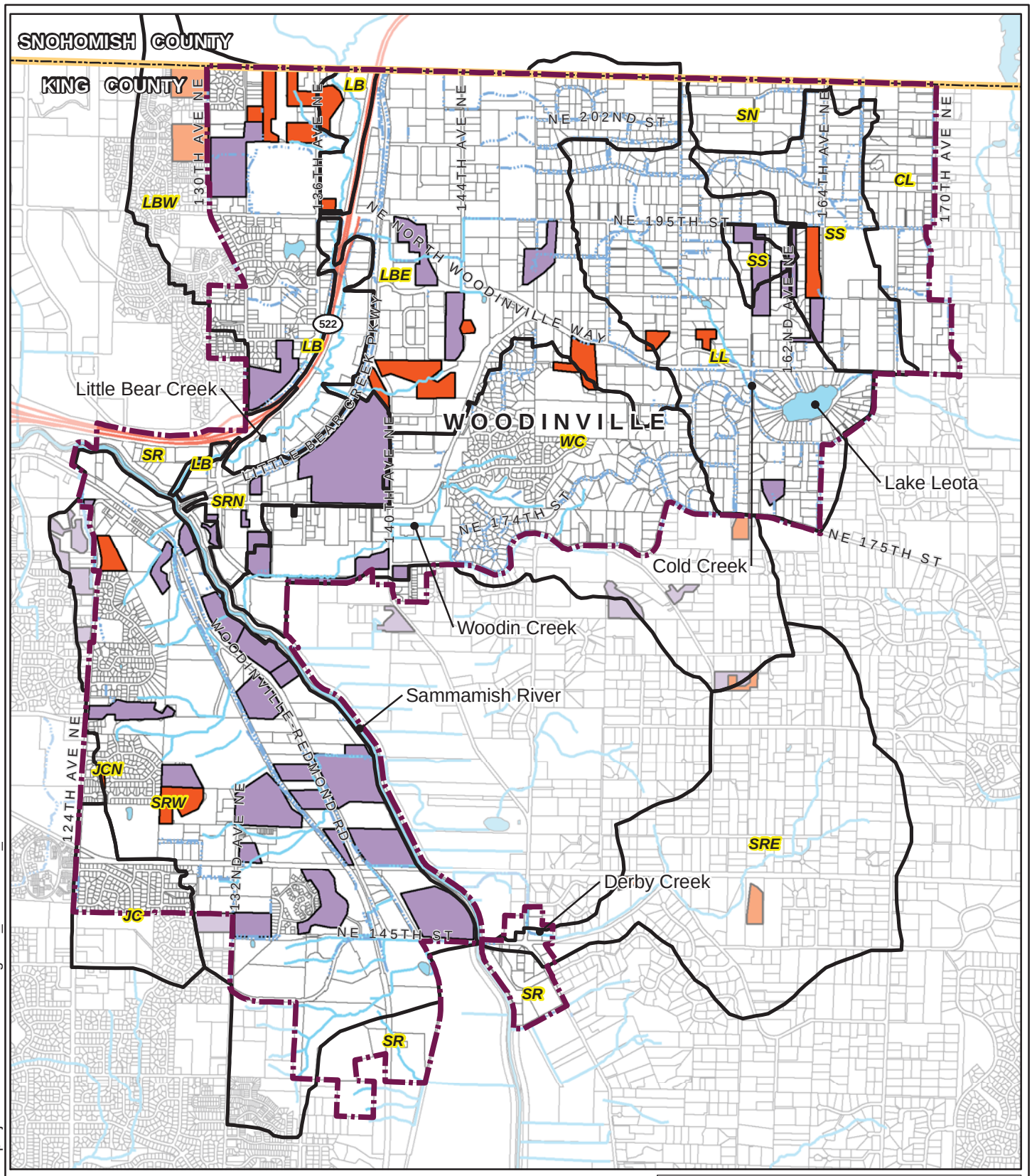
STORMWATER MANAGEMENT PLAN

FIGURE 2

FUTURE IMPERVIOUS SURFACE LAND DESIGNATION

CITY OF WOODINVILLE

OCTOBER 2010



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N

LEGEND

- City Limits
- County Boundary
- SR Subbasin Boundary
- Lake
- Streams

New Development

- New Development Between 1990 - 2002
- New Development After 2002
- Parcel Boundary

0 0.25 0.5 Miles

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc., from the City of Woodinville, King County GIS and from Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

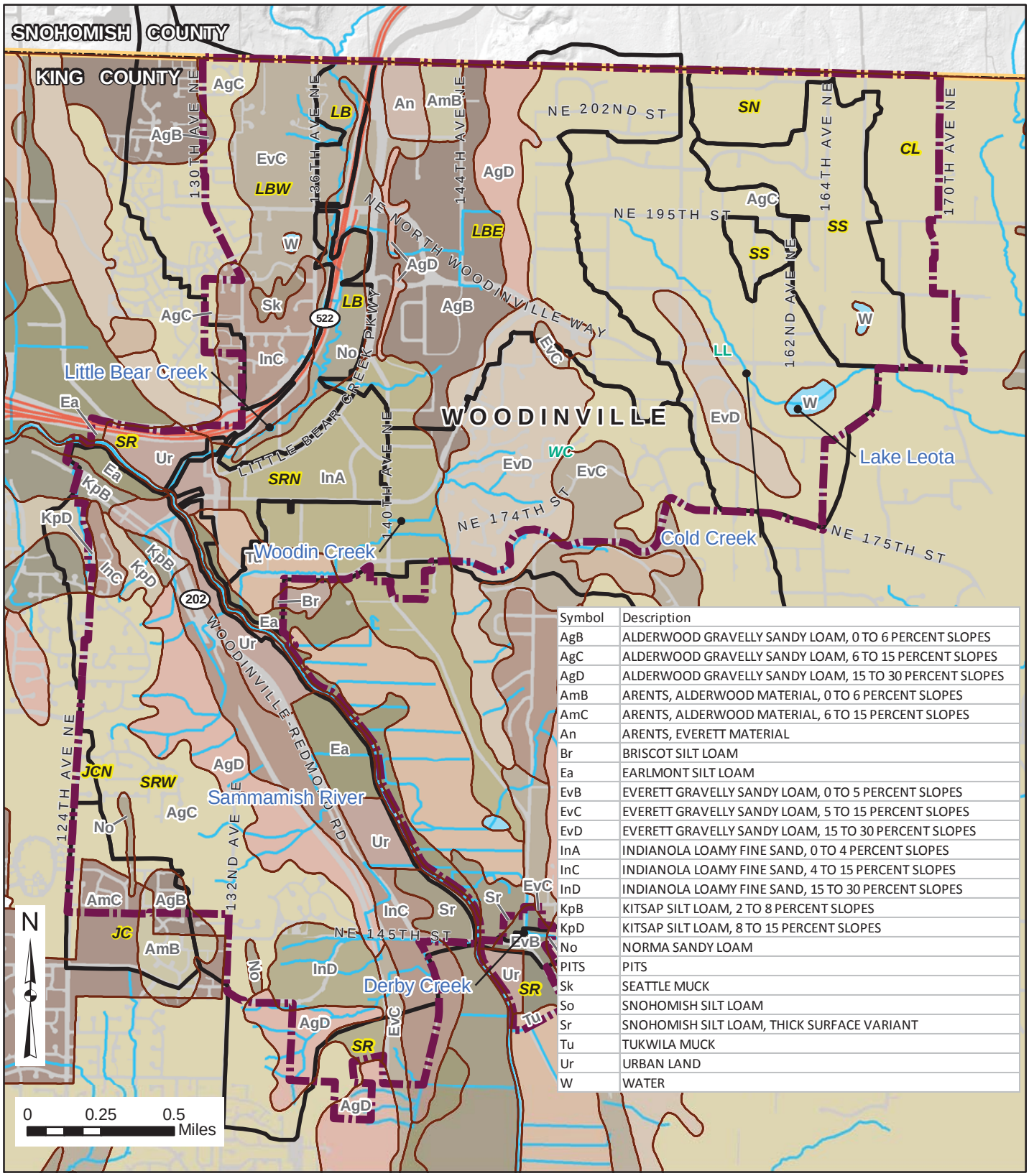
STORMWATER MANAGEMENT PLAN

FIGURE 3

NEW DEVELOPMENT AFTER 1990

CITY OF WOODINVILLE

OCTOBER 2010



Symbol	Description
AgB	ALDERWOOD GRAVELLY SANDY LOAM, 0 TO 6 PERCENT SLOPES
AgC	ALDERWOOD GRAVELLY SANDY LOAM, 6 TO 15 PERCENT SLOPES
AgD	ALDERWOOD GRAVELLY SANDY LOAM, 15 TO 30 PERCENT SLOPES
AmB	ARENTS, ALDERWOOD MATERIAL, 0 TO 6 PERCENT SLOPES
AmC	ARENTS, ALDERWOOD MATERIAL, 6 TO 15 PERCENT SLOPES
An	ARENTS, EVERETT MATERIAL
Br	BRISCOT SILT LOAM
Ea	EARLMONT SILT LOAM
EvB	EVERETT GRAVELLY SANDY LOAM, 0 TO 5 PERCENT SLOPES
EvC	EVERETT GRAVELLY SANDY LOAM, 5 TO 15 PERCENT SLOPES
EvD	EVERETT GRAVELLY SANDY LOAM, 15 TO 30 PERCENT SLOPES
InA	INDIANOLA LOAMY FINE SAND, 0 TO 4 PERCENT SLOPES
InC	INDIANOLA LOAMY FINE SAND, 4 TO 15 PERCENT SLOPES
InD	INDIANOLA LOAMY FINE SAND, 15 TO 30 PERCENT SLOPES
KpB	KITSAP SILT LOAM, 2 TO 8 PERCENT SLOPES
KpD	KITSAP SILT LOAM, 8 TO 15 PERCENT SLOPES
No	NORMA SANDY LOAM
PITS	PITS
Sk	SEATTLE MUCK
So	SNOHOMISH SILT LOAM
Sr	SNOHOMISH SILT LOAM, THICK SURFACE VARIANT
Tu	TUKWILA MUCK
Ur	URBAN LAND
W	WATER

K:/project/31324/GIS/mxds/Figures_H&Hmemo_Oct2010

LEGEND

- City Limits
- County Boundary
- Basin Boundary
- Highway
- Streams

Soil Type as Classified by NRCS

AgB, AgC, AgD, AmB, AmC, An, Br, Ea, EvB, EvC, EvD, InA, InC, InD, KpB, KpD, No, PITS, Sk, So, Sr, Tu, Ur, W

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc.(basin boundaries), from the City of Woodinville (city limits, hydrology,parcel boundaries,streets), King County GIS (county boundary,water bodies), NRCS soils data
This data is not to survey accuracy and is meant for planning purposes only.

STORMWATER MANAGEMENT PLAN

FIGURE 4

SOILS
(AS CLASSIFIED BY NRCS)

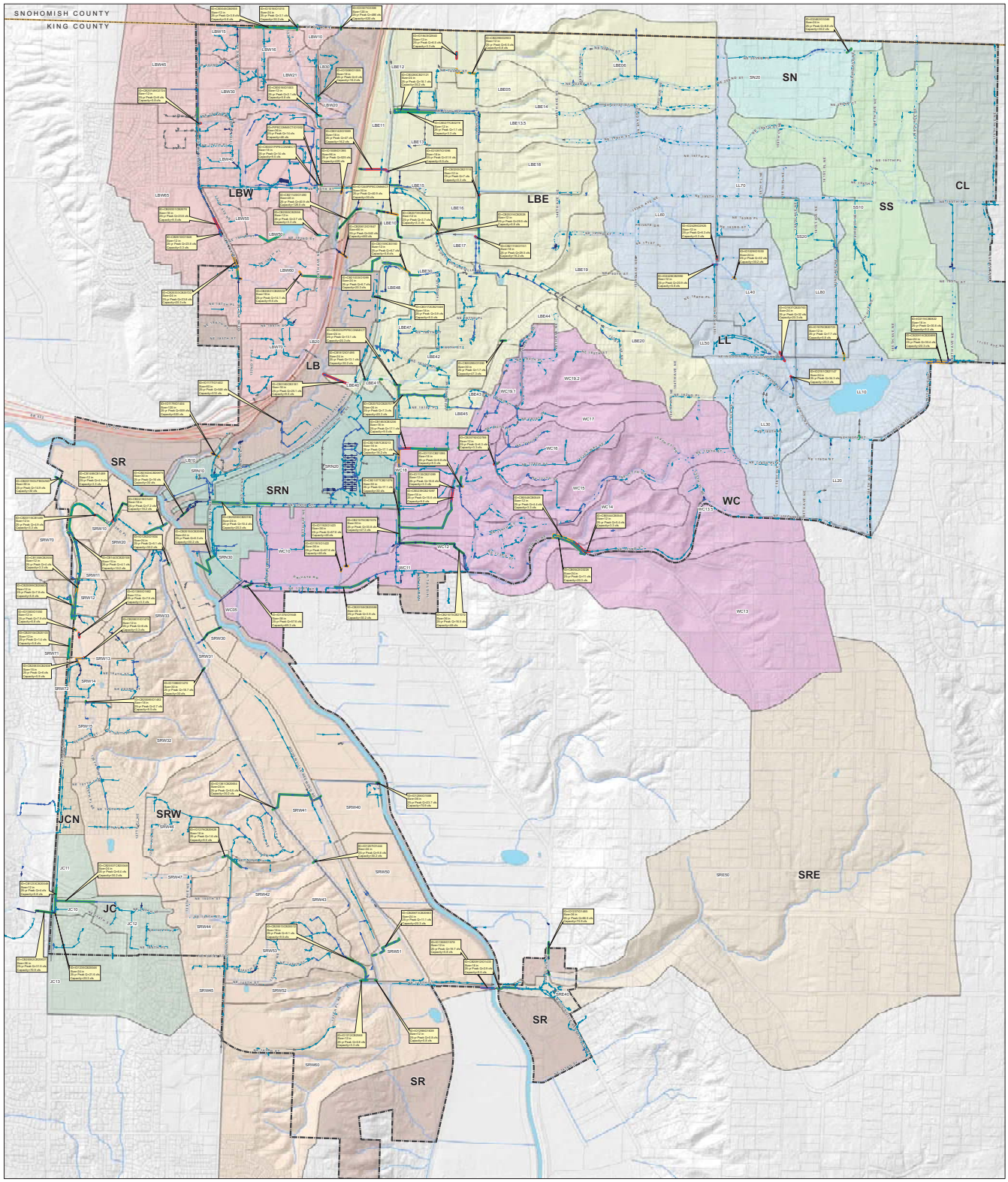
CITY OF WOODINVILLE

OCTOBER 2010

Woodinville SWM Plan Update
City of Woodinville, WA

City-Wide Hydraulics Map

April 2010



Legend

- Stream
- Stormwater Open Channel

City of Woodinville Stormwater Pipes 02/16/10

Size

- unknown size
- <= 12"
- <= 24"
- > 24"

Pipes Analyzed (25-yr percent capacity)

- 0% - 100%
- 101% - 150%
- 151% - 300%
- > 300%
- Woodinville City Limits
- Land Use (Revised by Otak 10/12/09)
- Waterbody

Subbasin Boundary

- Cottage Lake
- Jaunita Creek
- Jaunita Creek North
- Little Bear
- Little Bear East
- Little Bear West
- Lake Leota
- School North
- School River East
- Sammamish River
- Sammamish River North
- Sammamish River West
- School South
- Woodin Creek

N

1 inch = 500 feet

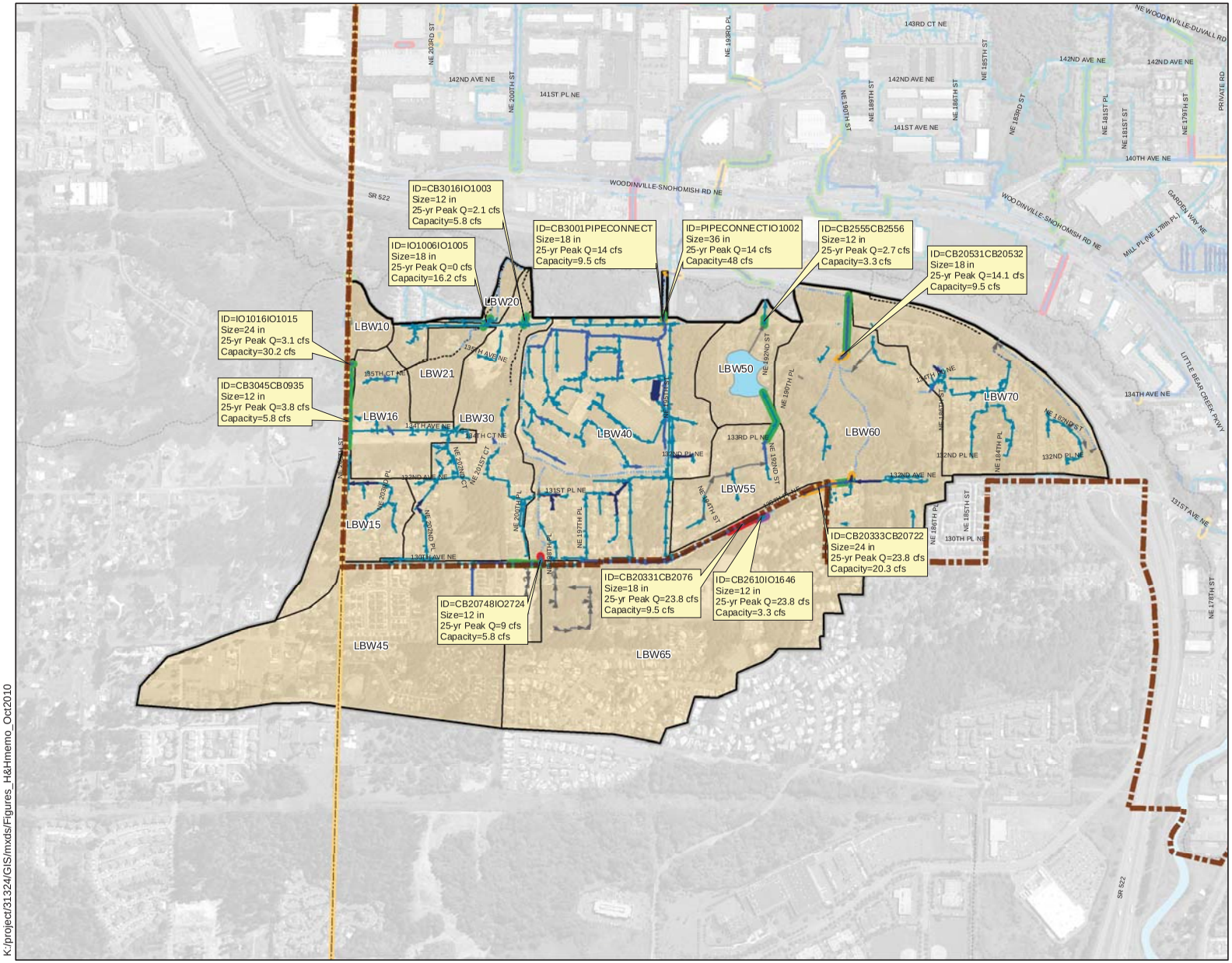
0 500 1,000 2,000 Feet

Disclaimer: The information shown is this map is assembled GIS data created and acquired by Otak inc. from the City of Woodinville, King County GIS and Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

City of Woodinville data received February 16, 2010

Notes:

1- 290 pipe segments were analyzed for hydraulic capacity based on the 25-year and 100-year events.
2- Discharges for all sub-basins shown were calculated using the Santa Barbara Urban Hydrograph (SBUH) methodology.
3- Composite curve numbers were estimated based on land use and soil type.
4- Detention in developments later than 1990 was accounted for by adjusting the curve number.
5- Pipe capacity was calculated for most pipe segments by assuming inlet control.
6- Headwater depth is assumed to be 3 feet above pipe crown.
7- Pipes are assumed to be free of debris.



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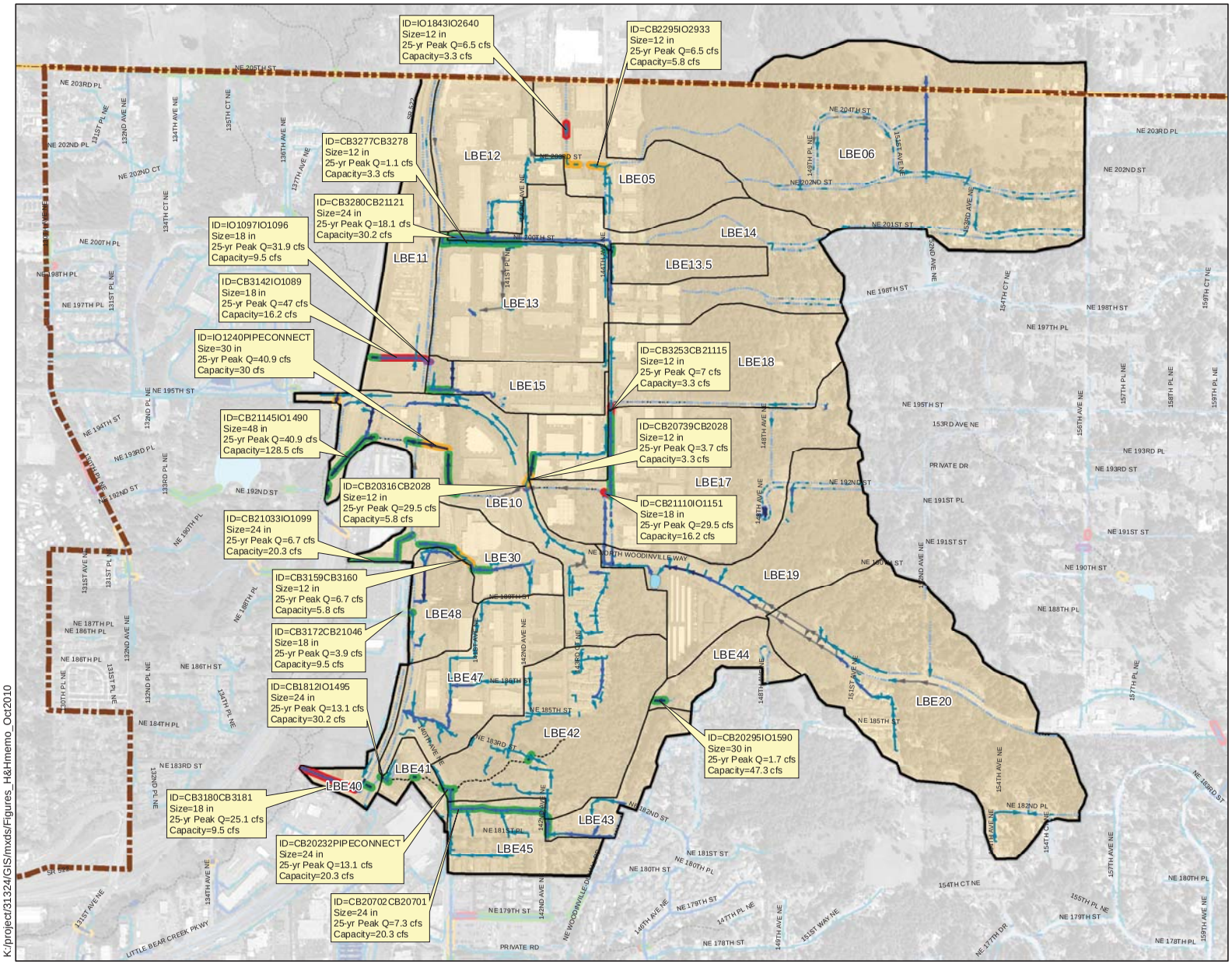


Legend

- Stream
- Stormwater Open Channel

City of Woodinville Stormwater Pipes 02/16/10

Size

- unknown size
- <= 12"
- <= 24"
- > 24"

Pipes Analyzed (25-yr percent capacity)

- Woodinville City Limits
- County Boundary
- Waterbody
- Little Bear East Basin
- LBE60 Little Bear East Subbasins

N

0 350 700 1,400 Feet

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc., from the City of Woodinville, King County GIS and Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

City of Woodinville data received Feb. 16, 2010. Aerial Imagery from 2005.

STORMWATER MANAGEMENT PLAN

FIGURE 7

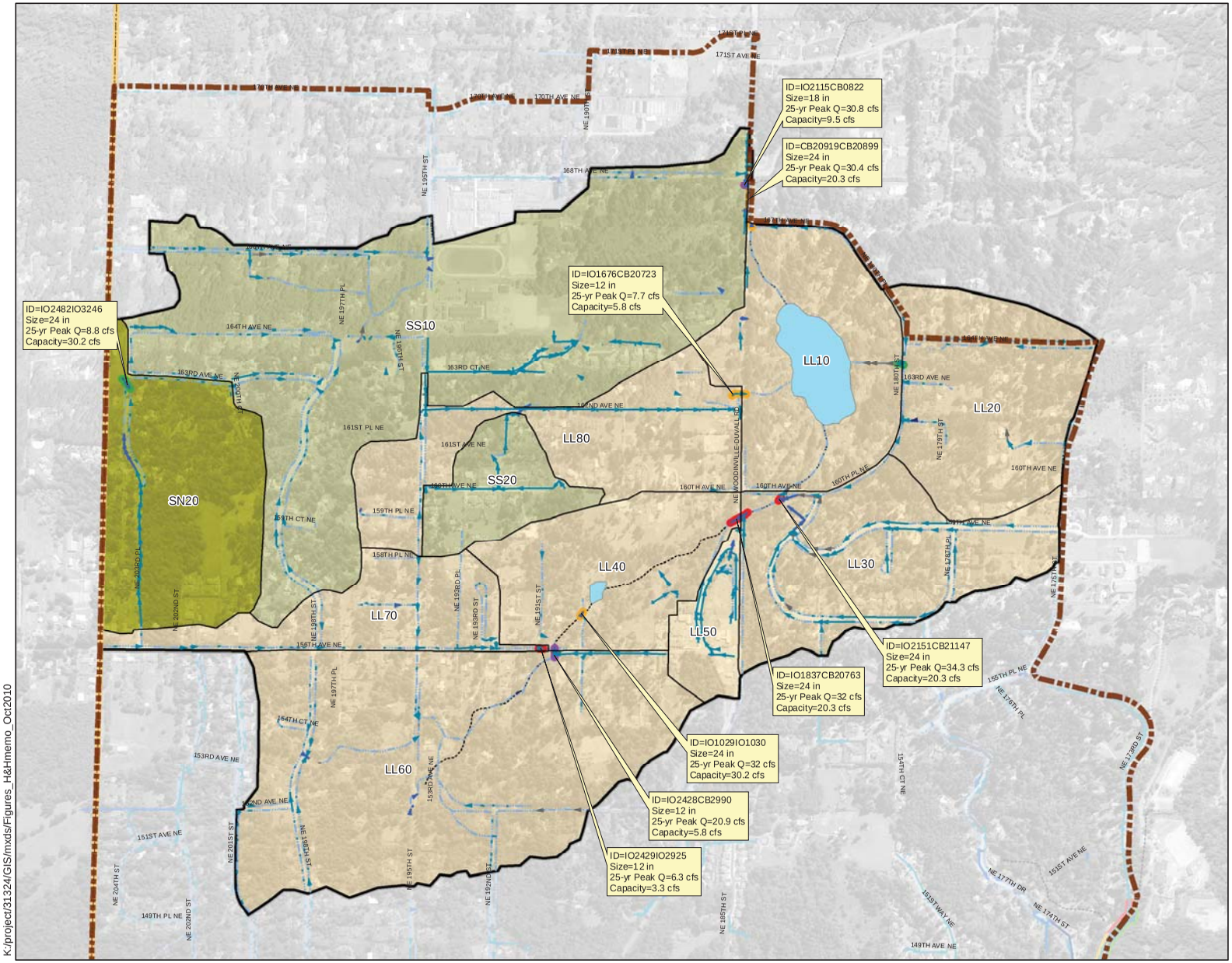
LITTLE BEAR EAST BASIN
CITY-WIDE HYDRAULIC ANALYSIS

CITY OF WOODINVILLE

otak

OCTOBER 2010

K:/project/31324/GIS/mxds/Figures_H&Hmemo_Oct2010



K:/project/31324/GIS/mxds/Figures_H&Hmemo_Oct2010

Legend

- Stream
- Stormwater Open Channel

City of Woodinville Stormwater Pipes 02/16/10

Size

- unknown size
- <= 12"
- <= 24"
- > 24"

Pipes Analyzed (25-yr percent capacity)

- 0% - 100%
- 101% - 150%
- 151% - 300%
- > 300%
- Woodinville City Limits
- Waterbody
- County Boundary
- School South Basin
- School North Basin
- Lake Leota Basin
- LL20 Lake Leota Subbasins and School South Subbasins

N

0 350 700 1,400 Feet

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc., from the City of Woodinville, King County GIS and Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

City of Woodinville data received Feb. 16, 2010. Aerial Imagery from 2005.

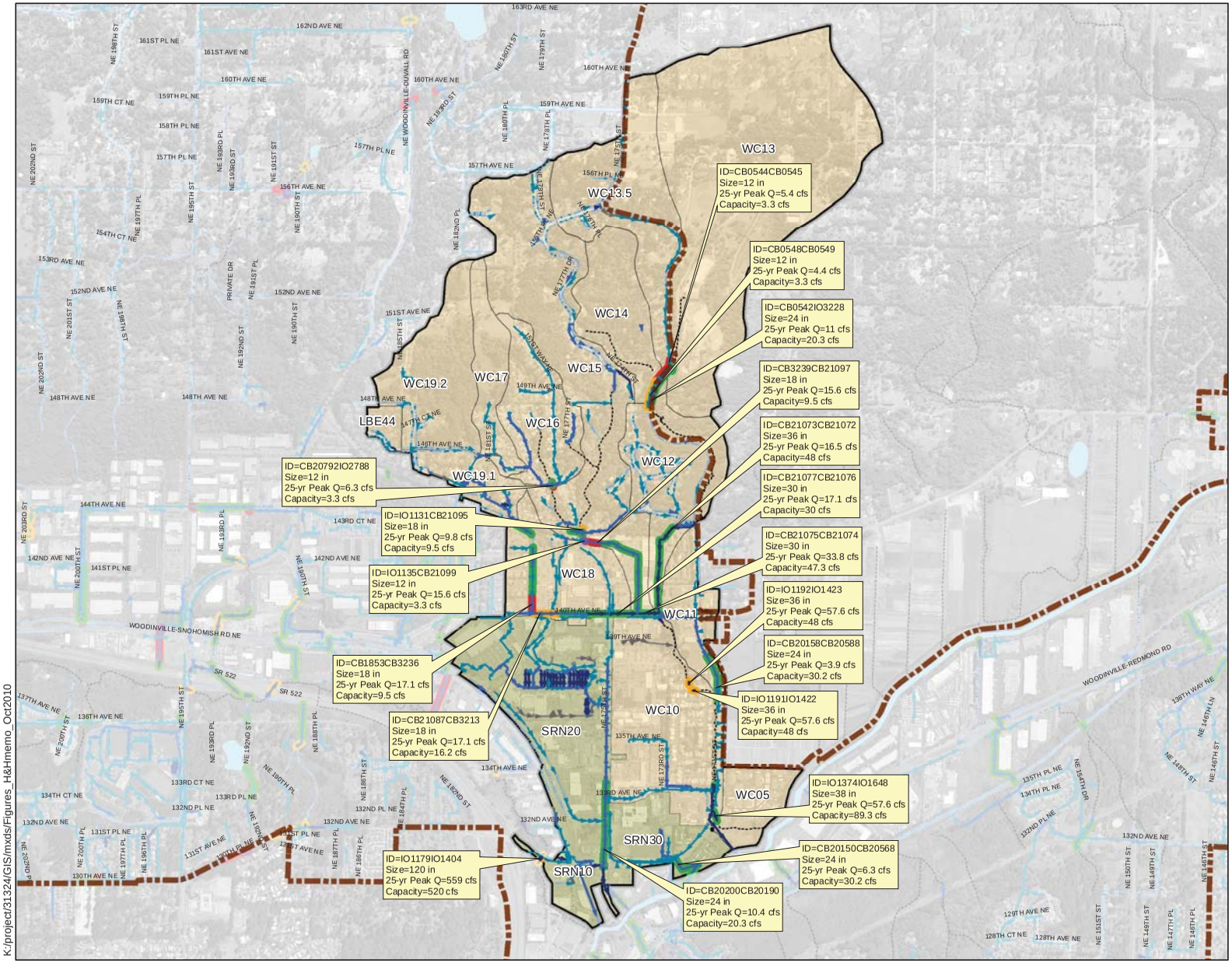
STORMWATER MANAGEMENT PLAN

FIGURE 8

LAKE LEOTA AND SCHOOL BASINS
CITY-WIDE HYDRAULIC ANALYSIS

CITY OF WOODINVILLE

OCTOBER 2010



Legend

- Stream
- Stormwater Open Channel

City of Woodinville Stormwater Pipes 02/16/10

Size

- unknown size
- <= 12"
- <= 24"
- > 24"

Pipes Analyzed (25-yr percent capacity)

- 0% - 100%
- 101% - 150%
- 151% - 300%
- > 300%
- Woodinville City Limits
- Waterbody
- County Boundary
- Sammamish River North Basin
- Woodin Creek Basin
- WC16 Sammamish River North Subbasins and Woodin Creek Subbasins

N

0 350 700 1,400 Feet

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc., from the City of Woodinville, King County GIS and Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

City of Woodinville data received Feb. 16, 2010. Aerial Imagery from 2005.

STORMWATER MANAGEMENT PLAN

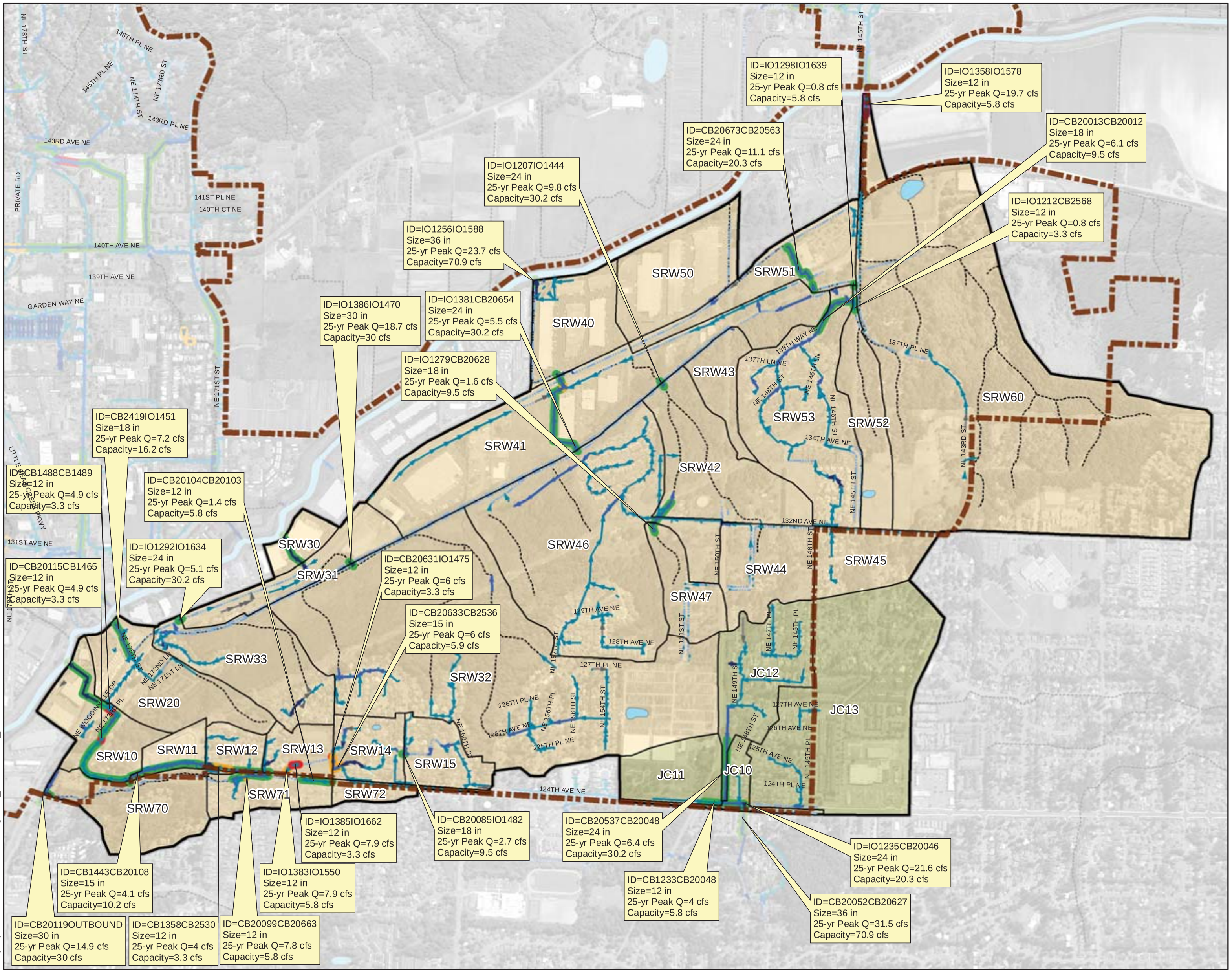
FIGURE 9

WOODIN CREEK AND SAMMAMISH RIVER NORTH BASINS CITY-WIDE HYDRAULIC ANALYSIS

CITY OF WOODINVILLE

OCTOBER 2010

K:/project/31324/GIS/mxds/Figures_H&Hmemo_Oct2010



Legend

- Stream
- Stormwater Open Channel

City of Woodinville Stormwater Pipes 02/16/10

Size

- unknown size
- <= 12"
- <= 24"
- > 24"

Pipes Analyzed (25-yr percent capacity)

- 0% - 100%
- 101% - 150%
- 151% - 300%
- > 300%
- Woodinville City Limits
- Waterbody
- County Boundary
- Juanita Creek Basin
- Sammamish River West Basin
- SRW44 Juanita Creek Subbasins and Sammamish River West Subbasins

N

0 350 700 1,400 Feet

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc., from the City of Woodinville, King County GIS and Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

City of Woodinville data received Feb. 16, 2010. Aerial Imagery from 2005.

STORMWATER MANAGEMENT PLAN

FIGURE 10

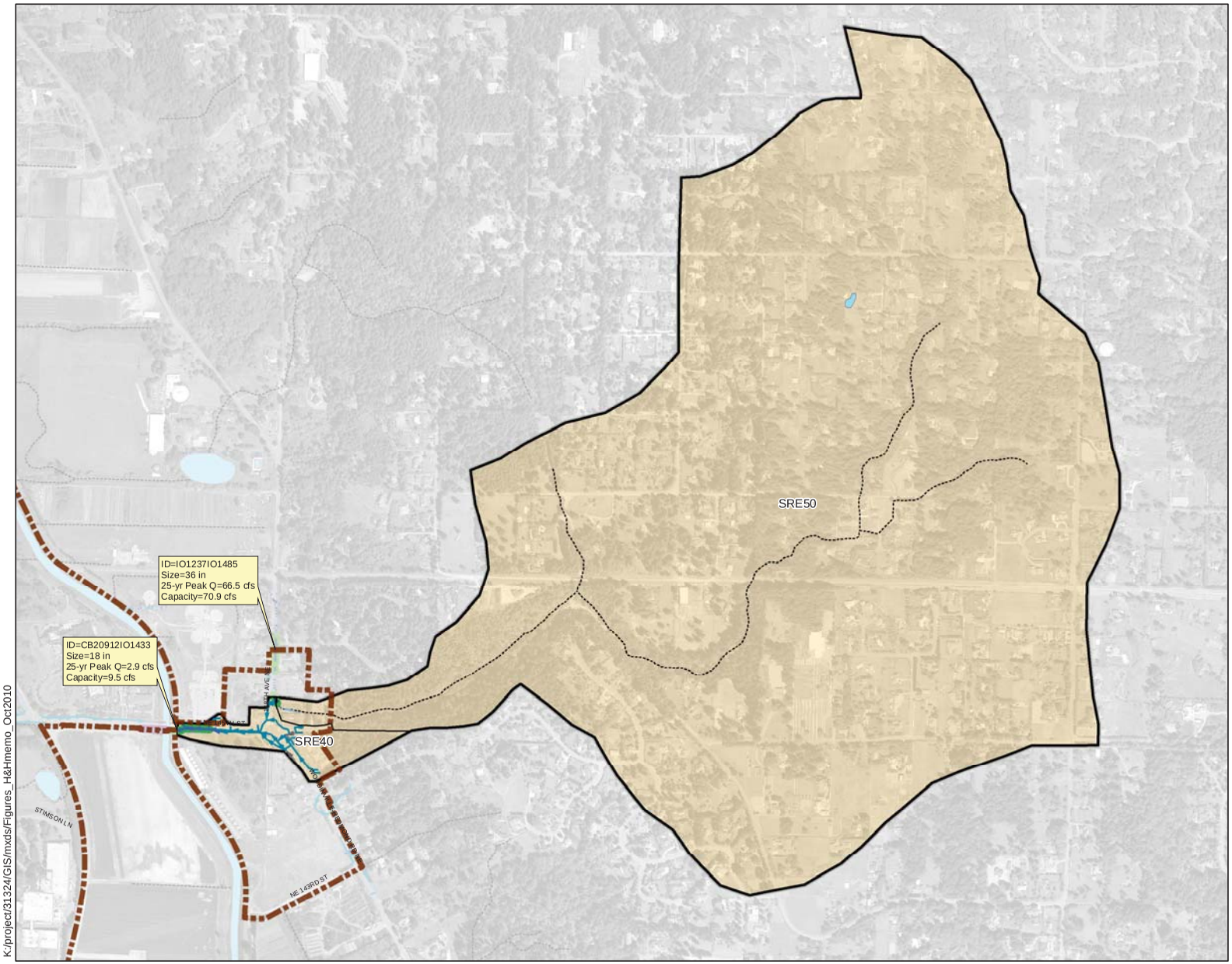
SAMMAMISH RIVER WEST AND JUANITA CREEK BASINS CITY-WIDE HYDRAULIC ANALYSIS

CITY OF WOODINVILLE

otak

OCTOBER 2010

K:/project/31324/GIS/mxds/Figures_H&Hmemo_Oct2010



Legend

- Stream
- Stormwater Open Channel

City of Woodinville Stormwater Pipes 02/16/10

Size

- unknown size
- <= 12"
- <= 24"
- > 24"

Pipes Analyzed (25-yr percent capacity)

- 0% - 100%
- 101% - 150%
- 151% - 300%
- > 300%
- Woodinville City Limits
- Waterbody
- County Boundary
- Sammamish River East Basin
- SRE50 Sammamish River East Subbasins

N

0 350 700 1,400 Feet

Disclaimer: The information shown in this map is assembled GIS data created and acquired by Otak Inc., from the City of Woodinville, King County GIS and Snohomish County GIS. This data is not to survey accuracy and is meant for planning purposes only.

City of Woodinville data received Feb. 16, 2010. Aerial Imagery from 2005.

STORMWATER MANAGEMENT PLAN

FIGURE 11

SAMMAMISH RIVER EAST BASIN
CITY-WIDE HYDRAULIC ANALYSIS

CITY OF WOODINVILLE

OCTOBER 2010

K:/project/31324/GIS/mxds/Figures_H&Hmemo_Oct2010

Appendix A—Little Bear Creek at Woodinville Flood Analysis Memorandum (Otak, 2008)

Memorandum

10230 NE Points Drive
Suite 400
Kirkland, WA 98033
Phone (425) 822-4446
Fax (425) 827-9577

To: Richard A. Leahy, City of Woodinville
Thomas E. Hansen, PE, City of Woodinville

From: Scott Stoneman, PE
Greg Laird, PE

Copies:

Date: July 11, 2008

Subject: Little Bear Creek at Woodinville Flood Analysis

Project No.: 31210

Introduction

Woodinville was one of the areas in the region hit hardest by the December 3, 2007 storm. Flood waters from Little Bear Creek caused property damage and forced road closures of city street and highways SR-522 and SR-202 when the creek overtopped the roads. The City of Woodinville desires to know the cause of the flooding and if action in their part is needed to reduce future flooding.

This memo provides a hydraulic/hydrologic investigation of the December 3, 2007 Little Bear Creek flood event within the City of Woodinville. This investigation provides an estimation of the design capacity of five culvert crossings within the City of Woodinville, the estimated peak flow of the flood event, the recurrence interval of the flood, a flood delineation map, and provides recommendations for which culvert should be replaced.

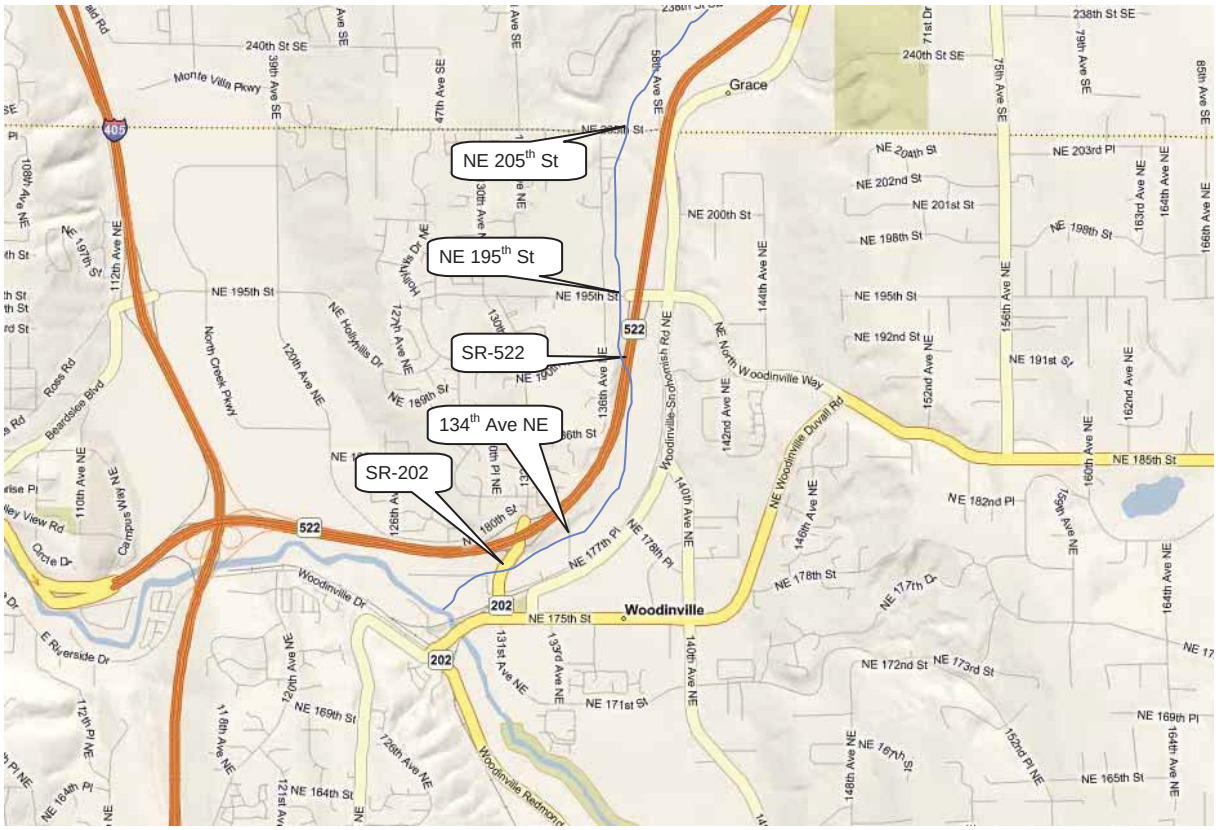
Existing Culvert Capacity

Five culverts along Little Bear Creek were analyzed for their design capacity. The culverts starting upstream at the Snohomish County/City of Woodinville boundary include the crossings at NE 205th Street, NE 195th Street, SR-522, 134th Avenue NE, and SR-202 (Figure 1).

Dimensions, materials, and inlet configurations data were collected for each culvert. During the site visit, the height to backwater overflow, relative to the culvert invert, was surveyed. The overflow is the lowest elevation in which water can flow through an alternate route than the culvert, such as over a road, or in the case of the SR-202 culvert, over the adjacent parking lot.

Invert and overflow heights were then roughly adjusted to match the NAVD88 datum by use of 2003 King County LIDAR mapping. In each case, the overflow measurement was set to elevation found on the LIDAR map. The overflow measurement was used because the road surfaces are much more accurate than the creek bottom on the LIDAR mapping.

Figure 1 – Vicinity Map



To estimate the water surface elevations resulting from the specific stream flow discharges in Little Bear Creek, a HEC-RAS model was then constructed to include all five culverts. The elevations of the culvert inverts and roadways plus the culvert dimensions were included in the HEC-RAS model. To reflect the geometry of the creek in the model, one channel section was approximated and used for the entire reach. The channel is not critical, since the culverts are the constricting elements of the Little Bear Creek system. The assumption was borne out, since the model indicates the culverts are inlet controlled, which means that the capacity of the culverts to convey stream flows is limited by how well the stream flow enters the culvert, as opposed to the depth of water at the culvert outlet, or the friction within the culvert.

For reference, the WSDOT Hydraulics Manual requires that culverts be designed so that the headwater to depth (HW/D) ratio should be less than 1.25 for the 25-year event. WSDOT also requires that no overtopping of the traveled roadway can occur during the 100-year event. Table 1 presents each of the five culvert's capacity rating for both the 25- and 100-year events based on the surveyed data and the HEC-RAS model.

Table 1 Estimated Capacity of the Existing Culverts					
Location	Size/Type	Cross-sectional area (sf)	25-yr Design Capacity – 1.25 HW/D (cfs)	Height to Overflow (ft)	100-yr Design Capacity – Overtopping (cfs)
NE 205th Street	6' high x 10' wide concrete box	60	520	12	830
NE 195th Street	(2) 4' high x 7' wide concrete box	56	420	6	460
SR-522	(2) 5.2' high x 7' wide CMP arch	56	460	7	500
134th Avenue NE	(3) 5' diameter concrete pipe	59	510	10	820
SR-202	6' high x 10' wide concrete box	60	520	9	620

The NE 195th Street has the least capacity of the five culverts, likely resulting in the most frequent flooding of the five culverts. The NE 205th Street and 134th Avenue NE culverts have the greatest capacities for the 100-year event and likely result in the least frequent flooding.

Peak Discharge Estimates

The 2- through 100-year discharge rates have been estimated for Little Bear Creek down to NE 205th Street by Snohomish County. The discharge rates were calculated using a calibrated HSPF model of the basin within Snohomish County based on 2003 existing land use.

Discharges were then estimated at each of the downstream culverts by assuming that the discharge increases proportionally to the increase of tributary drainage area. Tributary drainage areas were taken from *King Co. Watershed Modeling Services - Green River Water Quality Assessment, and Sammamish-Washington, Analysis and Modeling Program Watershed Modeling Calibration Report*. Table 2 presents the approximate tributary drainage basin area at each of the culverts and the corresponding discharge based on the NE 205th Street culvert discharge.

Table 2 Statistical Peak Discharges				
Location	Drainage Area (acres)	Basin Size Ratio	25-yr Discharge (cfs)	100-yr Discharge (cfs)
NE 205th Street	8,508	100%	486	658
NE 195th Street	9,185	108%	525	710
SR-522	9,462	111%	540	732
134th Avenue NE	9,594	113%	548	742
SR-202	9,781	115%	559	756

Table 3 compares the statistical flood discharges (Table 2) to the culvert capacities (Table 1). Note that four of the five culverts are undersized for either the 25- or 100-year events or both. The only culvert that meets both the 25- and 100-year criteria is the NE 205th Street culvert. Furthermore, as

the Little Bear Creek subbasin becomes more built-out in the future, the peak flows will increase causing the culverts to flood more frequently.

Table 3
Comparison of Statistical Peak Discharges to Culvert Capacity

Location	25-yr			100-yr		
	Statistical Peak Discharge (cfs)	Design Capacity (cfs)	Percent of Design Capacity	Statistical Peak Discharge (cfs)	Design Capacity (cfs)	Percent of Design Capacity
NE 205th Street	486	520	93%	658	830	79%
NE 195th Street	525	420	**125%**	710	460	**154%**
SR-522	540	460	**117%**	732	500	**146%**
134th Avenue NE	548	510	**107%**	742	820	90%
SR-202	559	520	**108%**	756	620	**122%**

Bold indicates that culvert is undersized.

December 3, 2007 Flood Discharge

The discharge of flood events can most readily be estimated by measuring high water marks at locations upstream of where the stream is confined through a controlling section, for instance, upstream of a culvert or a bridge. It is also important that the culvert or bridge does not overtop because the discharge is then very sensitive to the water surface elevation.

Snohomish County collected photos and eyewitness accounts of the flooding that occurred at the NE 205th Street culvert. Water backed up behind the culvert and flooded the neighbor's house; however, it did not overtop the roadway. The water was said to have come within two feet of the top of the roadway.

HEC-RAS modeling indicates that a water surface two feet below the roadway results in a discharge of approximately 710 cfs. Further refinement of this peak discharge estimate may include making an appointment with the adjacent homeowner and surveying the high-water marks on the house shown on the photographs and creek cross-sections in the area.

Discharge was then estimated at each of the downstream culverts by assuming that the discharge increases proportionally to the increase of tributary drainage area, similarly to above. Table 4 presents the discharge based on the NE 205th Street culvert estimated discharge of 710 cfs.

Table 4 December 3, 2007 Estimated Flood Discharge			
Location	December 3, 2007 Estimated Discharge (cfs)	100-yr Design Capacity - Overtopping (cfs)	Percent of Design Capacity
NE 205th Street	710	830	86%
NE 195th Street	766	460	**167%**
SR-522	790	500	**158%**
134th Avenue NE	801	820	98%
SR-202	816	620	**132%**

Bold indicates that culvert is undersized.

Table 4 also compares the December 3, 2007 estimated flood discharges to design capacities of the culverts. Note that three of the five culverts overtopped during the December 3, 2007 event. Only the culverts at NE 205th Street and 134th Avenue NE did not overtop, which concurs with reporting and evidence.

A stump was reported to have clogged the SR-202 culvert. This exacerbated the flood problem and sent additional water down SR-202, under the railroad trestle, and beyond. Our modeling indicates that even if the culvert was not clogged, water would have overtopped the landscape area south of this culvert and then over the adjacent parking lot.

December 3, 2007 Flood Recurrence Interval

As stated above, the 2- through 100-year discharge rates have been estimated for Little Bear Creek down to NE 205th Street by Snohomish County. The estimated 100-year discharge rate for current land use at the NE 205th Street culvert is 658 cfs. Based solely on the reported high water level relative to NE 205th Street, the December 3, 2007 event is estimated at 710 cfs, which is 8% greater. Note that there are inherent uncertanties associated with both the estimated discharge for the December 3, 2007 flood event based on the reported high water level and the estimated discharge for the 100-year event based on the HSPF model completed in 2003. By these discharge estimates, the December 3, 2007 event can be said to be approximately the 100-year event.

The Office of the Washington State Climatologist (OWSC) has written a report on the December 2007 Record Flooding. OWSC described the contribution of three storms that hit the Puget Sound area. On December 1, snow fell throughout western Washington. On December 2, the snow changed to rain, and wind between 40 and 50 mph was observed between Olympia and Bellingham. On December 3, near record rainfall occurred around western Washington. The rain gage closest to Woodinville is operated by a private citizen and recorded 3.43 for December 3 and 4.89 for the period of December 1 through 4. Other gages nearby have similar values. According to data compiled by King County Surface Water Design Manual (2005), the 25-year, 24-hour precipitation ranges from 3.0 to 3.2 inches in the Woodinville vicinity and the 100-year, 24-hour precipitation

ranges from 3.7 to 3.8 inches. This shows that the December flood event was a result of a precipitation event greater than the 25-year 24-hour precipitation. However, the 1.27 to 1.54 inches of precipitation (rain and snow) that fell in the area on December 1 and 2 saturated the area's soils causing the December 3 precipitation to produce greater amounts of runoff than if the December 3 storm had occurred by itself. For example, a runoff curve number of 75 (low density urban area in good draining soils) will behave more like a CN of 88 with a wet antecedent condition. This equates to a 76 percent increase in the runoff generated by the 3.4 inch storm. For a CN of 85 (medium density urban areas with slow infiltrating soils) will behave more like a CN of 94. This equates to a 47 percent increase in the runoff generated by the 3.4 inch storm.

Therefore, the wet days of weather preceding the December 3 event likely caused at least a 25 percent increase in runoff and more likely over a 50 percent increase in runoff.

Flood Delineation Map

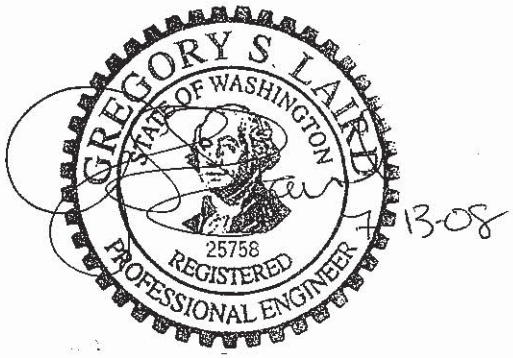
A flood delineation map was approximated for the December 3, 2007 event (Figure 2). The delineation map was created in GIS by overlaying the HEC-RAS water surface onto the LIDAR bare earth surface. The two surfaces were subtracted, using GIS, resulting in a new surface representing the water depth. Positive water depths were taken as flooded areas. Flood boundaries were then redrawn with engineering judgment using the modeled flood delineation as a guide.

Conclusion

The December 2007 flood was the largest flood on record for Little Bear Creek. It is approximately the 100-year recurrence interval. The high discharge was a result of an unusually large amount of precipitation and continuing increase of development in the tributary basin. The five culvert crossings analyzed were subjected to peak discharges greater than typically designed for, and resulted in overtopping of three of the five culvert crossings. All of the culverts except for the one at NE 205th Street are shown to be undersized by WSDOT design standards.

There has been some concern raised that development in the Little Bear Creek basin may have contributed to increase in flooding. Converting a rural basin to more residential and commercial land use will increase the amount of runoff from storm events. However, recent storm water management standards have required flow control facilities be installed to reduce the amount of runoff caused by increased amounts of impervious surfaces. In Snohomish County, these flow control facilities are designed to limit the peak discharges from developed to pre-developed conditions. In the Little Bear Creek basin, the Highway 9 widening and the Brightwater Wastewater Treatment facility are two significant developments to have occurred in recent years. These developments have flow control facilities and there were no reported failures of these facilities during the December events.

The culvert crossings at NE 195th Street, SR-522, 134th Avenue NE, and SR-202 need increased capacity in order to meet current hydraulic design criteria and to reduce the flooding problems. Increasing the capacity at these crossings will require either retrofitting or replacing the culverts. The culvert improvements will need to meet Washington State Department of Fish and Wildlife guidelines, which typically include constructing an oversized culvert that spans more than the width of the creek. Note that the NE 195th Street and 134th Avenue NE culverts are owned by the City of Woodinville, where the SR-522 and SR-202 are within the Washington State Department of Transportation right-of-way.



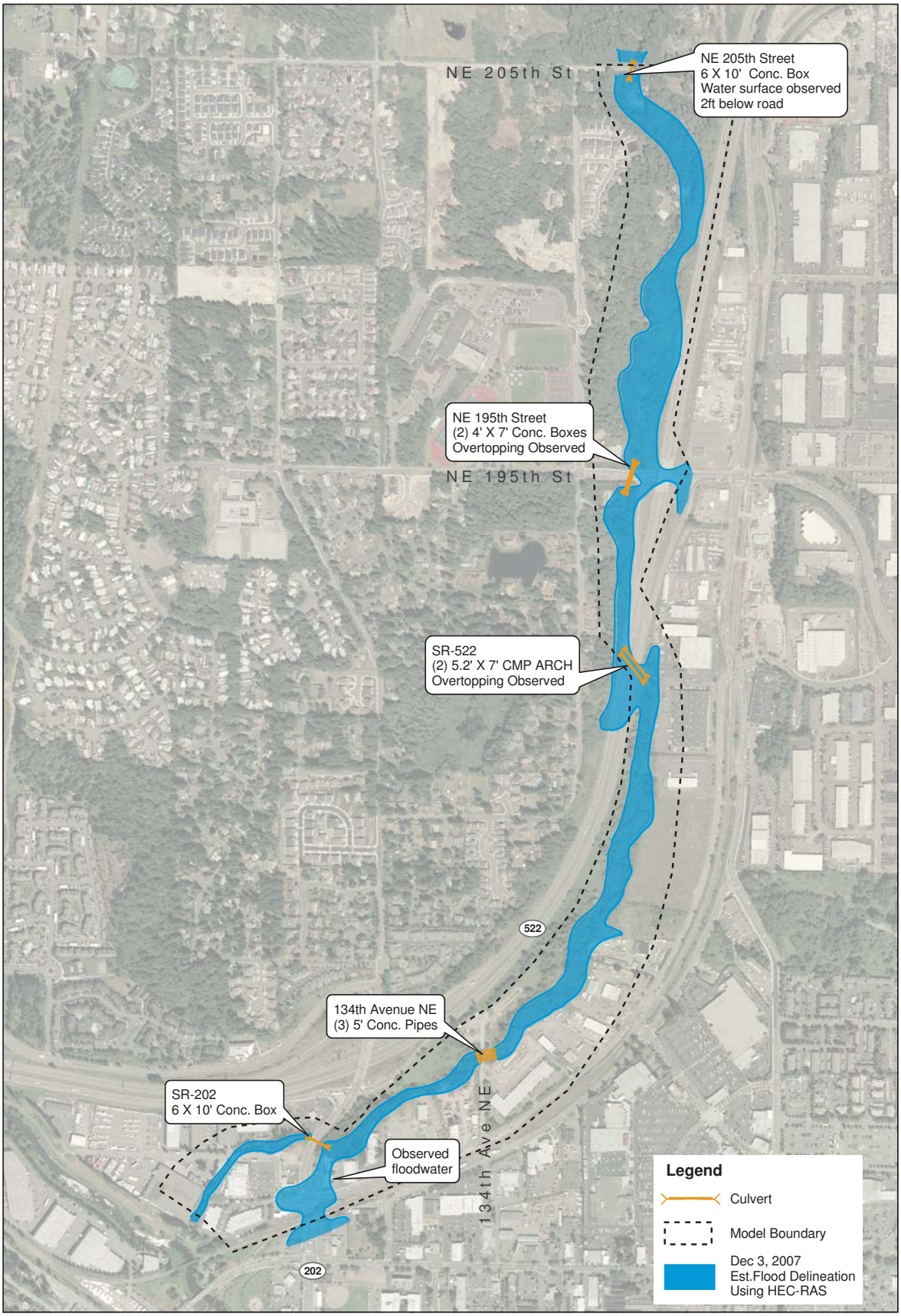


Figure 2

Little Bear Creek
Dec. 3, 2007 Flood Delineation
Woodinville, WA

Source: DEM data obtained from Puget Sound LiDAR Consortium and Otak GIS.
Disclaimer: This data is not to survey accuracy and is meant for planning purposes only.

0 315 630 1,260 Feet

FILE: K:/project/31210/Figure1.mxd

Appendix B—Calculations

Hydrologic Soil Groups

City of Woodinville
created by: sjs
checked by: jlc

Purpose: Assign hydrologic soil groups to GIS mapped soils based on the following.

Common Name	GIS Soil Type ID	Assigned Hydrologic Soil Group
Alderwood	AgB	C
Alderwood	AgC	C
Alderwood	AgD	C
Alderwood	Alderwood gravelly sandy loam, 2 to 8 percent slopes	C
Alderwood	Alderwood gravelly sandy loam, 8 to 15 percent slopes	C
Alderwood	Alderwood gravelly sandy loam, 15 to 25 percent slopes	C
Arents, Alderwood	AmB	B
Arents, Alderwood	AMC	B
Arents, Everett	An	B
Briscot	Br	D
Earlmont	Ea	C
Everett	EvB	A
Everett	EvC	A
Everett	EvD	A
Everett	Everett gravelly sandy loam, 0 to 8 percent slopes	A
Everett	Everett gravelly sandy loam, 8 to 15 percent slopes	A
Gravel Pit	PITS	A
Indianola	InA	A
Indianola	InC	A
Indianola	InD	A
Indianola	Indianola Loamy Sand, 15 to 25 percent slopes	A
Kitsap	KpB	C
Kitsap	KpD	C
Kitsap	Kitsap silt loam, 8 to 25 percent slopes	C
McKenna	McKenna gravelly silt loam, 0 to 8 percent slopes	D
Norma	No	D
Norma	Norma loam	D
Seattle	Sk	D
Snohomish	Sr	D
Tukwila	Tu	D
Unknown	0	C
Urban	Ur	D
Urban	Urban Land	D
Water	W	Water

Data Source:

Hydrologic Soil Groups from Dept. of Ecology. 2001. Stormwater Management Manual for Western Washington

Conversion from Land Use to Land Cover

City of Woodinville
created by: sjs/jlc
checked by: jlc

Purpose: Convert GIS mapped land uses to land cover based on the following table.

Land Uses

Land Use	Impervious percent	Forest percent	Grass percent	Bare ground percent	1990 Develop-ment	1998 Develop-ment	Total	*Notes*
Open Space	0%	80%	20%	0%	0%	0%	100%	*2*
Agriculture	0%	0%	50%	50%	0%	0%	100%	*2*
SFR Rural	1.0%	49.5%	49.5%	0%	0%	0%	100%	*1*
SFR Low	3%	30%	67%	0%	0%	0%	100%	*2*
Park/Recreation	15%	10%	60%	15%	0%	0%	100%	*2*
SFR Med	18%	0%	82%	0%	0%	0%	100%	*1*
Public Institution	20%	0%	60%	20%	0%	0%	100%	*2*
Greenhouse	25%	0%	40%	35%	0%	0%	100%	*2*
SFR High	41%	0%	59%	0%	0%	0%	100%	*1*
Multi Family	67%	0%	33%	0%	0%	0%	100%	*1*
ROW	86%	0%	14%	0%	0%	0%	100%	*1*
Commercial	86%	0%	14%	0%	0%	0%	100%	*1*
Industrial	86%	0%	14%	0%	0%	0%	100%	*1*
1990 Development	0%	0%	0%	0%	100%	0%	100%	*3*
1998 Development	0%	0%	0%	0%	0%	100%	100%	*3*

1. Land cover from Snohomish County. 2002. Hydrologic Modeling Protocols, Ver. 1.4.
2. Otak assumed land covers
3. See Otak Memo dated Nov. 12, 2009 for development later than 1990 and development later than 1998.

Curve Numbers

City of Woodinville
created by: sjs
checked by: jlc

Purpose: Assign curve numbers for each soil group and land cover based on the following.

Hydrologic Soil Group	Impervious CN	Forest CN	Grass CN	Bare ground CN	1990 Develop-ment	1998 Develop-ment
A	98	30	49	72	60	60
B	98	55	69	82	65	60
C	98	70	79	87	70	60
D	98	77	84	89	80	60
Water	100	100	100	100	80	60

Source: NRCS. 1986. Urban Hydrology for Small Watersheds.TR-55. Tables 2-2a, 2-2b, and 2-2c.
Forest CN is woods in good condition.
Grass CN is open space and/or pasture in fair condition.
Bare Ground CN is the same as dirt roads.
For development later than 1990 and 1998, see Otak Memo dated Nov. 12, 2009

Table 2-2a Runoff curve numbers for urban areas 1/

Cover description: Cover type and hydrologic condition	Average percent impervious area 2/	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) 3/:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89

Table 2-2b Runoff curve numbers for cultivated agricultural lands 1/

Cover description: Cover type	Treatment 2/	Hydrologic condition 3/	Curve numbers for hydrologic soil group: A	B	C	D
Fallow	Bare soil	—	77	86	91	94

Table 2-2c Runoff curve numbers for other agricultural lands 1/

Cover description: Cover type	Hydrologic condition	Curve numbers for hydrologic soil group: A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. 2/	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Woods. 3/	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 4/	55	70	77

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

Method: Use "Pivot Table" to subtotal subbasin areas and compute composite curve numbers from exported GIS soil/landuse/subbasin data.

PIVOT TABLE

		Sum of Area		Basin								
Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	JC10	JC11	JC12	JC13	LB10	LB20	LB30	LBE05	LBE06
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A					0.79	6.53			
14%	69.0		B				8.68				10.64	0.57
14%	79.0		C				1.33		0.13		0.96	4.03
14%	84.0		D					2.23	13.22		0.23	
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C		11.90	0.00						
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A						7.34			
14%	69.0		B								0.50	
14%	79.0		C						0.03		2.21	
14%	84.0		D					0.30	8.05			
14%	100.0		Water									
33%	49.0	Multi Family	A									
33%	69.0		B				18.67					
33%	79.0		C	0.08		0.17	0.85		0.09			
33%	84.0		D						2.36			
33%	100.0		Water									
100%	33.8	Open Space	A						6.91	13.31		
100%	57.8		B		0.15	0.28	0.64					
100%	71.8		C	0.19	1.51	2.74	0.07		0.01		8.92	32.86
100%	78.4		D			0.26			17.26	2.65		
100%	100.0		Water									
85%	50.8	Park/Recreation	A									
85%	69.6		B									
85%	79.4		C									
85%	84.1		D					0.27				
85%	100.0		Water					0.03				
80%	54.8	Public Institution	A									
80%	72.3		B				0.00					
80%	81.0		C									
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A					0.54	11.43	2.44		
14%	69.0		B	0.06		1.54	10.85				1.46	0.02
14%	79.0		C	3.07	0.82	4.15	3.76		1.89		0.25	9.96
14%	84.0		D			0.42		0.43	11.58	5.09	0.01	0.01
14%	100.0		Water									
59%	49.0	SFR High	A							0.02		
59%	69.0		B	0.60		0.75	3.48					
59%	79.0		C	0.11	0.01	3.09	1.19					
59%	84.0		D			0.00						
59%	100.0		Water									
97%	43.1	SFR Low	A						1.89	0.24		
97%	64.7		B				0.01					
97%	76.2		C									41.88
97%	81.8		D						2.18			
97%	100.0		Water									
82%	49.0	SFR Med	A									
82%	69.0		B	1.26		3.49	18.73					
82%	79.0		C	0.35		6.41	4.81					12.12
82%	84.0		D			0.82	0.12					
82%	100.0		Water									
99%	39.5	SFR Rural	A							9.42		
99%	62.0		B									
99%	74.5		C			0.85						9.91
99%	80.5		D							2.83		
99%	100.0		Water									
100%	60.0	1998 Developmen	A							6.87		
100%	60.0		B									
100%	60.0		C									
100%	60.0		D							0.29		
100%	60.0		Water									
100%	60.0	1990 Developmen	A									
100%	65.0		B									
100%	70.0		C				0.01					
100%	80.0		D									
100%	80.0		Water									
		Grand Total		5.73	14.38	24.99	73.22	4.59	90.89	43.17	25.17	111.37

basin name	JC10	JC11	JC12	JC13	LB10	LB20	LB30	LBE05	LBE06
area	5.73	14.38	24.99	73.22	4.59	90.89	43.17	25.17	111.37
pervious Area	2.39	10.70	16.10	32.78	0.86	37.35	36.55	11.19	95.28
Pervious CN	72.6	80.8	75.2	70.6	77.0	66.6	48.4	71.7	74.9
impervious	58%	26%	36%	55%	81%	59%	15%	56%	14%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Sum of Area

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	LBE10	LBE11	LBE12	LBE13	LBE13.5	LBE14	LBE15	LBE16	LBE17
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A		2.02	0.01	1.64		0.02			
14%	69.0		B			19.79	0.12		6.18			
14%	79.0		C	4.46	0.13	0.00	7.29		5.38	0.84	7.73	23.57
14%	84.0		D	1.20	5.00	0.27						
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A		1.35		2.83					
14%	69.0		B			1.81	0.64		0.54			
14%	79.0		C	4.99			16.02	1.19	0.00	11.51	0.00	6.79
14%	84.0		D		0.11							
14%	100.0		Water									
33%	49.0	Multi Family	A									
33%	69.0		B									
33%	79.0		C	0.13					0.00			
33%	84.0		D									
33%	100.0		Water									
100%	33.8	Open Space	A		0.02							
100%	57.8		B			0.65						
100%	71.8		C	6.54				7.37	11.05	0.00	0.02	3.07
100%	78.4		D	0.37	0.00							
100%	100.0		Water									
85%	50.8	Park/Recreation	A									
85%	69.6		B									
85%	79.4		C									
85%	84.1		D									
85%	100.0		Water									
80%	54.8	Public Institution	A									
80%	72.3		B									
80%	81.0		C									
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A	0.29	7.67	1.33	1.78		0.04			
14%	69.0		B			0.88	0.83		1.09			
14%	79.0		C	5.02	1.21		1.22	0.00	2.22	0.75	0.62	2.32
14%	84.0		D	6.31	4.34	0.02						
14%	100.0		Water									
59%	49.0	SFR High	A									
59%	69.0		B									
59%	79.0		C	0.16								
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A									
97%	64.7		B									
97%	76.2		C						8.04			10.58
97%	81.8		D	0.00								
97%	100.0		Water									
82%	49.0	SFR Med	A									
82%	69.0		B									
82%	79.0		C									
82%	84.0		D									
82%	100.0		Water									
99%	39.5	SFR Rural	A									
99%	62.0		B									
99%	74.5		C									1.07
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A									
100%	60.0		B									
100%	60.0		C	0.67								
100%	60.0		D	0.01								
100%	60.0		Water									
100%	60.0	1990 Developmen	A									
100%	65.0		B									
100%	70.0		C	14.23							0.12	6.16
100%	80.0		D									
100%	80.0		Water									
		Grand Total		44.38	21.85	24.76	32.37	8.56	34.57	13.10	8.48	53.57

basin name	**LBE10**	**LBE11**	**LBE12**	**LBE13**	**LBE13.5**	**LBE14**	**LBE15**	**LBE16**	**LBE17**
area	44.38	21.85	24.76	32.37	8.56	34.57	13.10	8.48	53.57
pervious Area	25.07	3.08	4.03	4.53	7.53	21.02	1.84	1.31	25.13
Pervious CN	71.7	65.8	66.4	72.7	72.0	73.6	79.0	78.1	74.6
impervious	44%	86%	84%	86%	12%	39%	86%	85%	53%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Sum of Area

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	LBE18	LBE19	LBE20	LBE30	LBE40	LBE41	LBE42	LBE43	LBE44
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A		1.15				0.05			
14%	69.0		B									
14%	79.0		C	7.58	4.70	0.12	2.20			0.02		
14%	84.0		D									
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A					0.74				
14%	69.0		B									
14%	79.0		C	0.85	1.43		7.32			3.20		
14%	84.0		D					1.14				
14%	100.0		Water									
33%	49.0	Multi Family	A						0.20	0.80	1.72	
33%	69.0		B									
33%	79.0		C	1.32			0.23			0.86	1.15	
33%	84.0		D				1.04					
33%	100.0		Water									
100%	33.8	Open Space	A		0.27	3.18		0.01		5.74	0.01	0.00
100%	57.8		B									
100%	71.8		C	13.24	8.01	4.57				10.70	0.01	
100%	78.4		D					0.13				
100%	100.0		Water									
85%	50.8	Park/Recreation	A						0.76			
85%	69.6		B									
85%	79.4		C									
85%	84.1		D									
85%	100.0		Water									
80%	54.8	Public Institution	A									
80%	72.3		B									
80%	81.0		C									
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A		1.77	2.85		1.68	0.41	0.68	2.01	2.62
14%	69.0		B									
14%	79.0		C	1.65	4.83	5.14	4.13	0.62		1.13	0.76	0.18
14%	84.0		D				0.04	0.58				
14%	100.0		Water									
59%	49.0	SFR High	A									
59%	69.0		B									
59%	79.0		C							0.27		
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A			1.76					0.49	0.02
97%	64.7		B									
97%	76.2		C	7.09	7.07	19.40						
97%	81.8		D									
97%	100.0		Water									
82%	49.0	SFR Med	A						0.34		2.40	4.66
82%	69.0		B									
82%	79.0		C								0.01	
82%	84.0		D									
82%	100.0		Water									
99%	39.5	SFR Rural	A			1.95						0.99
99%	62.0		B									
99%	74.5		C	0.76	4.32	24.04						
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A			2.89			2.70	5.32		
100%	60.0		B									
100%	60.0		C			3.52				6.13		
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A						0.03			
100%	65.0		B									
100%	70.0		C	0.03	2.33		0.56			4.00		
100%	80.0		D									
100%	80.0		Water									
		Grand Total		32.52	35.87	69.41	15.51	4.90	4.49	38.83	8.57	8.47

basin name	LBE18	LBE19	LBE20	LBE30	LBE40	LBE41	LBE42	LBE43	LBE44
area	32.52	35.87	69.41	15.51	4.90	4.49	38.83	8.57	8.47
pervious Area	22.74	23.68	61.54	2.89	0.81	3.79	33.29	3.81	5.21
Pervious CN	73.8	73.0	69.1	77.9	67.0	57.3	61.0	52.2	47.3
impervious	30%	34%	11%	81%	84%	16%	14%	56%	38%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Sum of Area

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	LBE45	LBE47	LBE48	LBW10	LBW15	LBW16	LBW20	LBW21	LBW30
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A	1.43								
14%	69.0		B									
14%	79.0		C	0.09	11.85	3.92						
14%	84.0		D									
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A									
14%	69.0		B									
14%	79.0		C		3.79	1.91						
14%	84.0		D									
14%	100.0		Water									
33%	49.0	Multi Family	A	6.00	0.03							
33%	69.0		B									
33%	79.0		C	5.56								
33%	84.0		D									
33%	100.0		Water									
100%	33.8	Open Space	A		0.30			0.11	2.25	1.84	3.71	4.25
100%	57.8		B									
100%	71.8		C		0.19	1.44						
100%	78.4		D									
100%	100.0		Water									
85%	50.8	Park/Recreation	A									
85%	69.6		B									
85%	79.4		C									
85%	84.1		D									
85%	100.0		Water									
80%	54.8	Public Institution	A									2.76
80%	72.3		B									
80%	81.0		C									
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A	1.22	1.72		1.08	0.41	0.00	0.33	0.00	1.66
14%	69.0		B									
14%	79.0		C	0.44	4.15	2.84		3.32	0.01			1.88
14%	84.0		D									
14%	100.0		Water									
59%	49.0	SFR High	A						0.00		0.01	0.05
59%	69.0		B									
59%	79.0		C					0.80	0.00			0.46
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A				1.99	0.07	2.16		1.41	0.66
97%	64.7		B									
97%	76.2		C					2.52	2.54			0.48
97%	81.8		D									
97%	100.0		Water									
82%	49.0	SFR Med	A					0.01	0.25		0.03	0.10
82%	69.0		B									
82%	79.0		C					4.90	0.65			2.23
82%	84.0		D									
82%	100.0		Water									
99%	39.5	SFR Rural	A				0.47	0.04				1.36
99%	62.0		B									
99%	74.5		C					3.14				5.06
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A	0.03	2.23		0.02	0.23	6.43	0.31	2.14	9.40
100%	60.0		B									
100%	60.0		C	0.00	0.80			0.04	0.00			0.02
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A									3.85
100%	65.0		B									
100%	70.0		C									2.20
100%	80.0		D									
100%	80.0		Water									
		Grand Total		14.77	25.05	10.11	3.57	15.60	14.30	2.47	7.30	36.42

basin name	LBE45	LBE47	LBE48	LBW10	LBW15	LBW16	LBW20	LBW21	LBW30
area	14.77	25.05	10.11	3.57	15.60	14.30	2.47	7.30	36.42
pervious Area	4.29	6.54	2.66	2.57	11.07	13.99	2.19	7.25	32.10
Pervious CN	62.4	66.8	75.1	42.9	75.7	56.7	37.9	43.4	59.4
impervious	71%	74%	74%	28%	29%	2%	11%	1%	12%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	LBW40	LBW45	LBW50	LBW55	LBW60	LBW65	LBW70	LL10	LL20
				Sum of Area								
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A									
14%	69.0		B									
14%	79.0		C									
14%	84.0		D									
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A									
14%	69.0		B									
14%	79.0		C									
14%	84.0		D									
14%	100.0		Water									
33%	49.0	Multi Family	A							0.24		
33%	69.0		B									
33%	79.0		C									
33%	84.0		D									
33%	100.0		Water									
100%	33.8	Open Space	A	2.95		1.51		5.21		0.15		1.27
100%	57.8		B									
100%	71.8		C		9.83			0.06	3.75		5.27	1.10
100%	78.4		D	0.00				5.05		0.44		
100%	100.0		Water								8.84	
85%	50.8	Park/Recreation	A									
85%	69.6		B									
85%	79.4		C						5.13			
85%	84.1		D									
85%	100.0		Water									
80%	54.8	Public Institution	A	34.50								
80%	72.3		B									
80%	81.0		C	0.11					9.40			
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A	4.54		0.88	0.96	7.06	1.25	9.04		
14%	69.0		B									
14%	79.0		C	1.78	7.04		1.71	0.50	21.49		5.21	4.62
14%	84.0		D	0.12				1.14		2.14		
14%	100.0		Water									
59%	49.0	SFR High	A	0.45			0.01	2.11	0.85	0.44		
59%	69.0		B									
59%	79.0		C	0.53	9.12		0.08	0.22	28.09			
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A	0.35		7.61		7.00		3.66		6.07
97%	64.7		B									
97%	76.2		C	3.12	11.90			3.00	4.27		28.50	27.43
97%	81.8		D			0.02		4.04		0.10		
97%	100.0		Water			2.10					0.08	
82%	49.0	SFR Med	A	2.44		0.91	3.84	15.79	0.32	7.08		
82%	69.0		B									
82%	79.0		C	1.08	6.39		7.79	0.48	6.98		7.83	1.43
82%	84.0		D					1.01				
82%	100.0		Water									
99%	39.5	SFR Rural	A									4.28
99%	62.0		B									
99%	74.5		C		7.35						7.40	8.01
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A	0.28								
100%	60.0		B									
100%	60.0		C		17.72				1.50			
100%	60.0		D	0.13								
100%	60.0		Water									
100%	60.0	1990 Developmen	A	3.60						13.34		2.81
100%	65.0		B									
100%	70.0		C	9.09								0.52
100%	80.0		D									
100%	80.0		Water									
		Grand Total		65.08	69.34	13.02	14.39	52.66	83.03	36.63	63.12	57.54

basin name	LBW40	LBW45	LBW50	LBW55	LBW60	LBW65	LBW70	LL10	LL20
area	65.08	69.34	13.02	14.39	52.66	83.03	36.63	63.12	57.54
pervious Area	51.48	57.97	11.81	9.96	40.69	47.52	25.28	56.30	52.18
Pervious CN	58.3	70.9	52.2	69.1	56.1	77.3	54.9	79.7	67.3
impervious	21%	16%	9%	31%	23%	43%	31%	11%	9%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Sum of Area

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	LL30	LL40	LL50	LL60	LL70	LL80	SRE40	SRE50	SRN10
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A		0.77	4.70				2.83	1.11	0.60
14%	69.0		B									
14%	79.0		C			1.54					1.03	
14%	84.0		D									3.30
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A									0.01
14%	69.0		B									
14%	79.0		C									
14%	84.0		D									2.76
14%	100.0		Water									
33%	49.0	Multi Family	A									
33%	69.0		B									
33%	79.0		C									
33%	84.0		D									
33%	100.0		Water									
100%	33.8	Open Space	A	1.60		0.00				1.04	1.19	
100%	57.8		B									
100%	71.8		C	1.17	2.26	2.17	3.24	3.87	6.21	0.00	51.80	
100%	78.4		D							0.50		
100%	100.0		Water									
85%	50.8	Park/Recreation	A							0.13		
85%	69.6		B									
85%	79.4		C									
85%	84.1		D							0.06		0.27
85%	100.0		Water									
80%	54.8	Public Institution	A									
80%	72.3		B									
80%	81.0		C									
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A	4.94	0.32	1.42	0.55			3.17	0.38	4.40
14%	69.0		B									
14%	79.0		C	6.20	1.38	2.62	13.22	5.90	4.72		45.75	
14%	84.0		D							0.48		3.06
14%	100.0		Water									
59%	49.0	SFR High	A		0.01							
59%	69.0		B									
59%	79.0		C		0.05		0.00				0.11	
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A	23.93	1.17	0.01	4.07			0.00	1.64	
97%	64.7		B									
97%	76.2		C	23.73	22.16	0.60	90.58	21.66	27.88		300.72	
97%	81.8		D									
97%	100.0		Water									
82%	49.0	SFR Med	A		0.20							
82%	69.0		B									
82%	79.0		C				0.62	3.05			2.29	
82%	84.0		D									
82%	100.0		Water									
99%	39.5	SFR Rural	A		0.76		0.81			2.46		
99%	62.0		B									
99%	74.5		C	2.53	16.00	0.27	25.29	0.76	6.07	0.58	155.72	
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A		0.91	0.01						
100%	60.0		B									
100%	60.0		C		1.32	0.00	2.42				7.52	
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A									
100%	65.0		B									
100%	70.0		C						8.57		0.59	
100%	80.0		D									
100%	80.0		Water									
		Grand Total		64.09	47.32	13.35	140.79	35.24	53.45	11.27	569.85	14.39

basin name	LL30	LL40	LL50	LL60	LL70	LL80	SRE40	SRE50	SRN10
area	64.09	47.32	13.35	140.79	35.24	53.45	11.27	569.85	14.39
pervious Area	53.06	44.26	4.49	125.74	28.96	48.50	5.63	517.25	2.20
Pervious CN	60.0	72.9	69.0	74.2	75.9	74.4	48.1	74.9	72.9
impervious	17%	6%	66%	11%	18%	9%	50%	9%	85%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	SRN20	SRN30	SRW10	SRW11	SRW12	SRW13	SRW14	SRW15	SRW20
			Sum of Area									
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C		0.12							
100%	86.5		D		0.71							
100%	100.0		Water									
14%	49.0	Commercial	A	13.00								
14%	69.0		B									
14%	79.0		C			2.89						0.49
14%	84.0		D	1.89		0.86						1.88
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A									
14%	69.0		B									
14%	79.0		C			3.08						
14%	84.0		D			0.19						0.00
14%	100.0		Water									
33%	49.0	Multi Family	A									
33%	69.0		B									
33%	79.0		C		1.63	0.53						5.54
33%	84.0		D		3.75	0.35						0.08
33%	100.0		Water									
100%	33.8	Open Space	A	2.06	0.00	2.20	0.02	0.01				0.74
100%	57.8		B									
100%	71.8		C			2.13		0.09	0.00	0.89	0.46	6.56
100%	78.4		D	0.01		0.33						2.42
100%	100.0		Water									
85%	50.8	Park/Recreation	A	0.00	0.93							
85%	69.6		B									
85%	79.4		C		0.68							
85%	84.1		D	0.03	6.81							
85%	100.0		Water									
80%	54.8	Public Institution	A	0.08	2.75							
80%	72.3		B									
80%	81.0		C						5.13			
80%	85.3		D		0.38	0.01						0.02
80%	100.0		Water									
14%	49.0	ROW	A	10.51	0.10	0.03	0.05	1.08				
14%	69.0		B									
14%	79.0		C		0.05	2.53	0.86	0.50	0.90	2.37	2.27	0.06
14%	84.0		D	1.89	2.62	1.96						7.03
14%	100.0		Water									
59%	49.0	SFR High	A					1.93				
59%	69.0		B									
59%	79.0		C			0.33		0.22	1.19	5.63	1.43	0.27
59%	84.0		D			0.06						0.20
59%	100.0		Water									
97%	43.1	SFR Low	A			1.29	0.00					
97%	64.7		B									
97%	76.2		C			0.23					1.09	0.05
97%	81.8		D									
97%	100.0		Water									
82%	49.0	SFR Med	A			0.05		1.55				0.99
82%	69.0		B									
82%	79.0		C			0.36		0.83	1.01	2.44	3.24	0.62
82%	84.0		D			0.28						0.17
82%	100.0		Water									
99%	39.5	SFR Rural	A									
99%	62.0		B									
99%	74.5		C									
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A	0.11			4.92	0.01				0.00
100%	60.0		B									
100%	60.0		C				0.08	0.00				
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A	53.86	1.21							
100%	65.0		B									
100%	70.0		C								3.31	
100%	80.0		D	0.65	2.33							
100%	80.0		Water									
		Grand Total		84.09	24.08	19.69	5.93	6.23	8.23	11.33	11.80	27.12

basin name	SRN20	SRN30	SRW10	SRW11	SRW12	SRW13	SRW14	SRW15	SRW20
area	84.09	24.08	19.69	5.93	6.23	8.23	11.33	11.80	27.12
pervious Area	60.59	16.21	8.84	5.14	3.56	5.76	6.54	8.65	14.70
Pervious CN	58.9	75.8	61.1	60.3	57.0	80.4	78.0	74.8	72.3
impervious	28%	33%	55%	13%	43%	30%	42%	27%	46%

Subbasin Area and Composite CN Calculations
City of Woodinville
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PIVOT TABLE

Sum of Area

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	SRW30	SRW31	SRW32	SRW33	SRW40	SRW41	SRW42	SRW43	SRW44
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A		0.20				3.19			
14%	69.0		B									
14%	79.0		C		0.23		0.04	0.05	0.26			
14%	84.0		D						0.48			
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C			15.74						
75%	86.3		D			3.47						
75%	100.0		Water									
14%	49.0	Industrial	A		1.07		0.03		8.44			
14%	69.0		B									
14%	79.0		C					0.03				
14%	84.0		D		0.03				0.75			
14%	100.0		Water									
33%	49.0	Multi Family	A									
33%	69.0		B									
33%	79.0		C							1.14		
33%	84.0		D									
33%	100.0		Water									
100%	33.8	Open Space	A		2.86	9.24	0.50		9.30			
100%	57.8		B									
100%	71.8		C			56.05	11.05		7.43	18.89	8.83	5.16
100%	78.4		D		0.16	0.03						
100%	100.0		Water									
85%	50.8	Park/Recreation	A									
85%	69.6		B									
85%	79.4		C									
85%	84.1		D									
85%	100.0		Water									
80%	54.8	Public Institution	A									
80%	72.3		B									
80%	81.0		C				0.00					
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A		8.26	2.97	0.84		7.81			
14%	69.0		B									
14%	79.0		C		0.95	8.95	3.73		5.06	1.10	0.76	0.98
14%	84.0		D		1.76	0.20	0.91		3.18			
14%	100.0		Water									
59%	49.0	SFR High	A									
59%	69.0		B									
59%	79.0		C			8.31	2.80				0.00	0.36
59%	84.0		D			0.34						
59%	100.0		Water									
97%	43.1	SFR Low	A									
97%	64.7		B									
97%	76.2		C			6.40	1.04			0.58		4.59
97%	81.8		D									
97%	100.0		Water									
82%	49.0	SFR Med	A		0.28		0.10					
82%	69.0		B									
82%	79.0		C			22.64	3.10					1.48
82%	84.0		D			0.23						
82%	100.0		Water									
99%	39.5	SFR Rural	A									
99%	62.0		B									
99%	74.5		C			3.05				7.14	0.04	7.14
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A									
100%	60.0		B									
100%	60.0		C			0.71						
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A	1.67	0.02			1.65	13.86			
100%	65.0		B									
100%	70.0		C			5.67	3.89	16.62	2.23	3.18	0.00	
100%	80.0		D	4.40	0.03		0.29	1.73	5.00			
100%	80.0		Water									
		Grand Total		6.07	15.84	144.00	28.31	20.07	66.99	32.03	9.63	19.70

basin name	SRW30	SRW31	SRW32	SRW33	SRW40	SRW41	SRW42	SRW43	SRW44
area	6.07	15.84	144.00	28.31	20.07	66.99	32.03	9.63	19.70
pervious Area	6.07	5.05	120.88	21.78	20.01	41.91	30.24	8.98	18.24
Pervious CN	74.5	44.3	71.9	72.3	70.0	59.2	72.4	71.9	74.5
impervious	0%	68%	16%	23%	0%	37%	6%	7%	7%

Subbasin Area and Composite CN Calculations
City of Woodinville
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checked by: jlc

PIVOT TABLE

Sum of Area

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	SRW45	SRW46	SRW47	SRW50	SRW51	SRW52	SRW53	SRW60	SRW70
100%	60.5	Agriculture	A								2.01	
100%	75.5		B									
100%	83.0		C									
100%	86.5		D								0.97	
100%	100.0		Water									
14%	49.0	Commercial	A					2.49				
14%	69.0		B									
14%	79.0		C					0.80				
14%	84.0		D									
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C		0.11							
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A				0.54	6.30			24.48	
14%	69.0		B									
14%	79.0		C					0.10			0.83	
14%	84.0		D				8.71					
14%	100.0		Water									
33%	49.0	Multi Family	A		0.01							
33%	69.0		B									
33%	79.0		C		0.88							8.80
33%	84.0		D									
33%	100.0		Water									
100%	33.8	Open Space	A		5.22		0.36	2.22	7.67	0.36	18.99	
100%	57.8		B	1.85								
100%	71.8		C	0.33	35.23	2.38		1.46	4.77	12.00	49.55	0.78
100%	78.4		D				1.39		1.28	0.00	0.68	
100%	100.0		Water									
85%	50.8	Park/Recreation	A									
85%	69.6		B									
85%	79.4		C									
85%	84.1		D								0.01	
85%	100.0		Water								0.00	
80%	54.8	Public Institution	A									
80%	72.3		B									
80%	81.0		C								10.96	
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A		1.77		0.32	5.25	1.43	0.50	7.34	
14%	69.0		B	0.44								
14%	79.0		C	0.67	1.82	0.15		1.91	0.30	5.78	7.82	1.19
14%	84.0		D				0.60			0.01	0.52	
14%	100.0		Water								0.01	
59%	49.0	SFR High	A						0.15	0.22		
59%	69.0		B									
59%	79.0		C		0.20					3.79	13.07	0.11
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A						1.21		7.99	
97%	64.7		B	2.68								
97%	76.2		C	1.02	1.35	4.50					11.83	3.93
97%	81.8		D								2.34	
97%	100.0		Water									
82%	49.0	SFR Med	A									
82%	69.0		B	3.09								
82%	79.0		C	0.38	0.26					1.98	0.12	0.03
82%	84.0		D									
82%	100.0		Water									
99%	39.5	SFR Rural	A								17.92	
99%	62.0		B									
99%	74.5		C		6.21	5.08				0.78	11.28	
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A									
100%	60.0		B									
100%	60.0		C		8.50							
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A		0.69		1.34	0.01	0.02	1.44		
100%	65.0		B									
100%	70.0		C	5.64	23.29	0.09				17.92		8.48
100%	80.0		D				12.93					
100%	80.0		Water									
		Grand Total		16.10	85.53	12.20	26.18	20.52	16.84	44.79	188.73	23.33

basin name	SRW45	SRW46	SRW47	SRW50	SRW51	SRW52	SRW53	SRW60	SRW70
area	16.10	85.53	12.20	26.18	20.52	16.84	44.79	188.73	23.33
pervious Area	14.41	81.60	11.88	17.44	6.04	15.25	37.36	144.94	16.24
Pervious CN	68.0	67.8	74.6	77.5	50.9	50.6	71.0	62.3	73.3
impervious	11%	5%	3%	33%	71%	9%	17%	23%	30%

Subbasin Area and Composite CN Calculations
City of Woodinville
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PIVOT TABLE

Sum of Area

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	SRW71	SRW72	SN20	SS10	SS20	WC05	WC10	WC11	WC12
100%	60.5	Agriculture	A								0.01	
100%	75.5		B									
100%	83.0		C						1.00			
100%	86.5		D						2.47	0.00		
100%	100.0		Water									
14%	49.0	Commercial	A							31.26	1.52	3.37
14%	69.0		B									
14%	79.0		C				2.13					
14%	84.0		D									
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A									
14%	69.0		B									
14%	79.0		C									
14%	84.0		D									
14%	100.0		Water									
33%	49.0	Multi Family	A							9.29	5.03	2.51
33%	69.0		B									
33%	79.0		C						3.12			
33%	84.0		D						8.82	10.53	0.01	
33%	100.0		Water									
100%	33.8	Open Space	A							2.64	0.78	0.58
100%	57.8		B									
100%	71.8		C	0.87	0.04	15.36	5.27					
100%	78.4		D									
100%	100.0		Water									
85%	50.8	Park/Recreation	A									
85%	69.6		B									
85%	79.4		C						1.46			
85%	84.1		D									
85%	100.0		Water									
80%	54.8	Public Institution	A							0.82	3.35	0.23
80%	72.3		B									
80%	81.0		C				24.18					
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A							2.28	2.98	8.21
14%	69.0		B									
14%	79.0		C	2.10	1.98	3.50	18.16	0.75				
14%	84.0		D						0.00	2.76	0.03	
14%	100.0		Water									
59%	49.0	SFR High	A									
59%	69.0		B									
59%	79.0		C		0.05							
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A								0.00	13.83
97%	64.7		B									
97%	76.2		C	1.59	0.57	25.61	98.80	7.97				
97%	81.8		D									
97%	100.0		Water				0.42					
82%	49.0	SFR Med	A								0.00	13.87
82%	69.0		B									
82%	79.0		C	1.45	1.87	0.01	0.80	0.76				
82%	84.0		D									
82%	100.0		Water									
99%	39.5	SFR Rural	A								0.00	1.88
99%	62.0		B									
99%	74.5		C			18.02	32.50	2.90				
99%	80.5		D									
99%	100.0		Water				2.53					
100%	60.0	1998 Developmen	A									
100%	60.0		B									
100%	60.0		C				7.75					
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A							0.22	6.48	
100%	65.0		B									
100%	70.0		C	5.08	0.01		6.37	9.40				
100%	80.0		D							6.88	0.14	
100%	80.0		Water									
		Grand Total		11.09	4.51	62.49	198.91	21.78	16.87	66.67	20.33	44.49

basin name	SRW71	SRW72	SN20	SS10	SS20	WC05	WC10	WC11	WC12
area	11.09	4.51	62.49	198.91	21.78	16.87	66.67	20.33	44.49
pervious Area	8.98	2.44	58.54	173.16	20.73	8.65	22.02	12.39	29.87
Pervious CN	72.7	78.2	74.6	75.8	73.3	83.3	63.3	55.4	45.5
impervious	19%	46%	6%	13%	5%	49%	67%	39%	33%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	WC13	WC13.5	WC14	WC15	WC16	WC17	WC18	WC19.1	WC19.2
		Sum of Area										
100%	60.5	Agriculture	A									
100%	75.5		B									
100%	83.0		C									
100%	86.5		D									
100%	100.0		Water									
14%	49.0	Commercial	A				9.70			21.01		
14%	69.0		B									
14%	79.0		C							0.56		
14%	84.0		D									
14%	100.0		Water									
75%	59.7	Greenhouse	A									
75%	75.1		B									
75%	82.7		C									
75%	86.3		D									
75%	100.0		Water									
14%	49.0	Industrial	A									
14%	69.0		B									
14%	79.0		C									
14%	84.0		D									
14%	100.0		Water									
33%	49.0	Multi Family	A				1.20			3.56	0.00	
33%	69.0		B									
33%	79.0		C				0.17			4.27	0.39	
33%	84.0		D									
33%	100.0		Water									
100%	33.8	Open Space	A	11.88	0.54		15.73	1.83	0.04	0.01	0.79	11.12
100%	57.8		B									
100%	71.8		C	8.11	4.21		1.16	0.01				0.55
100%	78.4		D									
100%	100.0		Water									
85%	50.8	Park/Recreation	A	7.09								
85%	69.6		B									
85%	79.4		C	0.14								
85%	84.1		D									
85%	100.0		Water									
80%	54.8	Public Institution	A	12.98								
80%	72.3		B									
80%	81.0		C	0.37								
80%	85.3		D									
80%	100.0		Water									
14%	49.0	ROW	A	6.66	3.88	0.45	6.57	6.08	1.76	4.95	5.06	2.75
14%	69.0		B									
14%	79.0		C	5.58	4.39	0.08	3.14	0.66		1.28	0.53	0.05
14%	84.0		D									
14%	100.0		Water									
59%	49.0	SFR High	A				0.21	1.39	0.32		1.07	0.03
59%	69.0		B									
59%	79.0		C									0.01
59%	84.0		D									
59%	100.0		Water									
97%	43.1	SFR Low	A	11.63	9.66	17.41	16.37	0.43	8.53		0.32	9.31
97%	64.7		B									
97%	76.2		C	58.49	27.79	3.17	29.24	0.58	3.48		0.22	2.79
97%	81.8		D									
97%	100.0		Water									
82%	49.0	SFR Med	A		0.23	0.02	15.86	19.31	4.84	0.12	12.04	7.77
82%	69.0		B									
82%	79.0		C	0.30	0.45		0.56	1.63	0.00	0.14	0.15	0.13
82%	84.0		D									
82%	100.0		Water									
99%	39.5	SFR Rural	A	11.90	2.23	9.10	0.52					2.29
99%	62.0		B									
99%	74.5		C	27.71	2.03	1.02	3.20		1.86			2.95
99%	80.5		D									
99%	100.0		Water									
100%	60.0	1998 Developmen	A									1.00
100%	60.0		B									
100%	60.0		C	0.96	2.50							1.66
100%	60.0		D									
100%	60.0		Water									
100%	60.0	1990 Developmen	A	2.25						0.82		
100%	65.0		B									
100%	70.0		C	5.93								
100%	80.0		D									
100%	80.0		Water									
		Grand Total		172.00	57.93	31.24	103.64	31.93	20.83	36.73	20.57	42.40

basin name	WC13	WC13.5	WC14	WC15	WC16	WC17	WC18	WC19.1	WC19.2
area	172.00	57.93	31.24	103.64	31.93	20.83	36.73	20.57	42.40
pervious Area	155.16	49.52	30.06	81.58	21.76	17.93	7.53	12.85	38.15
Pervious CN	64.1	66.2	46.5	56.0	50.3	54.0	57.3	49.1	47.7
impervious	10%	15%	4%	21%	32%	14%	80%	38%	10%

Subbasin Area and Composite CN Calculations
City of Woodinville
created by: sjs
checked by: jlc

PIVOT TABLE

Pervious Percent	Pervious Composite CN	Modified Land Use	Hyd Soil Type	Grand Total
		Sum of Area		
100%	60.5	Agriculture	A	2.02
100%	75.5		B	
100%	83.0		C	1.12
100%	86.5		D	4.16
100%	100.0		Water	
14%	49.0	Commercial	A	109.38
14%	69.0		B	45.98
14%	79.0		C	96.35
14%	84.0		D	30.56
14%	100.0		Water	
75%	59.7	Greenhouse	A	
75%	75.1		B	
75%	82.7		C	27.74
75%	86.3		D	3.47
75%	100.0		Water	
14%	49.0	Industrial	A	53.12
14%	69.0		B	3.48
14%	79.0		C	65.27
14%	84.0		D	22.03
14%	100.0		Water	
33%	49.0	Multi Family	A	30.59
33%	69.0		B	18.67
33%	79.0		C	36.93
33%	84.0		D	26.94
33%	100.0		Water	
100%	33.8	Open Space	A	164.53
100%	57.8		B	3.57
100%	71.8		C	462.86
100%	78.4		D	32.97
100%	100.0		Water	8.84
85%	50.8	Park/Recreation	A	8.92
85%	69.6		B	
85%	79.4		C	7.41
85%	84.1		D	7.45
85%	100.0		Water	0.04
80%	54.8	Public Institution	A	57.46
80%	72.3		B	0.00
80%	81.0		C	50.15
80%	85.3		D	0.41
80%	100.0		Water	
14%	49.0	ROW	A	182.77
14%	69.0		B	17.19
14%	79.0		C	283.40
14%	84.0		D	59.24
14%	100.0		Water	0.01
59%	49.0	SFR High	A	9.27
59%	69.0		B	4.84
59%	79.0		C	82.06
59%	84.0		D	0.60
59%	100.0		Water	
97%	43.1	SFR Low	A	164.17
97%	64.7		B	2.68
97%	76.2		C	962.05
97%	81.8		D	8.67
97%	100.0		Water	2.60
82%	49.0	SFR Med	A	115.39
82%	69.0		B	26.58
82%	79.0		C	116.18
82%	84.0		D	2.63
82%	100.0		Water	
99%	39.5	SFR Rural	A	68.39
99%	62.0		B	
99%	74.5		C	412.04
99%	80.5		D	2.83
99%	100.0		Water	2.53
100%	60.0	1998 Developmen	A	45.83
100%	60.0		B	
100%	60.0		C	63.82
100%	60.0		D	0.43
100%	60.0		Water	
100%	60.0	1990 Developmen	A	109.16
100%	65.0		B	
100%	70.0		C	165.50
100%	80.0		D	34.38
100%	80.0		Water	
		Grand Total		4327.67

basin name	
area	4327.67
pervious Area	3260.05
Pervious CN	68.2
impervious	25%

Single Basin SBUH/Level Pool Routing Analysis

City of Woodinville
created by: sjs
checked by:

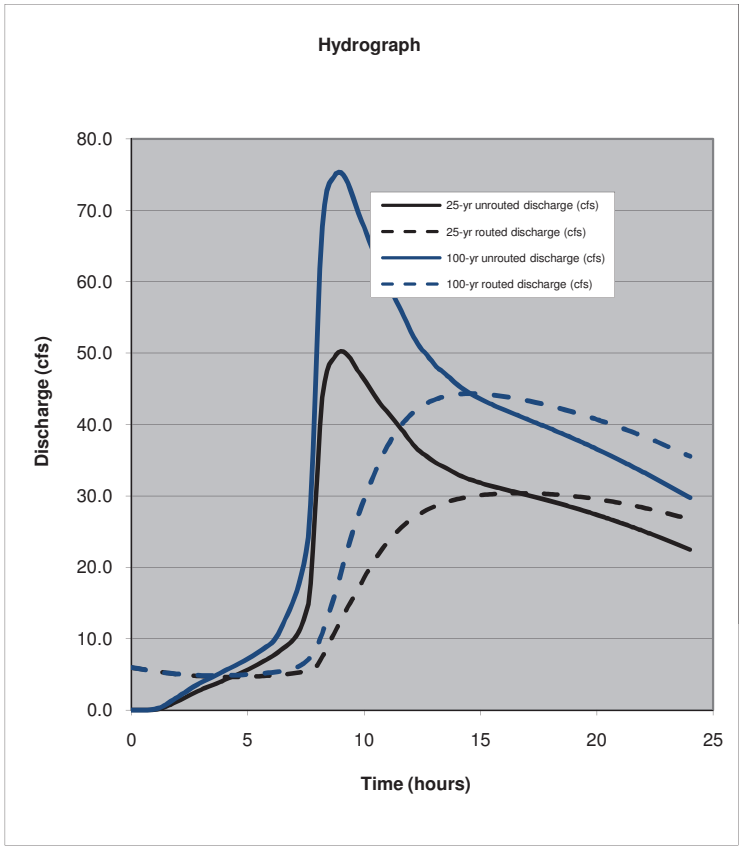
Purpose: Calculate routed discharge for basins with significant detention.
Basin: Lake Leota - LL10+
Method: Use Excel built-in SBUH and Level Pool Routing add-in tools.

Stage-Storage-Discharge Table

Surface Area = 10.7 acres (measured in cad using aerial photo)
outlet - assume cipolletti weir

weir base width (ft)	5
begin stage (ft)	0.5

stage (ft)	area (ac)	storage (ac-ft)	discharge (cfs)
0	10.7	0	0
0.5	10.7	5.35	6.0
1	10.7	10.7	16.8
1.5	10.7	16.05	30.9
2	10.7	21.4	47.6
2.5	10.7	26.75	66.5



SBUH Input

	25-yr	100-yr
25-yr, 24-hr precip (in)	3.3	4.0
SCS Storm	Type IA	

copied from subbasin combination calculations

area (ac)	474.9
pervious area (ac)	413.5
pervious CN-value	72.2
percent impervious	13%
basin length (ft)	8700
tc (min)	88.0

Results

	25-yr	100-yr
unrouted discharge (cfs)	50.3	75.4
routed discharge (cfs)	30.4	44.3

Single Basin SBUH/Level Pool Routing Analysis

City of Woodinville
created by: sjs
checked by:

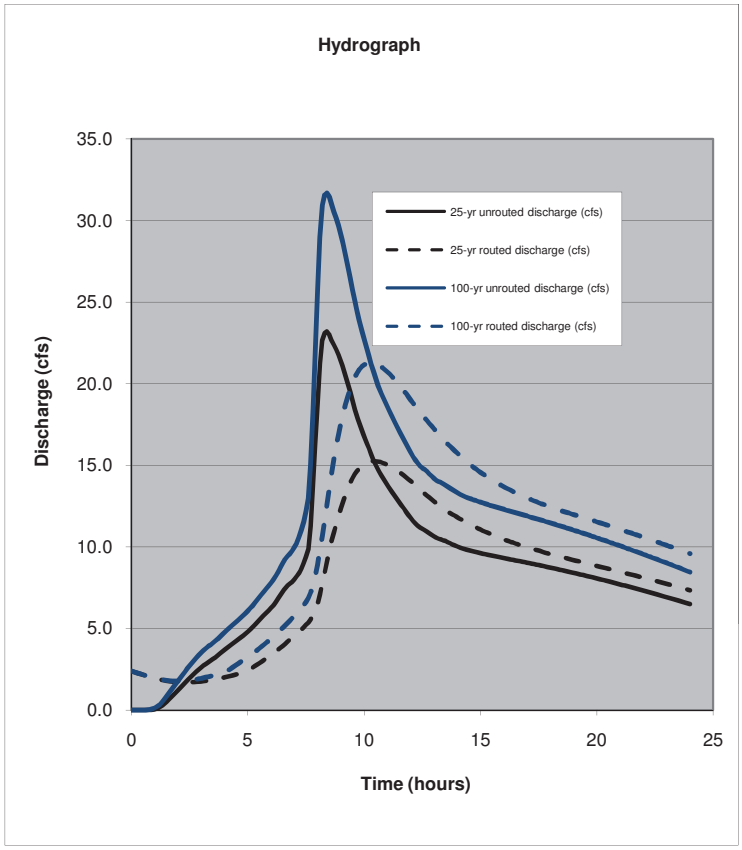
Purpose: Calculate routed discharge for basins with significant detention.
Basin: Little Bear Creek West 60 (LBW60+)
Method: Use Excel built-in SBUH and Level Pool Routing add-in tools.

Stage-Storage-Discharge Table

Surface Area = 2acres (approximated using aerial photo)
outlet - assume cipolletti weir (adjust width so that nearly entire volume is used)

weir base width (ft)	2
begin stage (ft)	0.5

stage (ft)	area (ac)	storage (ac-ft)	discharge (cfs)
0	2	0	0
0.5	2	1	2.4
1	2	2	6.7
1.5	2	3	12.4
2	2	4	19.0
2.5	2	5	26.6



SBUH Input

	25-yr	100-yr
25-yr, 24-hr precip (in)	3.3	4.0
SCS Storm	Type IA	

copied from subbasin combination calculations

area (ac)	135.7
pervious area (ac)	88.2
pervious CN-value	67.6
percent impervious	35%
basin length (ft)	5000
tc (min)	63.3

Results

	25-yr	100-yr
unrouted discharge (cfs)	23.2	31.7
routed discharge (cfs)	15.3	21.3

Single Basin SBUH/Level Pool Routing Analysis

City of Woodinville
created by: sjs
checked by:

Purpose: Calculate routed discharge for basins with significant detention.
Basin: Little Bear Creek East (LBE13+)
Method: Use Excel built-in SBUH and Level Pool Routing add-in tools.

Stage-Storage-Discharge Table

Surface Area = .25 acres (approximated using aerial photo, 1000ftx10ft)
outlet - assume cipolletti weir (adjust width so that nearly entire volume is used)

weir base width (ft)	0.9
begin stage (ft)	0.5

stage (ft)	area (ac)	storage (ac-ft)	discharge (cfs)
0	0.25	0	0
1	0.25	0.25	3.0
2	0.25	0.5	8.6
3	0.25	0.75	15.7
4	0.25	1	24.2
5	0.25	1.25	33.9

SBUH Input

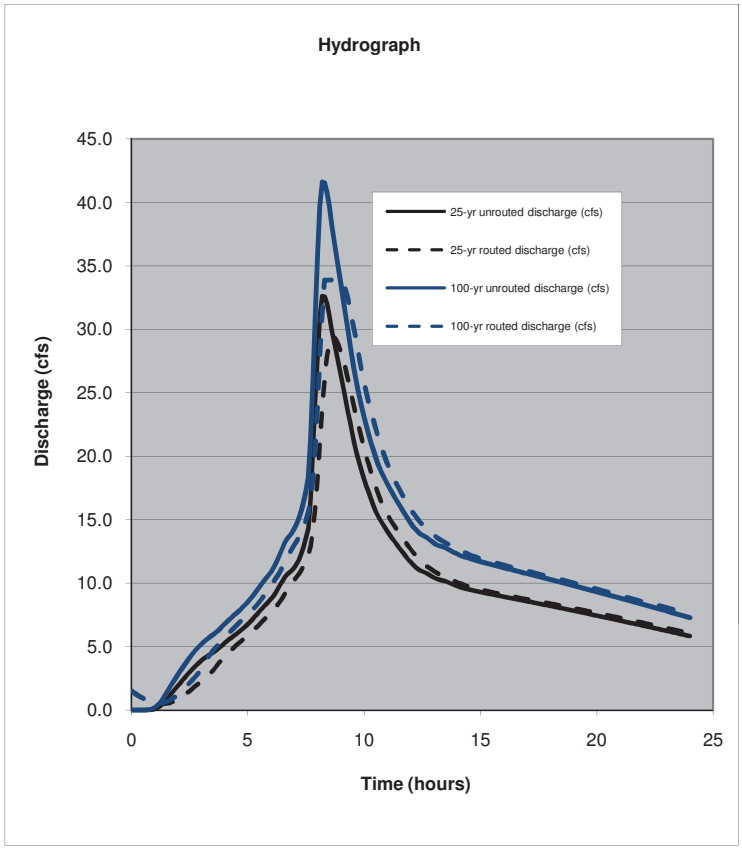
	25-yr	100-yr
25-yr, 24-hr precip (in)	3.3	4.0
SCS Storm	Type IA	

copied from subbasin combination calculations

area (ac)	100.3
pervious area (ac)	37.1
pervious CN-value	72.4
percent impervious	63%
basin length (ft)	2800
tc (min)	48.7

Results

	25-yr	100-yr
unrouted discharge (cfs)	32.6	41.6
routed discharge (cfs)	29.4	33.9



Single Basin SBUH/Level Pool Routing Analysis

City of Woodinville
created by: sjs
checked by:

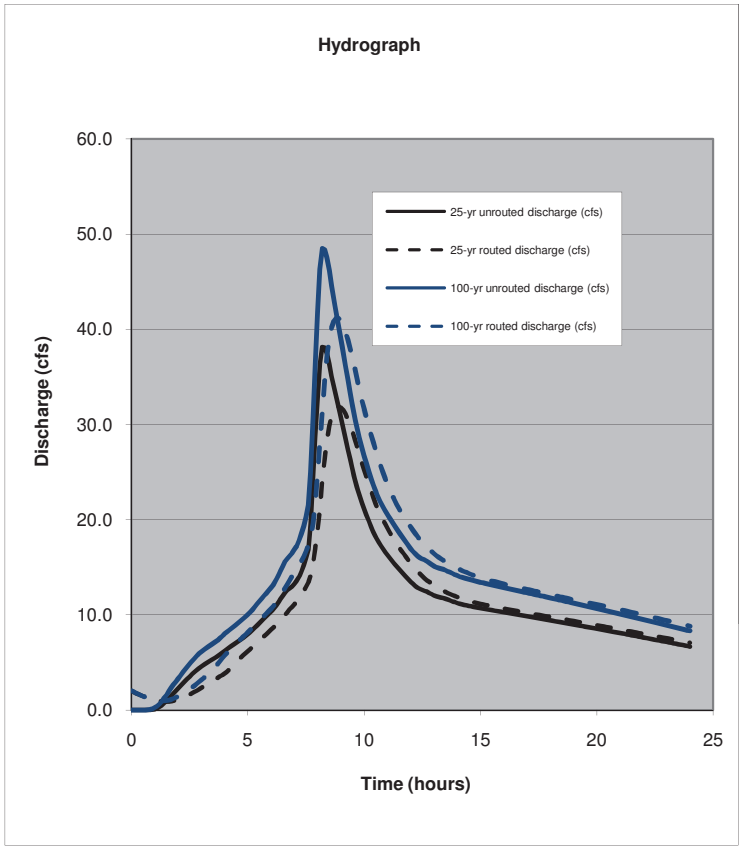
Purpose: Calculate routed discharge for basins with significant detention.
Basin: Little Bear Creek East (LBE15+)
Method: Use Excel built-in SBUH and Level Pool Routing add-in tools.

Stage-Storage-Discharge Table

Surface Area = .50 acres (approximated using aerial photo, 1000ftx20ft)
outlet - assume cipolletti weir (adjust width so that nearly entire volume is used)

weir base width (ft)	1.2
begin stage (ft)	0.5

stage (ft)	area (ac)	storage (ac-ft)	discharge (cfs)
0	0.5	0	0
1	0.5	0.5	4.0
2	0.5	1	11.4
3	0.5	1.5	21.0
4	0.5	2	32.3
5	0.5	2.5	45.2



SBUH Input

	25-yr	100-yr
25-yr, 24-hr precip (in)	3.3	4.0
SCS Storm	Type IA	

copied from subbasin combination calculations

area (ac)	113.4
pervious area (ac)	39.0
pervious CN-value	72.7
percent impervious	66%
basin length (ft)	2800
tc (min)	48.7

Results

	25-yr	100-yr
unrouted discharge (cfs)	38.2	48.5
routed discharge (cfs)	31.9	41.2

City of Woodinville Precipitation

City of Woodinville
created by: sjs
checked by: jlc

Purpose: Precipitation depths summarized in table below are used in the SBUH analysis.

Recurrence Interval	24-hr Precipitation Depths within the City Limits of Woodinville (in)		
	min	max	average
6-mo	1.41	1.56	1.5
2-yr	2.0	2.2	2.1
10-yr	2.7	2.9	2.8
25-yr	3.2	3.4	3.3
100-yr	3.9	4.1	4.0

source: MGS Engineering Consultants and Oregon Climate Service 1/2006. GIS IMG File.

SBUH Calculations and Combined Subbasin Area/CN Calculations
City of Woodinville
created by: sjs/jlc
checked by: sjs

Purpose: Calculate peak discharges for the 25-yr and 100-yr events using the SBUH methodology.

Method:
1. Calculate area, pervious area, pervious CN, and percent impervious for the combined subbasins based on the subbasins areas and composite CNs.
2. Measured basin lengths were estimated using GIS for each of the combined subbasins
3. Approximate time of concentration based on an initial 30 minutes for sheet flow to concentrate plus concentrated flow velocity at 2.5 fps for the distance of the measured basin length.
4. Calculate the 25- and 100-yr peak flows using SBUH method (built-in Excel function). Precipitation is referenced on attached sheet.
5. Override values based on attached calculations. For example, the Lake Leota basin has additional natural storage/detention routing calculations.

combined subbasin ID	contributing subbasins (with percent indicating only portion of basin in case of diversion)	area (ac)	Perv. Area (ac)	Perv. CN	Percent Impervious	Meas'd Basin Length (ft)	Tc (min)	25-yr Peak Q (cfs)	100-yr Peak Q (cfs)	Override values 25-yr Peak Q (cfs)	Override values 100-yr Peak Q (cfs)
JC10+	JC10 JC11 JC12 JC13	118.3	62.0	73.6	48%	3300	52	31.5	41.4		
JC11+	JC11 JC12	39.4	26.8	77.4	32%	3300	52	9.4	12.8		
JC11	JC11	14.4	10.7	80.8	26%	1800	42	4.0	5.4		
JC12	JC12	25.0	16.1	75.2	36%	1800	42	6.4	8.7		
JC13	JC13	73.2	32.8	70.6	55%	2400	46	21.6	27.9		
SRW10+	SRW10 SRW11 (15%) SRW12 (15%) SRW13 (5%) SRW14 (5%) SRW15 (5%)	23.1	11.2	62.4	51%	5700	68	4.9	6.3		
SRW11de	SRW11 (15%) SRW12 (15%) SRW13 (5%) SRW14 (5%) SRW15 (5%)	3.4	2.4	67.2	31%	5700	68	0.5	0.7		
SRW11dw	SRW11 (85%) SRW12 (85%) SRW13 (95%) SRW14 (95%) SRW15 (95%)	40.1	27.3	72.4	32%	3900	56	7.9	10.8		
SRW11+	SRW11 SRW12 SRW13 (40%) SRW14 (40%) SRW15 (40%)	24.7	17.1	68.0	31%	3900	56	4.1	5.7		
SRW12+	SRW12 SRW13 (40%) SRW14 (40%) SRW15 (40%)	18.8	11.9	71.3	36%	3200	51	4.0	5.4		
SRW13de	SRW13 (40%) SRW14 (40%) SRW15 (40%) SRW15 (40%)	17.3	11.8	76.6	31%	3200	51	4.0	5.5		
SRW13dw	SRW13 (60%) SRW14 (60%) SRW15 (60%) SRW15 (60%)	25.9	17.8	76.6	31%	3200	51	6.0	8.2		
SRW13+	SRW13 SRW14 SRW15	31.4	21.0	77.4	33%	2600	47	7.9	10.7		
SRW14+	SRW14 SRW15	23.1	15.2	76.2	34%	1900	43	6.0	8.1		
SRW15	SRW15	11.8	8.6	74.8	27%	1200	38	2.7	3.8		
SRW20	SRW20	27.1	14.7	72.3	46%	2400	46	7.2	9.5		
SRW30+	SRW30 SRW31 SRW32 SRW33	194.2	153.8	71.1	21%	6000	70	25.9	37.7		
SRW31+	SRW31 SRW32 SRW33	188.2	147.7	71.0	21%	5400	66	26.0	37.7		
SRW32	SRW32	144.0	120.9	71.9	16%	4800	62	18.7	27.9		
SRW33	SRW33	28.3	21.8	72.3	23%	2300	45	5.1	7.3		
SRW40+	SRW40 SRW41 SRW42 SRW43 SRW44 SRW45 SRW46 SRW47	262.3	227.3	68.1	13%	6300	72	23.7	36.7		
SRW41+	SRW41 SRW42 SRW43 SRW44 SRW45 SRW46 SRW47	242.2	207.3	67.9	14%	5900	69	22.7	35.0		
SRW42+	SRW42 SRW43 SRW44 SRW45 SRW47	89.7	83.7	72.4	7%	3700	55	9.8	15.6		
SRW44+	SRW44 SRW45	35.8	32.6	71.7	9%	1800	42	4.4	7.1		
SRW45	SRW45	16.1	14.4	68.0	11%	1500	40	1.6	2.7		
SRW47	SRW47	12.2	11.9	74.6	3%	1400	39	1.6	2.6		
SRW46	SRW46	85.5	81.6	67.8	5%	5900	69	5.5	9.4		
SRW51+	SRW51 SRW52 SRW53	82.2	58.7	63.6	29%	4300	59	11.1	15.4		
SRW52	SRW52	16.8	15.3	50.6	9%	2500	47	0.8	0.9		
SRW53	SRW53	44.8	37.4	71.0	17%	3100	51	6.1	9.2		
SRW60	SRW60	188.7	144.9	62.3	23%	5100	64	19.7	28.1		
SRW70+	SRW70 SRW71 SRW72 SRW11 (85%) SRW12 (85%) SRW13 (95%) SRW14 (95%) SRW15 (95%)	79.1	55.0	73.0	30%	4600	61	14.9	20.5		
SRW71+	SRW71 SRW72 SRW13 (60%) SRW14 (60%) SRW15 (60%)	34.4	24.0	75.7	30%	2900	49	7.8	10.7		
SRW72	SRW72	4.5	2.4	78.2	46%	1600	41	1.4	1.9		
SRE40	SRE40	11.3	5.6	48.1	50%	1100	37	2.9	3.6		
SRE50	SRE50	569.9	517.3	74.9	9%	8000	83	66.5	99.6		
SRN20+	SRN20 SRN10	98.5	62.8	59.4	36%	3600	54	16.0	20.8		
SRN20	SRN20	84.1	60.6	58.9	28%	4000	57	10.4	13.7		
SRN10	SRN10	14.4	2.2	72.9	85%	4000	57	5.5	6.9		
SRN30	SRN30	24.1	16.2	75.8	33%	1200	38	6.3	8.6		
WC10+	WC10 WC11 WC12 WC13 WC13.5 WC14 WC15 WC16 WC17 WC18 WC19.1 WC19.2	648.7	478.8	57.6	26%	11000	103	57.6	75.7		

SBUH Calculations and Combined Subbasin Area/CN Calculations
City of Woodinville
created by: sjs/jlc
checked by: sjs

Purpose: Calculate peak discharges for the 25-yr and 100-yr events using the SBUH methodology.

Method:
1. Calculate area, pervious area, pervious CN, and percent impervious for the combined subbasins based on the subbasins areas and composite CNs.
2. Measured basin lengths were estimated using GIS for each of the combined subbasins
3. Approximate time of concentration based on an initial 30 minutes for sheet flow to concentrate plus concentrated flow velocity at 2.5 fps for the distance of the measured basin length.
4. Calculate the 25- and 100-yr peak flows using SBUH method (built-in Excel function). Precipitation is referenced on attached sheet.
5. Override values based on attached calculations. For example, the Lake Leota basin has additional natural storage/detention routing calculations.

combined subbasin ID	contributing subbasins (with percent indicating only portion of basin in case of diversion)								area (ac)	Perv. Area (ac)	Perv. CN	Percent Impervious	Meas'd Basin Length (ft)	Tc (min)	25-yr Peak Q (cfs)	100-yr Peak Q (cfs)	Override values 25-yr Peak Q (cfs)	Override values 100-yr Peak Q (cfs)
WC11	WC11								20.3	12.4	55.4	39%	2100	44	3.9	4.7		
WC12+	WC12	WC13	WC13.5	WC14					305.6	264.6	60.4	13%	8900	89	16.5	25.8		
WC13	WC13								172.0	155.2	64.1	10%	3900	56	11.0	18.5		
WC14+	WC14	WC13.5							89.2	79.6	58.8	11%	3500	53	4.4	7.0		
WC13.5	WC13.5								57.9	49.5	66.2	15%	3500	53	5.4	8.6		
WC15++	WC15	WC16	WC17	WC18	WC19.1	WC19.2			256.1	179.8	52.9	30%	3800	55	33.8	41.3		
WC15+	WC15	WC16	WC17						156.4	121.3	54.7	22%	3800	55	15.6	19.2		
WC15	WC15								103.6	81.6	56.0	21%	3800	55	9.8	12.4		
WC16+	WC16	WC17							52.8	39.7	52.0	25%	2300	45	6.3	7.7		
WC16	WC16								31.9	21.8	50.3	32%	2300	45	4.9	6.0		
WC18+	WC18	WC19.1	WC19.2						99.7	58.5	49.2	41%	5200	65	17.1	20.9		
WC19.1+	WC19.1	WC19.2							63.0	51.0	48.0	19%	2600	47	5.7	6.9		
LBE05	LBE05								25.2	11.2	71.7	56%	5400	66	6.5	8.4		
LBE11+	LBE11	LBE12	LBE13	LBE13.5	LBE14	LBE15			135.2	42.0	72.2	69%	2800	49	47.0	59.4		
LBE15+	LBE15	LBE13	LBE13.5	LBE14	LBE12				113.4	39.0	72.7	66%	2800	49	38.2	48.5	31.9	41.2
LBE13+	LBE13	LBE13.5	LBE14	LBE12					100.3	37.1	72.4	63%	2800	49	32.6	41.6	29.4	33.9
LBE13.5	LBE13.5								8.6	7.5	72.0	12%	2800	49	1.1	1.7		
LBE14+	LBE14	LBE12							59.3	25.0	72.5	58%	2800	49	18.1	23.4		
LBE14	LBE14								34.6	21.0	73.6	39%	2000	43	8.8	11.9		
LBE15	LBE15								13.1	1.8	79.0	86%	2000	43	5.8	7.2		
LBE10+	LBE10	LBE16	LBE17	LBE18	LBE19	LBE20			244.2	159.5	71.7	35%	8200	85	40.9	55.7		
LBE16	LBE16								8.5	1.3	78.1	85%	1900	43	3.7	4.6		
LBE17+	LBE17	LBE18	LBE19	LBE20					191.4	133.1	71.7	30%	8200	85	29.5	40.9		
LBE17++	LBE17	LBE18							86.1	47.9	74.2	44%	8200	85	17.9	23.7		
LBE18	LBE18								32.5	22.7	73.8	30%	2500	47	7.0	9.7		
LBE30	LBE30								15.5	2.9	77.9	81%	1900	43	6.7	8.3		
LBE40+	LBE40	LBE41	LBE42	LBE43	LBE44	LBE45	LBE47	LBE48	115.2	60.4	60.4	48%	3300	52	25.1	32.0		
LBE41+	LBE41	LBE42	LBE43	LBE44	LBE45				75.1	50.4	58.7	33%	800	35	13.1	16.9		
LBE42+	LBE42	LBE44							47.3	38.5	59.1	19%	1800	42	4.4	6.2		
LBE44	LBE44								8.5	5.2	47.3	38%	1200	38	1.7	2.0		
LBE45+	LBE45	LBE43							23.3	8.1	57.6	65%	2400	46	7.3	9.0		
LBE43	LBE43								8.6	3.8	52.2	56%	2000	43	2.3	2.8		
LBE47	LBE47								25.0	6.5	66.8	74%	3000	50	8.8	11.0		
LBE48	LBE48								10.1	2.7	75.1	74%	2100	44	3.9	5.0		
LBW15+	LBW15	LBW16							29.9	25.1	65.1	16%	1500	40	3.1	4.9		
LBW15	LBW15								15.6	11.1	75.7	29%	1500	40	3.8	5.2		
LBW16	LBW16								14.3	14.0	56.7	2%	1900	43	0.4	0.6		
LBW21	LBW21								7.3	7.2	43.4	1%	900	36	0.0	0.1		
LBW30	LBW30								36.4	32.1	59.4	12%	2400	46	2.1	3.3		
LBW40+	LBW40	LBW45							134.4	109.4	64.9	19%	3300	52	14.0	21.3		
LBW45	LBW45								69.3	58.0	70.9	16%	3800	55	9.0	13.6		

SBUH Calculations and Combined Subbasin Area/CN Calculations
City of Woodinville
created by: sjs/jlc
checked by: sjs

Purpose: Calculate peak discharges for the 25-yr and 100-yr events using the SBUH methodology.

Method:
1. Calculate area, pervious area, pervious CN, and percent impervious for the combined subbasins based on the subbasins areas and composite CNs.
2. Measured basin lengths were estimated using GIS for each of the combined subbasins
3. Approximate time of concentration based on an initial 30 minutes for sheet flow to concentrate plus concentrated flow velocity at 2.5 fps for the distance of the measured basin length.
4. Calculate the 25- and 100-yr peak flows using SBUH method (built-in Excel function). Precipitation is referenced on attached sheet.
5. Override values based on attached calculations. For example, the Lake Leota basin has additional natural storage/detention routing calculations.

combined subbasin ID	contributing subbasins (with percent indicating only portion of basin in case of diversion)								area (ac)	Perv. Area (ac)	Perv. CN	Percent Impervious	Meas'd Basin Length (ft)	Tc (min)	25-yr Peak Q (cfs)	100-yr Peak Q (cfs)	Override values 25-yr Peak Q (cfs)	Override values 100-yr Peak Q (cfs)
LBW50+	LBW50	LBW55							27.4	21.8	60.0	21%	2400	46	2.7	3.9		
LBW55	LBW55								14.4	10.0	69.1	31%	1600	41	2.8	3.9		
LBW60+	LBW60	LBW65							135.7	88.2	67.6	35%	5000	63	23.2	31.7	14.1	19.7
LBW65	LBW65								83.0	47.5	77.3	43%	2400	46	23.8	31.5		
LBW70	LBW70								36.6	25.3	54.9	31%	2400	46	5.4	6.7		
SN20	SN20								62.5	58.5	74.6	6%	2100	44	8.8	13.7		
SS10+	SS10	SS20							220.7	193.9	75.5	12%	5900	69	30.8	45.6		
LL10+	LL10	LL20	LL30	LL40	LL50	LL60	LL70	LL80	474.9	413.5	72.2	13%	8700	88	50.3	75.4	30.4	44.3
LL20	LL20								57.5	52.2	67.3	9%	1600	41	5.2	8.7		
LL30+	LL30	LL40	LL50	LL60	LL70				300.8	256.5	71.1	15%	6000	70	34.3	51.7		
LL40+	LL40	LL50	LL60	LL70					236.7	203.4	74.1	14%	5600	67	32.0	47.4		
LL50	LL50								13.4	4.5	69.0	66%	1500	40	4.7	6.0		
LL60	LL60								140.8	125.7	74.2	11%	2600	47	20.9	31.6		
LL70	LL70								35.2	29.0	75.9	18%	3700	55	6.3	9.0		
LL80	LL80								53.5	48.5	74.4	9%	2800	49	7.7	11.7		

Pipe Capacity Calculations

City of Woodinville
created by: sjs
checked by: jlc

Purpose: Calculate typical storm pipe and culvert capacities based on typical pipe configurations.
Method: Use built-in excel function that solves the FHWA HDS-5 methodology.
Assumptions:

1. Slope varies from 2% for smaller dia. pipes to 0.5% for large dia. pipes.
2. Maximum headwater depth is set at 3 feet above the pipe crown.
3. Tailwater is set equal to the half the diameter of the pipe.

Round Concrete or Polyethylene

Pipe Size (in)	n-value	assum'd Length (ft)	assum'd slope (ft/ft)	Headwtr (ft)	Tailwtr (ft)	Calc'd Capacity (cfs)
12	0.013	300	0.02	4.0	0.5	5.8
15	0.013	300	0.02	4.3	0.6	10.2
18	0.013	300	0.02	4.5	0.8	16.2
24	0.013	300	0.02	5.0	1.0	30.2
30	0.013	300	0.01	5.5	1.3	47.3
36	0.013	300	0.01	6.0	1.5	70.9
42	0.013	300	0.01	6.5	1.8	98.5
48	0.013	300	0.005	7.0	2.0	128.5
54	0.013	300	0.005	7.5	2.3	169.0
60	0.013	300	0.005	8.0	2.5	212.5
72	0.013	300	0.005	9.0	3.0	316.7
84	0.013	300	0.005	10.0	3.5	445.3

Round CMP

Pipe Size (in)	n-value	assum'd Length (ft)	assum'd slope (ft/ft)	Headwtr (ft)	Tailwtr (ft)	Calc'd Capacity (cfs)
12	0.024	300	0.02	4.0	0.5	3.3
15	0.024	300	0.02	4.3	0.6	5.9
18	0.024	300	0.02	4.5	0.8	9.5
24	0.024	300	0.02	5.0	1.0	20.3
30	0.024	300	0.01	5.5	1.3	30.0
36	0.024	300	0.01	6.0	1.5	48.0
42	0.024	300	0.01	6.5	1.8	71.7
48	0.024	300	0.005	7.0	2.0	89.3
54	0.024	300	0.005	7.5	2.3	120.7
60	0.024	300	0.005	8.0	2.5	158.3
72	0.024	300	0.005	9.0	3.0	251.7
84	0.024	300	0.005	10.0	3.5	371.1

Manning Roughness Values
City of Woodinville
created by: sjs
checked by: jlc

Purpose: Assign Manning's roughness values to pipes materials reported by GIS database

Material reported by GIS	Assigned Manning's Roughness
CMP	0.024
CONC	0.013
Concrete	0.013
CP	0.024
CPEP	0.011
DI	0.013
HDPE	0.011
OTHER	0.024
PCV	0.011
PVC	0.011
Steel	0.013
0	0.024
(blank)	0.024
????	0.024

note: blank and unknown values are conservatively assumed to have an n-value of 0.024.

Hydraulic Capacity Performance Analysis
City of Woodinville
created by: sjs/jlc
checked by: sjs

Purpose: A hydraulic capacity performance analysis for selected pipe segments throughout the City is summarized below.
Method:

1. Input pipe segment related to the GIS database pipe ID.
2. Input combined subbasin ID based on location of pipe and contributing subbasins.
3. 25-yr and 100-yr peak discharges are looked up automatically from SBUH calculation spreadsheet.
4. Pipe size and type are looked up from GIS database.
5. Approximate capacity is looked up from pipe capacity calculations.
6. Percent capacity during 25-year peak flow event equal to 25-year peak dischage divided by approximate capacity.

Pipe ID	combined subbasin ID	25-yr Peak Discharge (cfs)	100-yr Peak Discharge (cfs)	Pipe Size (in)	Pipe Type	n-value	Approx. Capacity (cfs)	Percent Capacity during 25-yr Peak Flow	comment
CB20052CB20627	JC10+	31.5	41.4	36	Concrete	0.013	70.9	44%	
CB20046CB20052	JC10+	31.5	41.4	36	Concrete	0.013	70.9	44%	
CB20048CB20046	JC11+	9.4	12.8	24	CMP	0.024	20.3	47%	
CB1233CB20048	JC11	4.0	5.4	12	Concrete	0.013	5.8	69%	
CB20537CB20048	JC12	6.4	8.7	24	Concrete	0.013	30.2	21%	
CB20538CB20537	JC12	6.4	8.7	24	Concrete	0.013	30.2	21%	
IO1235CB20046	JC13	21.6	27.9	24	CMP	0.024	20.3	106%	
IO1843IO2640	LBE05	6.5	8.4	12	0	0.024	3.3	198%	
CB2294IO2932	LBE05	6.5	8.4	12	Concrete	0.013	5.8	112%	
IO2442CB2292	LBE05	6.5	8.4	12	HDPE	0.011	5.8	112%	
IO2443IO3208	LBE05	6.5	8.4	12	Concrete	0.013	5.8	112%	
CB2295IO2933	LBE05	6.5	8.4	12	Concrete	0.013	5.8	112%	
IO1088UNDEFINED	LBE11+	47.0	59.4	42	CMP	0.024	71.7	66%	
CB3142IO1089	LBE11+	47.0	59.4	18	HDPE	0.011	16.2	291%	
IO1090CB3142	LBE11+	47.0	59.4	18	CONC	0.013	16.2	291%	
IO1097IO1096	LBE15+	31.9	41.2	18	OTHER	0.024	9.5	335%	
CB21120IO1154	LBE13.5	1.1	1.7	12	CMP	0.024	3.3	34%	
CB3277CB3278	LBE13.5	1.1	1.7	12	CMP	0.024	3.3	34%	
CB3274CB3277	LBE13.5	1.1	1.7	12	CMP	0.024	3.3	34%	
CB21118CB21116	LBE13.5	1.1	1.7	12	CMP	0.024	3.3	34%	
CB21117CB21118	LBE13.5	1.1	1.7	48	CMP	0.024	89.3	1%	
IO1156IO1155	LBE14+	18.1	23.4	24	CMP	0.024	20.3	89%	
CB21121IO1157	LBE14+	18.1	23.4	24	CONC	0.013	30.2	60%	
CB3280CB21121	LBE14+	18.1	23.4	24	CONC	0.013	30.2	60%	
CB3281CB3280	LBE14+	18.1	23.4	24	CMP	0.024	20.3	89%	
CB21122CB3281	LBE14+	18.1	23.4	24	CONC	0.013	30.2	60%	
UNDEFINEDCB21028	LBE15	5.8	7.2	18	HDPE	0.011	16.2	36%	
CB21129CB21128	LBE15	5.8	7.2	18	HDPE	0.011	16.2	36%	
CB21130CB21129	LBE15	5.8	7.2	18	HDPE	0.011	16.2	36%	
CB21131CB21130	LBE15	5.8	7.2	15	DI	0.013	10.2	57%	
IO1241IO1489	LBE10+	40.9	55.7	48	Concrete	0.013	128.5	32%	
CB21145IO1490	LBE10+	40.9	55.7	48	DI	0.013	128.5	32%	
IO1080CB21145	LBE10+	40.9	55.7	48	DI	0.013	128.5	32%	
IO1082IO1081	LBE10+	40.9	55.7	36	CONC	0.013	70.9	58%	
PIPECONNECTIO1083	LBE10+	40.9	55.7	30	Concrete	0.013	47.3	86%	
IO1240PIPECONNECT	LBE10+	40.9	55.7	30	CMP	0.024	30.0	136%	
CB20721IO1245	LBE10+	40.9	55.7	36	CMP	0.024	48.0	85%	
CB20611CB20721	LBE10+	40.9	55.7	36	HDPE	0.011	70.9	58%	
CB20606CB20611	LBE10+	40.9	55.7	36	HDPE	0.011	70.9	58%	
IO1231CB20606	LBE10+	40.9	55.7	36	HDPE	0.011	70.9	58%	
CB20739CB2028	LBE16	3.7	4.6	12	0	0.024	3.3	114%	
CB2643CB20739	LBE16	3.7	4.6	60	CMP	0.024	158.3	2%	
CB20316CB2028	LBE17+	29.5	40.9	12	HDPE	0.011	5.8	510%	
CB21110IO1151	LBE17+	29.5	40.9	18	CONC	0.013	16.2	183%	
CB21111CB21110	LBE17++	17.9	23.7	24	CMP	0.024	20.3	88%	
CB21112CB21111	LBE17++	17.9	23.7	24	CMP	0.024	20.3	88%	
CB21113CB21112	LBE17++	17.9	23.7	24	CMP	0.024	20.3	88%	
CB21114CB21113	LBE17++	17.9	23.7	24	CMP	0.024	20.3	88%	
CB21115CB21114	LBE18	7.0	9.7	24	CMP	0.024	20.3	35%	
CB3253CB21115	LBE18	7.0	9.7	12	CMP	0.024	3.3	213%	
CB21033IO1099	LBE30	6.7	8.3	24	CMP	0.024	20.3	33%	
CB2493CB21033	LBE30	6.7	8.3	24	CMP	0.024	20.3	33%	

Hydraulic Capacity Performance Analysis
City of Woodinville
created by: sjs/jlc
checked by: sjs

Purpose: A hydraulic capacity performance analysis for selected pipe segments throughout the City is summarized below.
Method:

1. Input pipe segment related to the GIS database pipe ID.
2. Input combined subbasin ID based on location of pipe and contributing subbasins.
3. 25-yr and 100-yr peak discharges are looked up automatically from SBUH calculation spreadsheet.
4. Pipe size and type are looked up from GIS database.
5. Approximate capacity is looked up from pipe capacity calculations.
6. Percent capacity during 25-year peak flow event equal to 25-year peak dischage divided by approximate capacity.

Pipe ID	combined subbasin ID	25-yr Peak Discharge (cfs)	100-yr Peak Discharge (cfs)	Pipe Size (in)	Pipe Type	n-value	Approx. Capacity (cfs)	Percent Capacity during 25-yr Peak Flow	comment
IO3270CB2493	LBE30	6.7	8.3	18	0	0.024	9.5	70%	
IO3269CB2493	LBE30	6.7	8.3	18	CMP	0.024	9.5	70%	
IO1296CB20324	LBE30	6.7	8.3	24	Concrete	0.013	30.2	22%	
CB3161IO1101	LBE30	6.7	8.3	18	CMP	0.024	9.5	70%	
CB21035CB3161	LBE30	6.7	8.3	18	CMP	0.024	9.5	70%	
CB3160CB21035	LBE30	6.7	8.3	12	PVC	0.011	5.8	115%	
CB3159CB3160	LBE30	6.7	8.3	12	PVC	0.011	5.8	115%	
CB21034CB3159	LBE30	6.7	8.3	18	CONC	0.013	16.2	41%	
CB3158CB21034	LBE30	6.7	8.3	18	CMP	0.024	9.5	70%	
CB3172CB21046	LBE48	3.9	5.0	18	CMP	0.024	9.5	41%	
IO1107CB3172	LBE48	3.9	5.0	18	CONC	0.013	16.2	24%	
CB3181IO1122	LBE40+	25.1	32.0	18	CMP	0.024	9.5	263%	
CB3180CB3181	LBE40+	25.1	32.0	18	CMP	0.024	9.5	263%	
IO1158IO1117	LBE40+	25.1	32.0	36	CONC	0.013	70.9	35%	
CB1812IO1495	LBE41+	13.1	16.9	24	Concrete	0.013	30.2	43%	
IO1243CB1812	LBE41+	13.1	16.9	24	Concrete	0.013	30.2	43%	
IO3303IO3304	LBE41+	13.1	16.9	60	CMP	0.024	158.3	8%	
PIPECONNECTIO1415	LBE41+	13.1	16.9	72	CMP	0.024	251.7	5%	
CB20232PIPECONNECT	LBE41+	13.1	16.9	24	CMP	0.024	20.3	64%	
IO1184CB20232	LBE42+	4.4	6.2	72	CMP	0.024	251.7	2%	
IO3265IO3266	LBE42+	4.4	6.2	72	CMP	0.024	251.7	2%	
CB20295IO1590	LBE44	1.7	2.0	30	Concrete	0.013	47.3	4%	
CB20231CB20232	LBE45+	7.3	9.0	18	Concrete	0.013	16.2	45%	
CB21090CB21091	LBE45+	7.3	9.0	18	CONC	0.013	16.2	45%	
CB20701CB21090	LBE45+	7.3	9.0	18	CONC	0.013	16.2	45%	
CB20702CB20701	LBE45+	7.3	9.0	24	CMP	0.024	20.3	36%	
CB2581CB2590	LBE45+	7.3	9.0	24	Concrete	0.013	30.2	24%	
CB2582CB2581	LBE45+	7.3	9.0	24	Concrete	0.013	30.2	24%	
CB2583CB2582	LBE45+	7.3	9.0	24	CMP	0.024	20.3	36%	
CB2579CB2583	LBE45+	7.3	9.0	24	CMP	0.024	20.3	36%	
CB2580CB2579	LBE43	2.3	2.8	18	CMP	0.024	9.5	24%	
CB2578CB2580	LBE43	2.3	2.8	24	CMP	0.024	20.3	11%	
CB20502CB2578	LBE43	2.3	2.8	24	CMP	0.024	20.3	11%	
CB20501CB20502	LBE43	2.3	2.8	15	CMP	0.024	5.9	39%	
CB20500CB20501	LBE43	2.3	2.8	15	CMP	0.024	5.9	39%	
IO1016IO1015	LBW15+	3.1	4.9	24	CONC	0.013	30.2	10%	
CB3044CB3043	LBW15	3.8	5.2	12	HDPE	0.011	5.8	65%	
CB0935CB3044	LBW15	3.8	5.2	12	HDPE	0.011	5.8	65%	
CB3045CB0935	LBW15	3.8	5.2	12	HDPE	0.011	5.8	65%	
IO1018CB3045	LBW15	3.8	5.2	12	HDPE	0.011	5.8	65%	
IO1006IO1005	LBW21	0.0	0.1	18	CONC	0.013	16.2	0%	
CB3016IO1003	LBW30	2.1	3.3	12	CONC	0.013	5.8	36%	
CB3016IO1003	LBW40+	14.0	21.3	12	CONC	0.013	5.8	242%	
PIPECONNECTIO1002	LBW40+	14.0	21.3	36	CMP	0.024	48.0	29%	
CB3001PIPECONNECT	LBW40+	14.0	21.3	18	CMP	0.024	9.5	147%	
CB20748IO2724	LBW45	9.0	13.6	12	Concrete	0.013	5.8	156%	
CB20356CB20748	LBW45	9.0	13.6	18	HDPE	0.011	16.2	56%	
CB2657CB20356	LBW45	9.0	13.6	18	HDPE	0.011	16.2	56%	
CB2555CB2556	LBW50+	2.7	3.9	12	CMP	0.024	3.3	83%	
CB2375IO1569	LBW55	2.8	3.9	12	HDPE	0.011	5.8	49%	
CB2173CB2375	LBW55	2.8	3.9	12	HDPE	0.011	5.8	49%	
CB20532IO1575	LBW60+	14.1	19.7	24	CMP	0.024	20.3	70%	

Hydraulic Capacity Performance Analysis
City of Woodinville
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Purpose: A hydraulic capacity performance analysis for selected pipe segments throughout the City is summarized below.
Method:

1. Input pipe segment related to the GIS database pipe ID.
2. Input combined subbasin ID based on location of pipe and contributing subbasins.
3. 25-yr and 100-yr peak discharges are looked up automatically from SBUH calculation spreadsheet.
4. Pipe size and type are looked up from GIS database.
5. Approximate capacity is looked up from pipe capacity calculations.
6. Percent capacity during 25-year peak flow event equal to 25-year peak dischage divided by approximate capacity.

Pipe ID	combined subbasin ID	25-yr Peak Discharge (cfs)	100-yr Peak Discharge (cfs)	Pipe Size (in)	Pipe Type	n-value	Approx. Capacity (cfs)	Percent Capacity during 25-yr Peak Flow	comment
CB20531CB20532	LBW60+	14.1	19.7	18	CMP	0.024	9.5	148%	
CB20325IO1502	LBW65	23.8	31.5	28	0	0.024	20.3	118%	
PIPECONNECTCB20325	LBW65	23.8	31.5	24	CPEP	0.011	30.2	79%	
CB20722PIPECONNECT	LBW65	23.8	31.5	24	CMP	0.024	20.3	118%	
CB20333CB20722	LBW65	23.8	31.5	24	CMP	0.024	20.3	118%	
CB20332CB20333	LBW65	23.8	31.5	24	CMP	0.024	20.3	118%	
CB2610IO1646	LBW65	23.8	31.5	12	CMP	0.024	3.3	726%	
CB20331CB2076	LBW65	23.8	31.5	18	CMP	0.024	9.5	250%	
CB20919CB20899	LL10+	30.4	44.3	24	CMP	0.024	20.3	150%	
CB20900CB20919	LL10+	30.4	44.3	24	CMP	0.024	20.3	150%	
IO1883CB20900	LL10+	30.4	44.3	24	Concrete	0.013	30.2	101%	
IO2115CB0822	SS10+	30.8	45.6	18	CMP	0.024	9.5	323%	
IO1884IO2704	LL80	7.7	11.7	12	Concrete	0.013	5.8	133%	
IO1676CB20723	LL80	7.7	11.7	12	CPEP	0.011	5.8	133%	
CB0644CB0645	LL20	5.2	8.7	12	Concrete	0.013	5.8	89%	
IO2104CB0644	LL20	5.2	8.7	12	HDPE	0.011	5.8	89%	
IO2151CB21147	LL30+	34.3	51.7	24	CMP	0.024	20.3	169%	
CB20763IO2667	LL40+	32.0	47.4	24	0	0.024	20.3	158%	
IO1837CB20763	LL40+	32.0	47.4	24	0	0.024	20.3	158%	
IO1029IO1030	LL40+	32.0	47.4	24	CONC	0.013	30.2	106%	
CB2990IO2924	LL60	20.9	31.6	12	HDPE	0.011	5.8	361%	
IO2428CB2990	LL60	20.9	31.6	12	HDPE	0.011	5.8	361%	
IO2429IO2925	LL70	6.3	9.0	12	CMP	0.024	3.3	191%	
IO2485IO3247	SN20	8.8	13.7	24	Concrete	0.013	30.2	29%	
IO2482IO3246	SN20	8.8	13.7	24	Concrete	0.013	30.2	29%	
IO2482IO3246	SRN10	5.5	6.9	24	Concrete	0.013	30.2	18%	
CB23024CB20675	SRN20+	16.0	20.8	30	CMP	0.024	30.0	53%	
CB20190VT	SRN20	10.4	13.7	24	CMP	0.024	20.3	51%	
CB20200CB20190	SRN20	10.4	13.7	24	CMP	0.024	20.3	51%	
CB20199CB20200	SRN20	10.4	13.7	24	CMP	0.024	20.3	51%	
CB20189CB20199	SRN20	10.4	13.7	24	CMP	0.024	20.3	51%	
CB20188CB20189	SRN20	10.4	13.7	24	CMP	0.024	20.3	51%	
CB20187CB20188	SRN20	10.4	13.7	24	CMP	0.024	20.3	51%	
CB20567IO1498	SRN30	6.3	8.6	24	HDPE	0.011	30.2	21%	
CB20568CB20567	SRN30	6.3	8.6	24	HDPE	0.011	30.2	21%	
CB20150CB20568	SRN30	6.3	8.6	24	HDPE	0.011	30.2	21%	
IO1374IO1648	WC10+	57.6	75.7	48	CMP	0.024	89.3	64%	48" equivalent
IO1246IO1497	WC10+	57.6	75.7	65	Concrete	0.013	212.5	27%	
IO1191IO1422	WC10+	57.6	75.7	36	CMP	0.024	48.0	120%	
IO1192IO1423	WC10+	57.6	75.7	36	CMP	0.024	48.0	120%	
CB20588IO1571	WC11	3.9	4.7	24	CMP	0.024	20.3	19%	
CB20158CB20588	WC11	3.9	4.7	24	Concrete	0.013	30.2	13%	
CB20161CB20160	WC11	3.9	4.7	24	CPEP	0.011	30.2	13%	
CB20162CB20161	WC11	3.9	4.7	24	CPEP	0.011	30.2	13%	
CB21066CB21065	WC12+	16.5	25.8	36	CONC	0.013	70.9	23%	
CB21067CB21066	WC12+	16.5	25.8	36	CONC	0.013	70.9	23%	
CB21068CB21067	WC12+	16.5	25.8	36	CONC	0.013	70.9	23%	
CB21069CB21068	WC12+	16.5	25.8	36	CONC	0.013	70.9	23%	
CB21070CB21069	WC12+	16.5	25.8	36	CONC	0.013	70.9	23%	
CB21071CB21070	WC12+	16.5	25.8	36	CONC	0.013	70.9	23%	
CB21072CB21071	WC12+	16.5	25.8	36	CONC	0.013	70.9	23%	
CB21073CB21072	WC12+	16.5	25.8	36	CMP	0.024	48.0	34%	

Hydraulic Capacity Performance Analysis
City of Woodinville
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Purpose: A hydraulic capacity performance analysis for selected pipe segments throughout the City is summarized below.
Method:

1. Input pipe segment related to the GIS database pipe ID.
2. Input combined subbasin ID based on location of pipe and contributing subbasins.
3. 25-yr and 100-yr peak discharges are looked up automatically from SBUH calculation spreadsheet.
4. Pipe size and type are looked up from GIS database.
5. Approximate capacity is looked up from pipe capacity calculations.
6. Percent capacity during 25-year peak flow event equal to 25-year peak dischage divided by approximate capacity.

Pipe ID	combined subbasin ID	25-yr Peak Discharge (cfs)	100-yr Peak Discharge (cfs)	Pipe Size (in)	Pipe Type	n-value	Approx. Capacity (cfs)	Percent Capacity during 25-yr Peak Flow	comment
CB0542IO3228	WC13	11.0	18.5	24	CMP	0.024	20.3	54%	
CB0543CB0542	WC13	11.0	18.5	24	CMP	0.024	20.3	54%	
CB20904CB20902	WC13	11.0	18.5	24	0	0.024	20.3	54%	
CB20905CB20904	WC13	11.0	18.5	24	0	0.024	20.3	54%	
INCOMINGCB20905	WC13	11.0	18.5	24	0	0.024	20.3	54%	
CBIO2955	WC14+	4.4	7.0	12	CMP	0.024	3.3	133%	
CB0549CB0550	WC14+	4.4	7.0	12	CMP	0.024	3.3	133%	
CB0548CB0549	WC14+	4.4	7.0	12	CMP	0.024	3.3	133%	
CB0547CB0548	WC14+	4.4	7.0	12	CMP	0.024	3.3	133%	
CB0546CB0547	WC13.5	5.4	8.6	12	CMP	0.024	3.3	166%	
CB0545CB0546	WC13.5	5.4	8.6	12	CMP	0.024	3.3	166%	
CB0544CB0545	WC13.5	5.4	8.6	12	CMP	0.024	3.3	166%	
CB21074CB21063	WC15++	33.8	41.3	30	CONC	0.013	47.3	71%	
CB21075CB21074	WC15++	33.8	41.3	30	CONC	0.013	47.3	71%	
UNDEFINEDCB21075	WC15+	15.6	19.2	24	CONC	0.013	30.2	52%	
CB20745CB20743	WC15+	15.6	19.2	21	Concrete	0.013	16.2	96%	
CB20744CB20745	WC15+	15.6	19.2	21	Concrete	0.013	16.2	96%	
CB20842CB20744	WC15+	15.6	19.2	18	Concrete	0.013	16.2	96%	
CB20843CB20842	WC15+	15.6	19.2	18	Concrete	0.013	16.2	96%	
CB21097CB20843	WC15+	15.6	19.2	24	CONC	0.013	30.2	52%	
CB3239CB21097	WC15+	15.6	19.2	18	CMP	0.024	9.5	163%	
CB21098CB3239	WC15+	15.6	19.2	18	CMP	0.024	9.5	163%	
CB21099CB21098	WC15+	15.6	19.2	18	CMP	0.024	9.5	163%	
IO1135CB21099	WC15+	15.6	19.2	12	CMP	0.024	3.3	474%	
CB21095IO1132	WC15	9.8	12.4	24	CMP	0.024	20.3	48%	
IO1131CB21095	WC15	9.8	12.4	18	CMP	0.024	9.5	103%	
CB21096CB21095	WC16+	6.3	7.7	18	CMP	0.024	9.5	66%	
IO1133CB21096	WC16+	6.3	7.7	18	CMP	0.024	9.5	66%	
CB20792IO2788	WC16+	6.3	7.7	12	CMP	0.024	3.3	191%	
CB20791CB20792	WC16	4.9	6.0	18	Concrete	0.013	16.2	30%	
CB21076CB21075	WC18+	17.1	20.9	30	CONC	0.013	47.3	36%	
CB21077CB21076	WC18+	17.1	20.9	30	CMP	0.024	30.0	57%	
CB21081CB21077	WC18+	17.1	20.9	30	CMP	0.024	30.0	57%	
CB21081CB21080	WC18+	17.1	20.9	30	CMP	0.024	30.0	57%	
CB21082CB21080	WC18+	17.1	20.9	30	CMP	0.024	30.0	57%	
CB21083CB21082	WC18+	17.1	20.9	24	CONC	0.013	30.2	57%	
CB21084CB21083	WC18+	17.1	20.9	24	CONC	0.013	30.2	57%	
CB3213CB21084	WC18+	17.1	20.9	18	CONC	0.013	16.2	106%	
CB21087CB3213	WC18+	17.1	20.9	18	CONC	0.013	16.2	106%	
CB3236CB21087	WC18+	17.1	20.9	18	CONC	0.013	16.2	106%	
CB1853CB3236	WC18+	17.1	20.9	18	CMP	0.024	9.5	180%	
CB1854CB1853	WC19.1+	5.7	6.9	12	Concrete	0.013	5.8	98%	
CB1855CB1854	WC19.1+	5.7	6.9	12	Concrete	0.013	5.8	98%	
IO1379CB1855	WC19.1+	5.7	6.9	18	Concrete	0.013	16.2	35%	
CB20677IO1663	WC19.1+	5.7	6.9	24	CMP	0.024	20.3	28%	
CB20715CB20677	WC19.1+	5.7	6.9	24	Concrete	0.013	30.2	19%	
IO1237IO1485	SRE50	66.5	99.6	36	Concrete	0.013	70.9	94%	
IO1236IO1484	SRE50	66.5	99.6	36	Concrete	0.013	70.9	94%	
IO1352IO1556	SRE50	66.5	99.6	36	Concrete	0.013	70.9	94%	
CB20912IO1433	SRE40	2.9	3.6	18	CMP	0.024	9.5	31%	
CB0847CB20912	SRE40	2.9	3.6	18	CPEP	0.011	16.2	18%	
CB0842CB0847	SRE40	2.9	3.6	18	DI	0.013	16.2	18%	

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1. Input pipe segment related to the GIS database pipe ID.
2. Input combined subbasin ID based on location of pipe and contributing subbasins.
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6. Percent capacity during 25-year peak flow event equal to 25-year peak dischage divided by approximate capacity.

Pipe ID	combined subbasin ID	25-yr Peak Discharge (cfs)	100-yr Peak Discharge (cfs)	Pipe Size (in)	Pipe Type	n-value	Approx. Capacity (cfs)	Percent Capacity during 25-yr Peak Flow	comment
CB20638IO1592	SRW10+	4.9	6.3	30	0	0.024	30.0	16%	
CB20640CB20638	SRW10+	4.9	6.3	30	Concrete	0.013	47.3	10%	
IO1339CB20640	SRW10+	4.9	6.3	30	Concrete	0.013	47.3	10%	
CB1499IO1543	SRW10+	4.9	6.3	12	Concrete	0.013	5.8	85%	
CB1489CB1499	SRW10+	4.9	6.3	12	CMP	0.024	3.3	150%	
CB1488CB1489	SRW10+	4.9	6.3	12	CMP	0.024	3.3	150%	
CB1469CB1488	SRW10+	4.9	6.3	12	HDPE	0.011	5.8	85%	
CB1468CB1469	SRW10+	4.9	6.3	15	HDPE	0.011	10.2	49%	
CB1466CB1468	SRW10+	4.9	6.3	15	HDPE	0.011	10.2	49%	
CB1465CB1466	SRW10+	4.9	6.3	12	Concrete	0.013	5.8	85%	
CB20115CB1465	SRW10+	4.9	6.3	12	CMP	0.024	3.3	150%	
CB1464CB20115	SRW10+	4.9	6.3	12	HDPE	0.011	5.8	85%	
CB2539CB1464	SRW10+	4.9	6.3	12	HDPE	0.011	5.8	85%	
CB1449CB2539	SRW11de	0.5	0.7	12	0	0.024	3.3	15%	
CB2397CB1449	SRW11de	0.5	0.7	12	0	0.024	3.3	15%	
CB1448CB2397	SRW11de	0.5	0.7	12	0	0.024	3.3	15%	
CB1447CB1448	SRW11de	0.5	0.7	12	0	0.024	3.3	15%	
CB1446CB1447	SRW11de	0.5	0.7	12	0	0.024	3.3	15%	
CB1445CB1446	SRW11de	0.5	0.7	12	0	0.024	3.3	15%	
CB20108CB1445	SRW11de	0.5	0.7	12	0	0.024	3.3	15%	
CB20188IO1568	SRW11dw	7.9	10.8	24	Concrete	0.013	30.2	26%	flow split
CB1443CB20108	SRW11+	4.1	5.7	15	HDPE	0.011	10.2	40%	
CB1442CB1443	SRW11+	4.1	5.7	15	HDPE	0.011	10.2	40%	
CB1440CB1442	SRW11+	4.1	5.7	15	HDPE	0.011	10.2	40%	
CB1439CB1440	SRW11+	4.1	5.7	15	HDPE	0.011	10.2	40%	
CB1434CB1438	SRW11+	4.1	5.7	15	0	0.024	5.9	69%	
CB1433CB1434	SRW12+	4.0	5.4	15	HDPE	0.011	10.2	39%	
CB20636CB1433	SRW12+	4.0	5.4	15	CMP	0.024	5.9	68%	
CB1358CB2530	SRW12+	4.0	5.4	12	CMP	0.024	3.3	122%	
CB1359CB1358	SRW12+	4.0	5.4	12	CMP	0.024	3.3	122%	
CB1410CB1359	SRW12+	4.0	5.4	12	CMP	0.024	3.3	122%	
CB1409CB1410	SRW12+	4.0	5.4	15	0	0.024	5.9	68%	
CB1408CB1409	SRW12+	4.0	5.4	15	0	0.024	5.9	68%	
CB1407CB1408	SRW12+	4.0	5.4	15	0	0.024	5.9	68%	
CB1406CB1407	SRW12+	4.0	5.4	15	HDPE	0.011	10.2	39%	
CB1405CB2396	SRW11dw	7.9	10.8	18	Concrete	0.013	16.2	49%	flow split
CB20095CB1405	SRW13+	7.9	10.7	18	0	0.024	9.5	83%	
IO1384CB20095	SRW13+	7.9	10.7	18	0	0.024	9.5	83%	
IO1383IO1550	SRW13+	7.9	10.7	12	HDPE	0.011	5.8	137%	
IO1385IO1662	SRW13+	7.9	10.7	12	CMP	0.024	3.3	242%	
CB20631IO1475	SRW14+	6.0	8.1	12	CMP	0.024	3.3	182%	
CB2536CB20631	SRW14+	6.0	8.1	15	CMP	0.024	5.9	101%	
CB20633CB2536	SRW14+	6.0	8.1	15	CMP	0.024	5.9	101%	
CB20085IO1482	SRW15	2.7	3.8	18	0	0.024	9.5	29%	
CB20119OUTBOUND	SRW70+	14.9	20.5	30	0	0.024	30.0	50%	
CB1504CB20119	SRW70+	14.9	20.5	30	CMP	0.024	30.0	50%	
CB20663IO1477	SRW71+	7.8	10.7	24	HDPE	0.011	30.2	26%	
CB20099CB20663	SRW71+	7.8	10.7	12	HDPE	0.011	5.8	134%	
CB2396CB20099	SRW71+	7.8	10.7	24	HDPE	0.011	30.2	26%	
IO1284CB2396	SRW72	1.4	1.9	12	0	0.024	3.3	44%	
CB20103IO1552	SRW72	1.4	1.9	12	CMP	0.024	3.3	44%	
CB20104CB20103	SRW72	1.4	1.9	12	Concrete	0.013	5.8	25%	

Hydraulic Capacity Performance Analysis
City of Woodinville
created by: sjs/jlc
checked by: sjs

Purpose: A hydraulic capacity performance analysis for selected pipe segments throughout the City is summarized below.
Method:

1. Input pipe segment related to the GIS database pipe ID.
2. Input combined subbasin ID based on location of pipe and contributing subbasins.
3. 25-yr and 100-yr peak discharges are looked up automatically from SBUH calculation spreadsheet.
4. Pipe size and type are looked up from GIS database.
5. Approximate capacity is looked up from pipe capacity calculations.
6. Percent capacity during 25-year peak flow event equal to 25-year peak dischage divided by approximate capacity.

Pipe ID	combined subbasin ID	25-yr Peak Discharge (cfs)	100-yr Peak Discharge (cfs)	Pipe Size (in)	Pipe Type	n-value	Approx. Capacity (cfs)	Percent Capacity during 25-yr Peak Flow	comment
CB20106CB20104	SRW72	1.4	1.9	12	CMP	0.024	3.3	44%	
IO1285CB20106	SRW72	1.4	1.9	12	CMP	0.024	3.3	44%	
CB2419IO1451	SRW20	7.2	9.5	18	Concrete	0.013	16.2	45%	
CB1565CB2419	SRW20	7.2	9.5	18	Concrete	0.013	16.2	45%	
CB20664IO1561	SRW31+	26.0	37.7	48	HDPE	0.011	128.5	20%	
CB20665CB20664	SRW31+	26.0	37.7	48	HDPE	0.011	128.5	20%	
IO1292IO1634	SRW33	5.1	7.3	24	HDPE	0.011	30.2	17%	
IO1386IO1470	SRW32	18.7	27.9	30	CMP	0.024	30.0	62%	
IO1256IO1588	SRW40+	23.7	36.7	36	HDPE	0.011	70.9	33%	
CB20672IO1562	SRW41+	22.7	35.0	36	Concrete	0.013	70.9	32%	
CB20137CB20672	SRW41+	22.7	35.0	24	Concrete	0.013	30.2	75%	
CB20138CB20137	SRW41+	22.7	35.0	24	0	0.024	20.3	112%	
CB20130CB20138	SRW46	5.5	9.4	15	0	0.024	5.9	93%	
CB20669CB20130	SRW46	5.5	9.4	24	PVC	0.011	30.2	18%	
CB20668CB20669	SRW46	5.5	9.4	24	PVC	0.011	30.2	18%	
CB20655CB20668	SRW46	5.5	9.4	24	PVC	0.011	30.2	18%	
CB20656CB20655	SRW46	5.5	9.4	24	PVC	0.011	30.2	18%	
CB20654CB20656	SRW46	5.5	9.4	24	PVC	0.011	30.2	18%	
IO1381CB20654	SRW46	5.5	9.4	24	DI	0.013	30.2	18%	
IO1207IO1444	SRW42+	9.8	15.6	24	Concrete	0.013	30.2	32%	
IO1207IO1444	SRW47	1.6	2.6	24	Concrete	0.013	30.2	5%	
CB20628CB20617	SRW47	1.6	2.6	18	DI	0.013	16.2	10%	
IO1279CB20628	SRW47	1.6	2.6	18	CMP	0.024	9.5	17%	
CB20559IO1429	SRW51+	11.1	15.4	24	CMP	0.024	20.3	55%	
CB20562CB20560	SRW51+	11.1	15.4	24	CMP	0.024	20.3	55%	
CB20563CB20562	SRW51+	11.1	15.4	24	CMP	0.024	20.3	55%	
CB20673CB20563	SRW51+	11.1	15.4	24	CMP	0.024	20.3	55%	
CB20561CB20673	SRW51+	11.1	15.4	24	CMP	0.024	20.3	55%	
IO1289CB20143	SRW51+	11.1	15.4	24	CMP	0.024	20.3	55%	
IO1210IO1446	SRW51+	11.1	15.4	24	Concrete	0.013	30.2	37%	
IO1298IO1639	SRW52	0.8	0.9	12	Concrete	0.013	5.8	13%	
CB2568IO1640	SRW52	0.8	0.9	12	Concrete	0.013	5.8	13%	
IO1212CB2568	SRW52	0.8	0.9	12	0	0.024	3.3	23%	
CB1052CB1051	SRW53	6.1	9.2	18	CMP	0.024	9.5	64%	
CB20011CB1052	SRW53	6.1	9.2	18	CMP	0.024	9.5	64%	
CB20012CB20011	SRW53	6.1	9.2	18	CMP	0.024	9.5	64%	
CB20013CB20012	SRW53	6.1	9.2	18	CMP	0.024	9.5	64%	
IO1358IO1578	SRW60	19.7	28.1	12	HDPE	0.011	5.8	341%	
Little Bear Creek Culverts									
IO3307IO3306		486.0	658.0	6'x10' Conc. Box			520.0	93%	from Otak Memo dated 7/11/2008
IO1008IO1395		525.0	710.0	(2) 5'x7' Conc. Box			420.0	125%	from Otak Memo dated 7/11/2008
CB20612IO1647		540.0	732.0	(2) 5.2'x7'CMPA			460.0	117%	from Otak Memo dated 7/11/2008
IO1177IO1402		548.0	742.0	(3) 5' Conc. Pipe			510.0	107%	from Otak Memo dated 7/11/2008
IO1179IO1404		559.0	756.0	6'x10' Conc. Box			520.0	108%	from Otak Memo dated 7/11/2008

	Summary
total number of pipes analyzed	298
total number of pipes greater than 100% capacity during 25-yr peak flow	74
percent of pipes greater than 100% capacity during 25-yr peak flow	25%

Appendix C—Comparison of Methods for Modeling Detention Technical Memorandum (Otak, 2009)

Technical Memorandum

10230 NE Points Drive
Suite 400
Kirkland, WA 98033
Phone (425) 822-4446
Fax (425) 827-9577

To: Tom Hanson

From: Scott Stoneman

Copies: Joe Simmler, Greg Laird

Date: November 12, 2009

Subject: Woodinville SWM Plan Update
Comparison of Methods for Modeling Detention

Project No.: 31324

Background and Rational
Per Task B5 of our Scope of Work (dated April 7, 2009), Otak has been conducting a City-wide Hydraulic Analysis to evaluate the capacity of the City's existing storm drains under both existing and future land-use conditions. The initial formulation of our model identified the contributing drainage areas for the City's network of pipes using the Santa Barbara Urban Hydrograph (SBUH) method. Initial results showed that over one-third of the storm drain pipes did not have sufficient capacity for the 25-year peak flow event, which is contrary to the City's experience.

This initial formulation of the model, appeared to be over estimating peak discharges. In order to modify the model to match observed field conditions, we adjusted the model in an attempt to include consideration for the effect that existing detention facilities were providing throughout the City.

Purpose and Objective
The purpose of this memorandum is to document the methodology that was developed in order to create a cost effective approach to estimate existing detention, match observed field conditions, and utilize the amount and type of data available from the City. Due to the limited amount of data that existed for each of the City's existing detention facilities, alternative methods were developed and tested to account for detention, without conducting flow routing through each individual detention facility.

Approach and Methodology
Detention facilities are designed to reduce the release rate of stormwater to a pre-developed condition. Currently, the state, county, and City standard for the pre-developed condition is defined as the forested condition. However, prior to 2005, the pre-developed condition was defined to be

the existing land use condition at or before 1979, which was typically forest or grass for the larger developments.

By reassigning the runoff curve number for those subbasins that have detention facilities to a value more similar to pre-developed land cover, the runoff from that subbasin into the City's storm drain could be modified to more closely approximate the performance of the detention facility.

To test this hypothesis, we compared our initial model formulation to a new revised model formulation using the adjusted Curve Number, and also using a formulation that included detention routing. To accomplish this comparison, the SBUH method was used to determine the size of the detention facility that met the targeted release rate. Three formulations were compared: the initial model formulation without detention, the model formulation using detention routing, and the model formulation where the Curve Number was adjusted to approximate detention.

These three model formulations were compared and contrasted under eight different scenarios, as presented in Table 1. Initial runoff rates were tested using four different hydrologic soil groups. Also tested was the significance of the proportion of the subbasin that is served by the detention facility.

Results
Table 1 summarizes the results of modeling detention by routing and by adjusting the Curve Number in terms of percent reduction in peak discharge, as compared to modeling a basin without detention (i.e. the initial model formulation).

Table 1
Comparison of Methods for Modeling Detention

Case No.	NRCS Hydrologic Soil Goup	Portion of Basin with Detention	Adjusted CN	Percent Reduction in Peak Discharge - Detention Routing	Percent Reduction in Peak Discharge – Adjusted Curve Number	Difference in Methods
1	A	20%	60	40%	45%	5%
2	A	50%	60	74%	77%	3%
3	B	20%	65	39%	40%	1%
4	B	50%	65	72%	71%	1%
5	C	20%	70	34%	35%	1%
6	C	50%	70	62%	63%	1%
7	D	20%	80	24%	23%	1%
8	D	50%	80	45%	45%	<1%

The adjusted Curve Numbers used in this analysis, as seen in Table 1, are higher than the pre-developed forested Curve Numbers. These Curve Numbers were increased in order to reduce the over-attenuation effects of the composite Curve Numbers and to better match the detention routing method. Detail spreadsheets are attached.

The results show that taking into account detention can significantly reduce the peak discharge, even when only as little as 20 percent of the basin is routed though detention. Comparing the detention routing and adjusted Curve Number together, there is a 1- 5 percent difference in the cases tested.

Recommendations

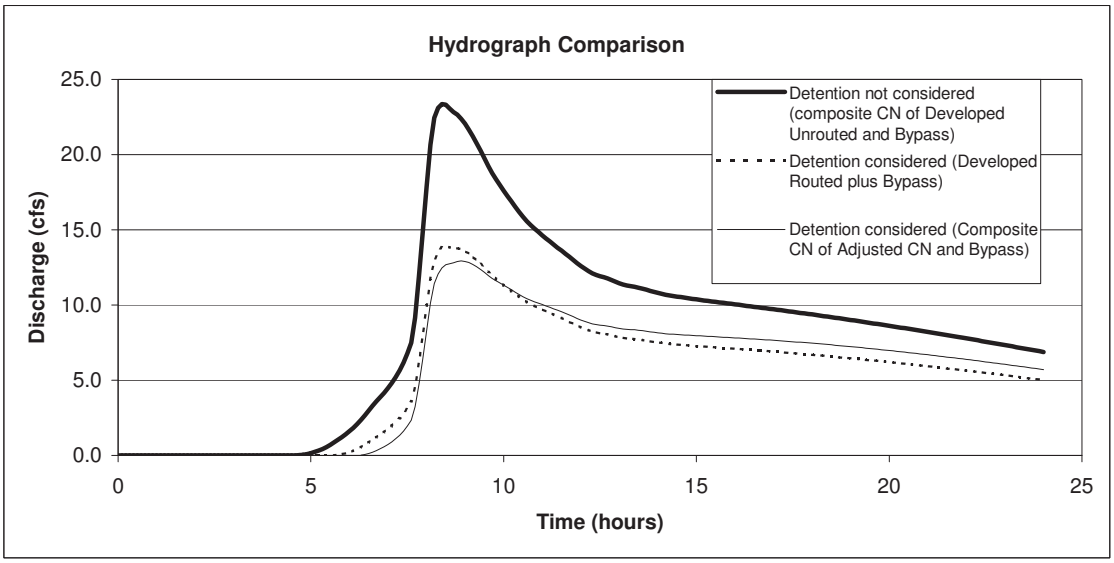
Based on these results, the Curve Number was adjusted to reflect pre-development (forested) conditions in order to account for detention in the City-Wide Hydraulic Analysis. However, the age of the detention facility would also need to be considered in the selection of the appropriate Curve Number.

Design requirements for pond sizing have become more stringent over the years. Prior to 1990, ponds were sized using the Y&W method, which resulted in small detention facilities that did not significantly reduce the peak flow. Between 1990 and 1998, ponds were sized using the SBUH method, which resulted in pond sizes of approximately 8,000 cubic feet (cf) per developed impervious acre. After 1998, ponds were sized using the KCRTS methodology, which resulted in pond sizes of approximately 18,000 cf per developed impervious acre.

In order to take into account of the larger ponds sized after 1998, the Curve Number is adjusted to 60. This is similar to ponds sized using the SBUH method for Type A soils, as in Cases 1 and 2. Cases 1 and 2 included ponds that had a total detention storage of 11,000 cf per developed impervious acre, which is the maximum volume of runoff generated from the 24-hour, 25-year event. For the ponds built between 1990 and 1998, the Curve Number shown in Table 1 are recommended. Detention facilities constructed prior to 1990 will not be included in the City-wide Hydraulic Analysis since they do not appreciably reduce peak discharges.

Attachments

Comparison of Methods for Modeling Detention -
Case 1 (Type A soil, 20% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	100.0	25.0	25.0	25.0		125.0		125.0
cn	78.0	98.0	30.0	60.0		82.0		74.4
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	13.91	13.94	0.00	0.78	0.00	**23.37**	**13.91**	**12.93**
						Reduction in Peak Discharge ->	**40%**	**45%**
						Percent difference ->		**4%**

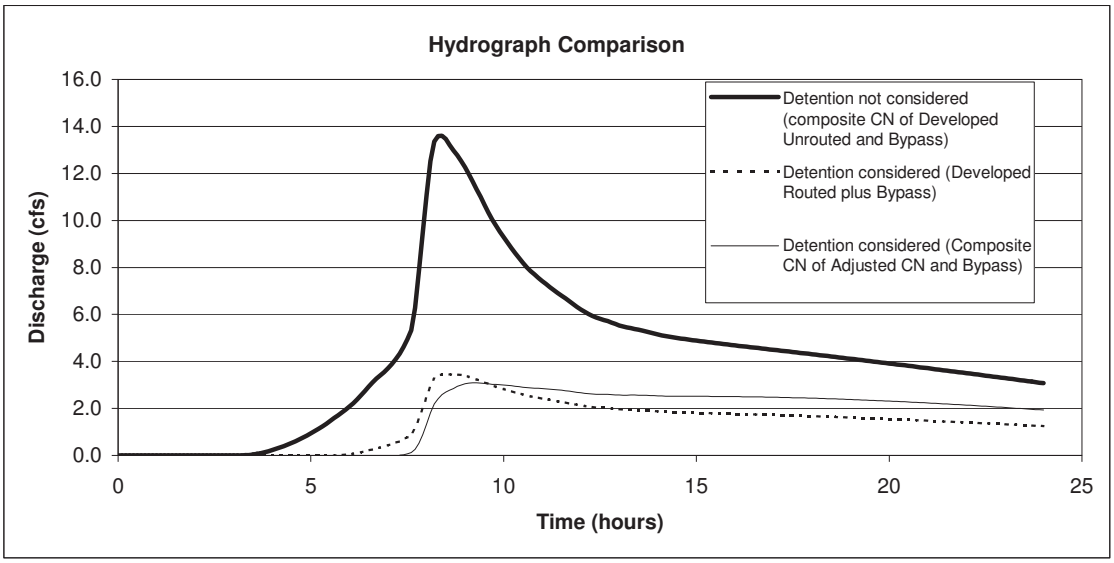
1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in) 0.01 <- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft) 10
total volume used (ac-ft) 6.3
total volume used (cf/ac) 11000

stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.00
2	2	0.00
4	4	0.00
6	6	0.00
8	8	0.00
10	10	0.00

25-yr precip (in) 3.3
SCS Storm Type IA

Comparison of Methods for Modeling Detention -
Case 2 (Type A soil, 50% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	25.0	25.0	25.0	25.0		50.0		50.0
cn	78.0	98.0	30.0	60.0		88.0		69.0
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	3.48	13.94	0.00	0.78	0.00	**13.61**	**3.48**	**3.09**
						Reduction in Peak Discharge ->	**74%**	**77%**
						Percent difference ->		**3%**

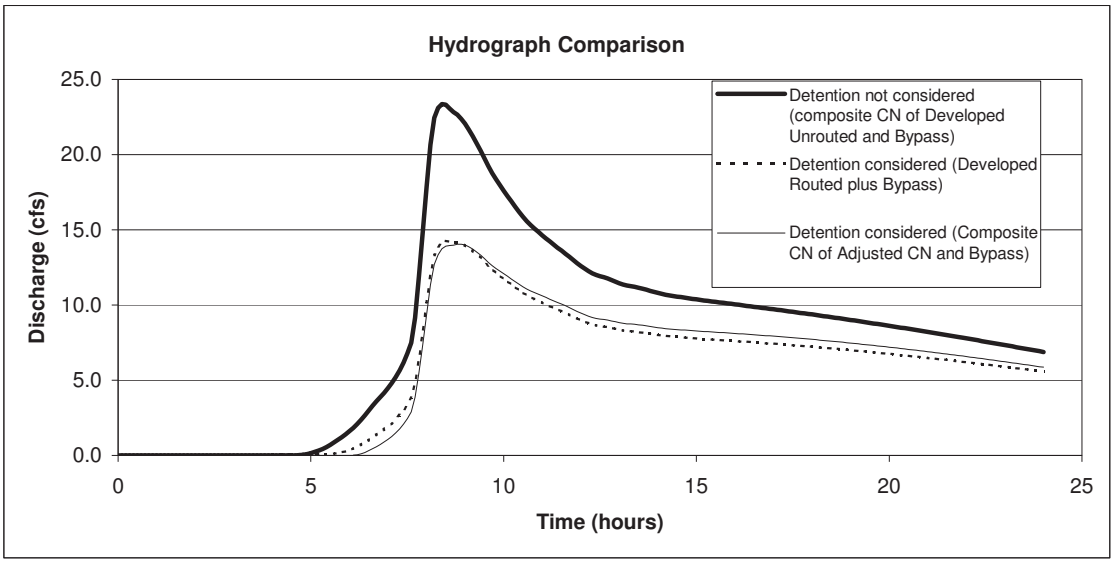
1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in) 0.01 <- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft) 10
total volume used (ac-ft) 6.3
total volume used (cf/ac) 11000

stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.0
2	2	0.0
4	4	0.0
6	6	0.0
8	8	0.0
10	10	0.0

25-yr precip (in) 3.3
SCS Storm Type IA

Comparison of Methods for Modeling Detention -
Case 3 (Type B soil, 20% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	100.0	25.0	25.0	25.0		125.0		125.0
cn	78.0	98.0	55.0	65.0		82.0		75.4
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	13.91	13.94	0.56	1.15	0.58	**23.37**	**14.27**	**14.05**
						Reduction in Peak Discharge ->	**39%**	**40%**
						Percent difference ->		**1%**

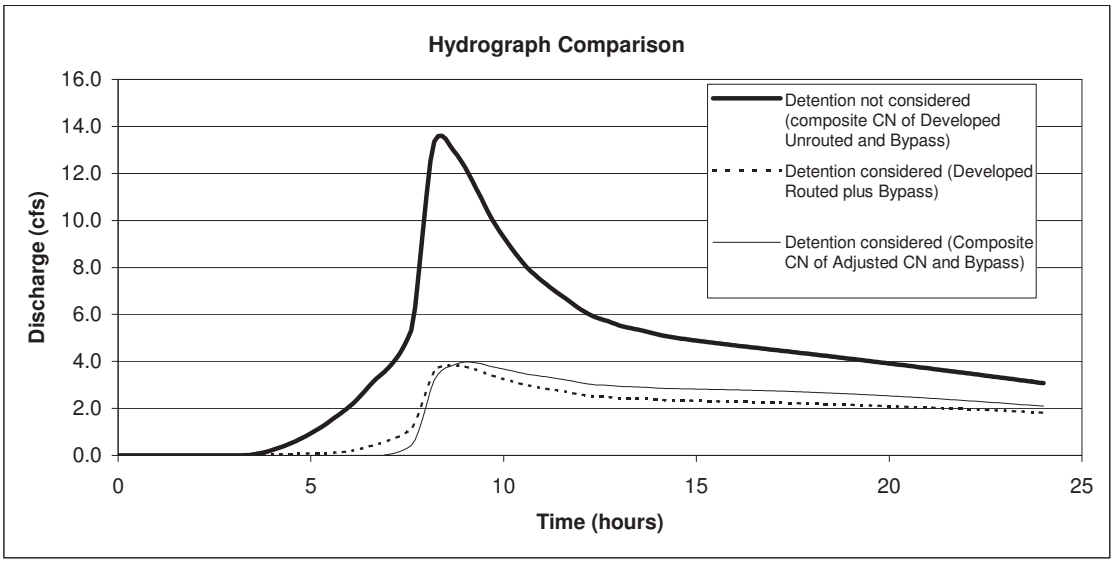
1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in)	3	<- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft)	10	
total volume used (ac-ft)	5.6	
total volume used (cf/ac)	9700	

stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.0
2	2	0.3
4	4	0.5
6	6	0.6
8	8	0.7
10	10	0.8

25-yr precip (in)	3.3
SCS Storm	Type IA

Comparison of Methods for Modeling Detention -
Case 4 (Type B soil, 50% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	25.0	25.0	25.0	25.0		50.0		50.0
cn	78.0	98.0	55.0	65.0		88.0		71.5
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	3.48	13.94	0.56	1.15	0.58	**13.61**	**3.84**	**3.98**
Reduction in Peak Discharge ->							**72%**	**71%**
Percent difference ->								**1%**

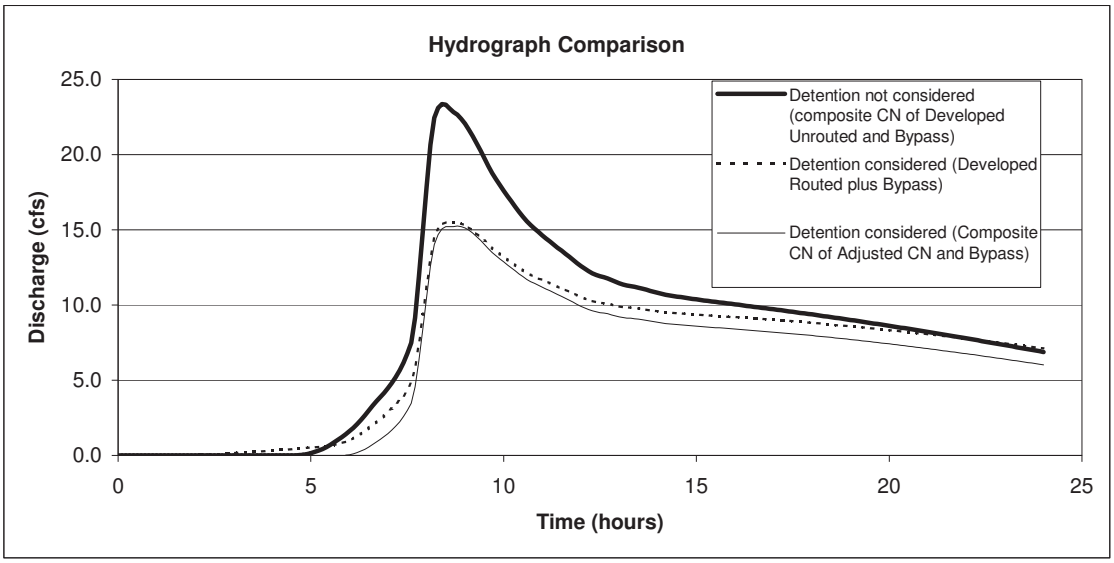
1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in)	3	<- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft)	10	
total volume used (ac-ft)	5.6	
total volume used (cf/ac)	9700	

stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.0
2	2	0.3
4	4	0.5
6	6	0.6
8	8	0.7
10	10	0.8

25-yr precip (in)	3.3
SCS Storm	Type IA

Comparison of Methods for Modeling Detention -
Case 5 (Type C soil, 20% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	100.0	25.0	25.0	25.0		125.0		125.0
cn	78.0	98.0	70.0	70.0		82.0		76.4
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	13.91	13.94	2.16	2.16	2.13	**23.37**	**15.50**	**15.24**
						Reduction in Peak Discharge ->	**34%**	**35%**
						Percent difference ->		**1%**

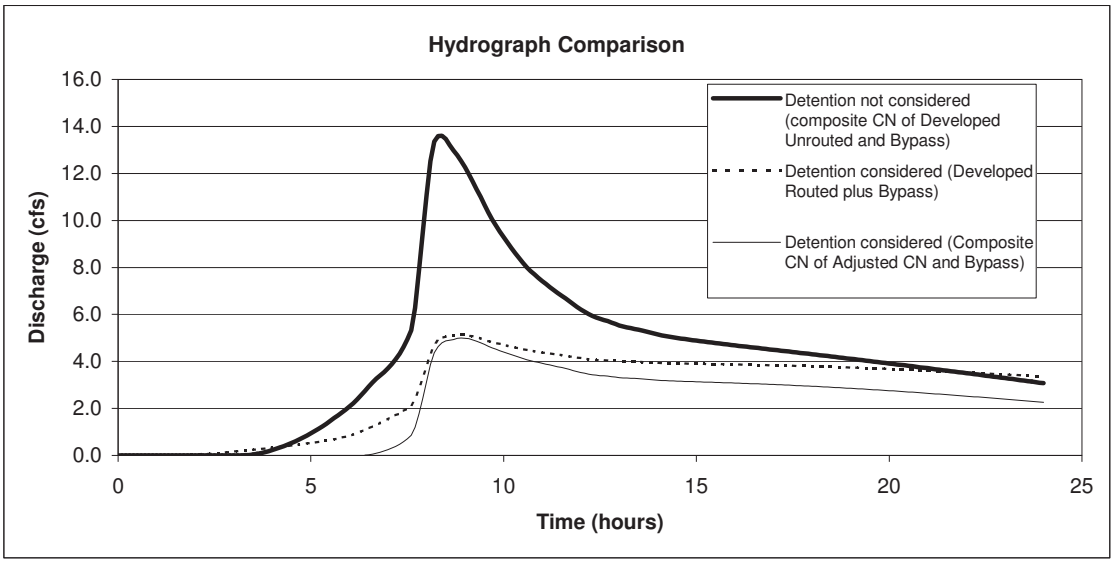
1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in)	5.5	<- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft)	5	
total volume used (ac-ft)	3.4	
total volume used (cf/ac)	5900	

stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.0
2	1	1.2
4	2	1.6
6	3	2.0
8	4	2.3
10	5	2.6

25-yr precip (in)	3.3
SCS Storm	Type IA

Comparison of Methods for Modeling Detention -
Case 6 (Type C soil, 50% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	25.0	25.0	25.0	25.0		50.0		50.0
cn	78.0	98.0	70.0	70.0		88.0		74.0
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	3.48	13.94	2.16	2.16	2.13	**13.61**	**5.14**	**4.99**
						Reduction in Peak Discharge ->	**62%**	**63%**
						Percent difference ->		**1%**

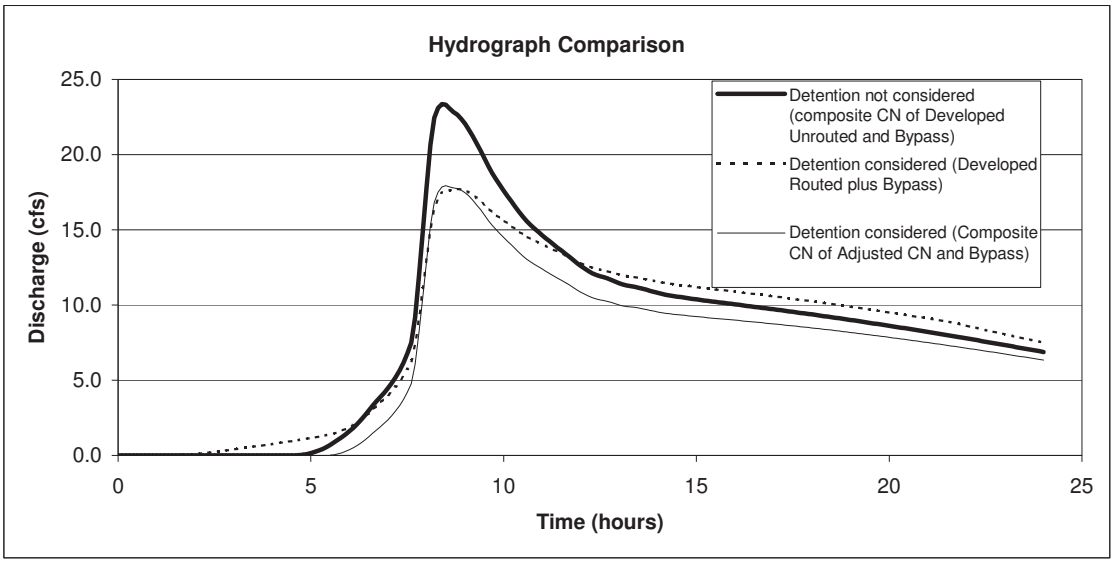
1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in)	5.5	<- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft)	5	
total volume used (ac-ft)	3.4	
total volume used (cf/ac)	5900	

stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.0
2	1	1.2
4	2	1.6
6	3	2.0
8	4	2.3
10	5	2.6

25-yr precip (in)	3.3
SCS Storm	Type IA

Comparison of Methods for Modeling Detention -
Case 7 (Type D soil, 20% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	100.0	25.0	25.0	25.0		125.0		125.0
cn	78.0	98.0	77.0	80.0		82.0		78.4
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	13.91	13.94	4.36	5.53	4.33	**23.37**	**17.72**	**17.94**
						Reduction in Peak Discharge ->	**24%**	**23%**
						Percent difference ->		**1%**

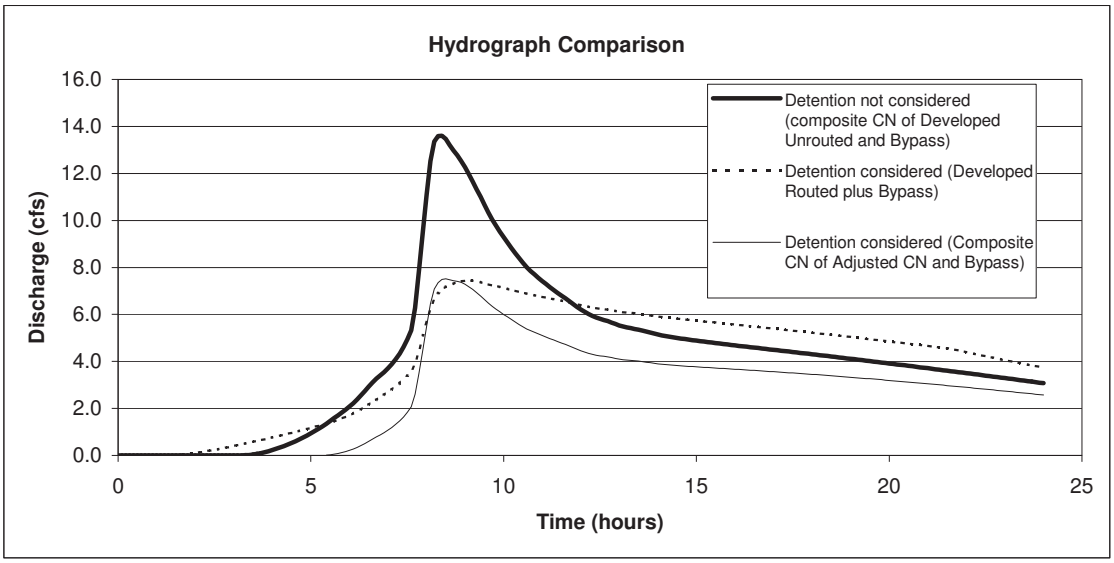
1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in)	9	<- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft)	5	
total volume used (ac-ft)	2.0	
total volume used (cf/ac)	3400	

stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.0000
2	1	3.1070
4	2	4.3940
6	3	5.3815
8	4	6.2140
10	5	6.9475

25-yr precip (in)	3.3
SCS Storm	Type IA

Comparison of Methods for Modeling Detention -
Case 8 (Type D soil, 50% of basin has detention)
City-Wide Hydraulic Analysis - City of Woodinville
created by: sjs
checked by:



	Bypass Area[1]	Developed Unrouted	Pre-developed	Adjusted CN[2]	Developed Routed[3]	Detention not considered (composite CN of Developed Unrouted and Bypass)	Detention considered (Developed Routed plus Bypass)	Detention considered (Composite CN of Adjusted CN and Bypass)
area (ac)	25.0	25.0	25.0	25.0		50.0		50.0
cn	78.0	98.0	77.0	80.0		88.0		79.0
tc (min)	60.0	30.0	30.0	30.0		60.0		60.0
peak discharge (cfs) ->	3.48	13.94	4.36	5.53	4.33	**13.61**	**7.44**	**7.52**
						Reduction in Peak Discharge ->	**45%**	**45%**
						Percent difference ->		**1%**

1. Assume CN value of 78 for bypass area because that is approximately the calculated average CN value for the City-wide Analysis.
2. Adjust Pre-developed CN so that both methods of considering detention match best.
3. Route using Modified Puls (Level-Pool) using the following facility, which matches the predeveloped discharge.

orifice dia (in)	9	<- adjust orifice so that developed routed discharge matches predeveloped discharge.
total volume (ac-ft)	5	
total volume used (ac-ft)	2.0	
total volume used (cf/ac)	3400	

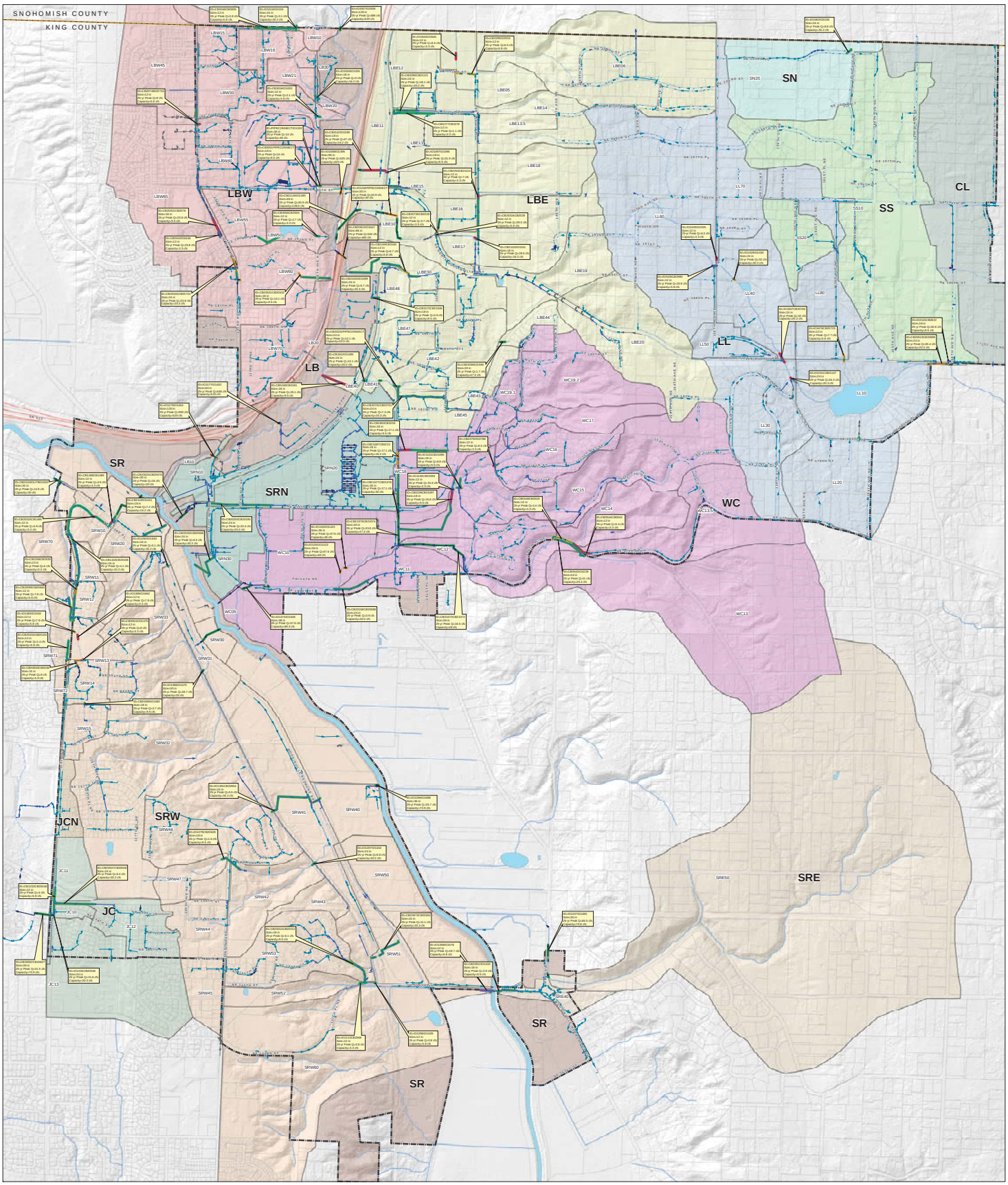
stage (ft)	storage (ac-ft)	discharge (cfs)
0	0	0.0
2	1	3.1
4	2	4.4
6	3	5.4
8	4	6.2
10	5	6.9

25-yr precip (in)	3.3
SCS Storm	Type IA

Woodinville SWM Plan Update
City of Woodinville, WA

City-Wide Hydraulics Map

April 2010



Legend

- Stream
- Stormwater Open Channel

City of Woodinville Stormwater Pipes 02/16/10

Size

- unknown size
- <= 12"
- <= 24"
- > 24"

Pipes Analyzed (25-yr percent capacity)

- 0% - 100%
- 101% - 150%
- 151% - 300%
- > 300%
- Woodinville City Limits
- Land Use (Revised by Otak 10/12/09)
- Waterbody

Subbasin Boundary

- Cottage Lake
- Jaunita Creek
- Jaunita Creek North
- Little Bear
- Little Bear East
- Little Bear West
- Lake Leota
- School North
- School River East
- Sammamish River
- Sammamish River North
- Sammamish River West
- School South
- Woodin Creek

N

1 inch = 500 feet

0 500 1,000 2,000 Feet

Disclaimer: The information shown is this map is assembled GIS data created and acquried by Otak inc. from the City of Woodinville, King County GIS and Snohomish County GIS, This data is not to survey accuracy and is meant for planning purposes only.

City of Woodinville data received February 16, 2010

Notes:

1- 290 pipe segments were analyzed for hydraulic capacity based on the 25-year and 100-year events.
2- Discharges for all sub-basins shown were calculated using the Santa Barbara Urban Hydrograph (SBUH) methodology.
3- Composite curve numbers were estimated based on land use and soil type.
4- Detention in developments later than 1990 was accounted for by adjusting the curve number.
5- Pipe capacity was calculated for most pipe segments by assuming inlet control.
6- Headwater depth is assumed to be 3 feet above pipe crown.
7- Pipes are assumed to be free of debris.